INFLUENCE OF INTEGRATED INSTRUCTION ON ATTITUDE TOWARD PHYSICS AND ACHIEVEMENT IN PHYSICS AMONG HIGHER SECONDARY STUDENTS OF KERALA IN INDIA AND SOUTH CAROLINA IN THE UNITED STATES

Thesis
Submitted for the degree of

DOCTOR OF PHILOSOPHY IN EDUCATION

By

MINI NARAYANAN

Supervised By

Dr. KUNNATHODI ABDUL GAFOOR
Professor

DEPARTMENT OF EDUCATION
UNIVERSITY OF CALICUT
2018

DECLARATION

I, **MINI NARAYANAN.,** do hereby declare that this thesis entitled as "**INFLUENCE OF INTEGRATED INSTRUCTION ON ATTITUDE TOWARD PHYSICS AND ACHIEVEMENT IN PHYSICS AMONG HIGHER SECONDARY STUDENTS OF KERALA IN INDIA AND SOUTH CAROLINA IN THE UNITED STATES**" is a genuine record of the research work done by me under the supervision of **Dr. ABDUL GAFOOR K**., Professor, Department of Education, University of Calicut, and that no part of the thesis has been presented earlier for the award of any Degree, Diploma or Associateship in any University.

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Place: Calicut University
Date:

Prof.(Dr.)Abdul Gafoor, K.
(Supervising teacher)

Dedication

I dedicate this work to my Ittunni

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Abstract

This study on influence of integrated instruction on attitude toward physics and achievement in physics bases on a set of presumptions. It assumes that teaching strategies are pivotal to learning especially in physics which is difficult and unpopular among students. It attempts to link declining attitude toward physics to students' classroom experiences and considers that constructivist strategies in their purest form fail to develop conceptual understanding for want of proper teacher guidance. It further argues that science instructional practices that combine teacher-centered and student-centered instructional strategies with more active teacher involvement than at present are critical in facing multitude of student interests. And, it seeks to amend physics education practices as emergent literature indicated that neither popular student-centered strategies nor minimally guided instructional approaches are effective.

Higher secondary stage is critical in physics learning especially for female students. Additionally, to examine the reported dissimilarity in student perception of physics and its instructional practices between India and US that indicate to culture specific effect of instructional strategies.This study sampled teachers and students from Kerala and South Carolina. These states are taken as largely representative of educational vision, goals and standards of India and USA, even as the two countries differ on demography, facilities, infrastructure, and prominent teaching strategies. It used a mixed methods research with an exploratory sequential design.

Prior to measuring students' learning outcomes, teachers were measured on their extents of student-centeredness and teacher-centeredness using a classroom practices inventory.Classrooms were categorized into four levels of integration of teacher-centered and student-centered strategies. Attitude toward physics and achievement in physics were measured using a newly developed scale of attitude toward physics and the Force Concept Inventory, respectively.

Responses reveal that though teachers and students agree on the desirability of more direct and constructivist strategies, students still perceive domination of lecturing in their physics classrooms. Student-centered instructional strategies are significantly and consistently higher among teachers in USA than in India. Significantly more Indian teachers use Teacher-dominant Integration (TI); more of those in USA use Fair Integration (FI). Indian female higher secondary students have higher Attitude toward Physics than those in USA, but male students of India and USA do not differ. Female students, especially those in USA possess lower Attitude toward Physics.The study reveals that higher student-centered strategies need not necessarily secure a concomitantly higher Attitude toward Physics.

Integrated Instruction significantly impact Attitude toward Physics or its factors in higher secondary students except of previously high attitude US male students. The attitude is higher for students receiving TI and FI than those receiving IT and SI. This is true for previously low attitude students in US irrespective of gender and such male students in India; but they enhance (only) Future Expectations on Physics in Indian female students. FI and TI enhance Self defined abilities and ease Perception of Content/Personal Difficulties in Learning Physics among Indian males.However, Integrated Instruction does not significantly affect the Attitude toward Physics of the US students with previously high attitude.

Gender and Nationality difference exists in the Achievement in Physics in favor of males and US students despite comparable type of instruction. Fair integration makes a positive impact on the Achievement in Physics of Indian students, irrespective of gender and previous achievement. Integrated instruction is not found adding to achievement in physics of previous high achievers of USA. Teacher dominant Integration is effective on Achievement in Physics for previously low achievers in USA. For formerly high achieving Indian females, instruction with Student Dominant Integration is equally effective as that with Fair integration.

The findings suggest the need for design of curriculum and activities with an efficient combination of teacher-centered and student-centered classroom practices. Teachers in India need to temper teacher-dominant instruction with more student-centeredness. Findings call for more emphasize on conceptual understanding in physics, strengthening teachers' pedagogical knowledge and dispositionespecially via modelling Fair Integration to student teachers.

Chapter I

INTRODUCTION

- *Need and Significance*
- *Statement of the Problem*
- *Definition of Key terms*
- *Objectives*
- *Research Questions*
- *Hypotheses*
- *Methodology*
- *Scope and Delimitations*

Introduction

Teaching strategies play a vital role in the learning process. Educators are in constant debate to choose the best instructional strategy for learners, whether it is student-centered or teacher-centered. Instructional practices in which the instructor has a spirited partaking, modify misconceptions that are deep-rooted in learners and thereby improve their attitude toward the subject (Trninic, 2018; Erinosho, 2013).Teacher-centeredness and Student-centeredness during instruction are not mutually exclusive. Though integration of student-centered and teacher-centered strategies can occur unintentionally, teachers are able to purposely integrate these two strategies based on the type of content, teaching and learning goals, prior knowledge or the learning level of students (Bakker, 2018; Chase & Abrahamson, 2018; Kirschner, Sweller & Clark, 2006).

Student' attitudes toward science are related to their learning experiences (Erinosho, 2013). Physics remains unpopular among students all over the world (Seth, Fatin, & Martina, 2007). The largest decline among students has been found toward learning physics when they transition from elementary level to secondary and higher secondary levels (Gafoor, 2013; Dancy & Henderson, 2010; Hazari, Sonnert, Sadler, & Shanahan, 2010). Integrated instruction improves mastery of content, develops scientific reasoning, and cultivate a positive attitude toward science, and seem to be more effective among diverse groups of students (Cajas, 2001). This study attempted to ascertain the effectiveness of integrating both teacher-centered and student-centered instructional strategies in teaching physics at higher secondary level in the Indian and US contexts.

The states of Kerala, India and South Carolina, USA were found typical for this cross-national study. Both Kerala and South Carolina are of average Socio-

Economic Status in India and USA, respectively. Public school education is very popular in both states as the public schools are of very high standards (SCDE, 2018; SCERT, 2010). According to the Kerala State Council for Educational Research and Training and the South Carolina Department of Education, the science standards and curriculum were found equivalent, and the content covered for physics in Grade 11 were also found comparable (SCDE, 2018; SCERT, 2010). The higher secondary physics curricula in Kerala and South Carolina have adopted the national vision, goals and standards, of the National Council of Educational Research and Training for India and Next Generation Science Standards for USA , respectively, which are remarkably comparable (NCERT, 2014; NGSS, 2012). Though samples for this study were considered from Kerala and South Carolina, since these states have adopted their respective national vision, goals and standards they are considered as general representations of India and USA.

After visiting classrooms in both the countries, the researcher felt that the existing instructional strategies do not generate a remarkable change in the student attitude toward physics. Students often become excellent test-takers and high achievers without developing an in-depth conceptual understanding or interest in the subject in a classroom with direct instructional strategies (Rai & Kumar, 2018; Trininic, 2018; Sharma, Ahluwalia, & Sharma, 2013). Contrarily, students engage in different activities in a classroom where they are exposed to inquiry-based instructional practices but without a proper grasp of the actual concept (Abrahamson & Kapur, 2018). A lack of positive attitude toward physics was observed in India as well as US albeit the difference in instructional strategies (Sharma, Ahluwalia, & Sharma, 2013; Hazari, Potvin, Tai, & Almarode, 2010). The dearth of proper conceptual understanding leads to lack of motivation and negative attitude toward the subject (Sharma et al., 2013; Beichner & Saul, 2003). In this context, the effect of integrated instruction is studied on students' attitude toward and achievement in physics. For doing this, classroom practices in the states of Kerala, India and South Carolina, USA were categorized by integrating teacher-centered and student-centered instructional strategies into various levels, with the help of a scheme and rationale. Then, effects of integrated instruction on student attitude toward physics and achievement in physics were studied.

Need and Significance

Physics is a subject that has the potential to inspire students irrespective of their gender difference (Hadzigeorgiou & Schulz, 2017). However, the content of physics challenges every student; female students lag even behind male students in learning and excelling physics concepts (Musasia, Abacha, & Biyoyo, 2012). The lack of interest leads to avoidance and opting out physics at higher grade levels. How does one make learning physics enjoyable with a firm understanding of the concepts? That was the question lingering the researcher ever since she became a student and later a teacher of physics.

Attitudes and interest in science depend on the quality and type of instruction and physics is not an exception. A firm understanding of the learning processes of students is inevitable to ensure effective learning. Students develop a negative attitude toward the subject if they do not attain proper understanding. Students enjoy learning when they have a deeper understanding of the underlying concepts rather than having a superficial knowledge in order to pass the high-stake examinations (Yerdelen-Damari & Elby, 2016).The decline in students' Attitude toward Physics is most likely connected to their classroom experiences including pedagogical variables (Gonen & Basaran, 2008; Elster, 2007; Trumper, 2006).

Therefore, this study surveys student Attitude toward Physics and Achievement in Physics by type of instructional strategies teachers practice in their classrooms.

Teaching practices addressing student beliefs in physics can have clearly measurable effects (Akinbobola, 2015; Ramsey, Nemeth, & Haberkorn, 2013; Krapp & Prenzel, 2011).There have been attempts of implementing and testing a number of instructional strategies to make learning physics interesting for the last few decades (do Carmo & Hönnicke, 2018; Cahyadi, 2007; Langley & Eylon, 2006; Napoli, 2004; Jonassen, 1991). Student-centered and inquiry-based strategies are accepted by many leading science teaching organizations like National Council for Teacher Education, USA (Zollman, 2012), NCERT (2010), National Science Teachers Association, USA (Motz, Biehle, & West, 2007), National Research Council, USA (Cajas, 2001), and the American Association for the Advancement of Science (AAAS, 1989), However, such attempts face difficulties in implementing them in a long run and to bring in desired results (Campbell, Zhang, & Neilson, 2011). New strategies are mostly constructed independent of existing strategies as foundation and thereby fail to be complete and successful in their pedagogical aspects.

The advocates of inquiry-based instructional strategies in physics argue that students must be aware of the process of their learning. They proclaim that "Physics isn't all that important" (Wenning, 2010). Nonetheless, student-centered strategies often become ineffective when students lack abstract level understanding in the absence of sufficient guidance from facilitators. Minimally guided instruction does not appear to proceed with respect to working memory or long-term memory (Conway, Cowan & Bunting, 2001). On the other hand, traditional approaches in teaching physics are made for the average student in which everyone is forced to progress at the same rate irrespective of their abilities in a teacher-centered environment. Any instructional strategy that ignores the limitation of human brain upon dealing with new information is likely to be ineffective (Kirschner, Sweller & Clark, 2006).

To maximize achievement with a concrete understanding, experts in science advocated for constructivist instructional strategies that are prevalent during the past few decades. However, constructivist strategies in their purest form fail to develop conceptual understanding due to the absence of proper guidance. Teaching through inductive method is not required to avoid teacher-centered strategies completely or rely on self-discovery. In other words, the instructor has an important role in facilitating learning by guiding, clarifying and even lecturing in an inductive method (Prince & Felder, 2006). Moreover, it has been discovered that "teaching by telling" is very effective in science and engineering classrooms after the introduction of the concept in an inductive way (Bransford, Brown, & Cocking, 2000). Ebenezer and Zoller (1993) argued that necessary emphasis must be placed on science teachers' role and their teaching styles if an educational change is to be achieved in the constructivist direction.

Trninic (2018) claims that direct instruction and discovery learning are not opposite but complimentary which could be repeated by exploratory practices. He suggests reconceptualization of repetitive activities as an exploratory practice in which direct instruction strategies are intimately integrated. An integration of constructivist and non-constructivist pedagogical approaches has been suggested in several recent researches in different parts of the world (Bakker, 2018; Chase & Abrahamson, 2018; Arsal, 2017; Lehtinen, 2017). Therefore, a proper bridging of product and process is necessary in the teaching-learning process of physics. An integrated approach of various classroom practices can be an appropriate instructional strategy at secondary school levels for the formation of models, attempting experiments and to make inferences. Such integrated approaches, if judiciously planned and meticulously carried out may lead to true comprehension and understanding of scientific principles as well as their application in a real world scenario (Davison, Miller, & Metheny, 1995).

Integration of classroom practices is not a novel concept for the science education community. Researchers were in search of a suitable methodology for science instruction by re-examining the enduring assertion of the limitations of direct instruction and the advantages of discovery methods. The Learning Cycle Lesson Plan model or the 5E Instructional model by the Biological Sciences Curriculum Study has been in ubiquitous use in science education since the 1980's. The 5E model consists of five components: Engagement, Exploration, Explanation, Elaboration, and Evaluation (Bybee, 1987). Each of these phases enhances the teaching-learning atmosphere by providing a sequence and organization of concepts, lessons or units. In an environment of integrating student-centered and teacher-centered instructional activities, the 5E model can be more efficient and effective on conceptual understanding (Bybee, 1987). Such an approach can benefit learners with retention of concepts and improved attitude toward science in a constructivist learning environment (Lawson, Abraham & Renner, 1989). Students view subject with a positive attitude when they develop self-confidence through an interactive learning environment with the 5Es. Attitude affects learning subjects like physics since it is correlated with achievement (Soomro, Qaisrani & Uqaili, 2011).

The process of teaching and learning using the 5E model is not purely inductive or deductive in practice. In a classroom adopting integrated instruction using 5E Instructional Model, the components of Engagement and Exploration help students recognize the relevance of the topic through inductive activities, whereas they receive additional knowledge and support in the Explanation phase from the instructor through a deductive manner. The development of an integrated instructional approach in this study considered combinations of inductive and deductive practices as the underlying principle with the 5E Instructional Model as a platform. This study intended to measure the effect of such instruction on attitude toward physics and achievement through improved conceptual understanding among the higher secondary school students of India and USA.

There are methodical, logical and educational justifications for situating this study in India and USA, apart from the personal experience of the investigator as a student and teacher of physics in these countries. There was felt difference between classroom practices in India and USA and this apparent difference was confirmed by other studies (Walper, Lange, Kleickmann, & Möller, 2014; Sharma et al., 2013). Despite the difference in instructional practices, perception of physics among students is similar in both countries. Students in India and USA exhibit lack of interest and motivation in learning Physics (Sharma et al., 2013; Hazari, Potvin, Tai, & Almarode, 2010; Sadler & Tai, 2007). Since students in both the countries are likewise to possess negative attitude toward physics even with the differences in demography, classroom facilities, and infrastructure, it is assumed that there is a common notion in beliefs, attitudes, preferences and expectations in learning physics among the secondary school student populations.

This study measured the extent of student-centeredness and teacher-centeredness among teachers of both countries and investigated if the extent of the integration of student-centeredness and teacher-centeredness influenced attitude toward and achievement in physics at the higher secondary level. Physics Education Research benefits from cross-national studies like this to modify physics instructional strategies for improved outcomes (Vistro-Yu, 2013; Caliskan, Selcuk, & Erol, 2010; Reddy, 2010).

There are academic and administrative reasons related to teacher and teaching, beyond the aforesaid differences in student demography and school infrastructure, for choosing US and Indian samples and the particular sequence and method of investigation for this study. In USA, teachers who are certified to teach science subjects are not necessarily "highly qualified" in their respective science subjects (White & Tyler, 2015). This fact mostly affects the quality of teacher-centered classroom practices as direct instruction requires well-structured teaching topics to be made meaningful by experts in the corresponding content area (Heitin, 2016). As a result, physics teachers with "pedagogical content knowledge" rather than having a combination of pedagogical content knowledge and an in-depth knowledge in the subject matter" adopt more student-centered instructional strategies during physics instruction and avoid direct instruction where the instructors should have in depth content knowledge (Loewenberg, Thames, & Phelps, 2008; Shulman, 1987). In contrast, the teachers who are assigned to teach physical sciences in India are highly qualified and usually more comfortable in handling the subject through direct instruction. However, they do not seem to possess sufficient knowledge in the research-based pedagogical practices (Rai & Kumar, 2018; Sharma et al., 2013). Lack of adequate pedagogical practices and the obstructions emerging from the infrastructure seem to be the possible reasons to gain more support and encouragement for teacher-centered instructional practices as opposed to accepting more student-centered strategies in the Indian scenario (Gafoor, Farooque, & Munavvir, 2013).

Other curricular differences are also noticeable while comparing higher secondary school physics in India and US. Physics is introduced as an optional subject to students in India at secondary school at a higher difficulty level whereas it is given as a requirement for graduation to most secondary students in the US, though at a lower difficulty level (NCERT, 2014; NGSS, 2012). The US students study physics at a similar difficulty level as the Indian students do only if they choose to study the Advanced Placement Physics as an elective. Indian students receive two years of instruction in physics, whereas the students in the US receive one year of instruction unless they pick a second year of physics as an elective. Physics experience of students in both India and USA is found to have a weak positive correlation with their performance in college. Their preparedness in learning college level physics seem inadequate even after taking one or more physics courses at high school level (NCERT, 2014; Lewin, 2013; Sharma et al., 2013; Sadler & Tai; 2007).

High school teachers in USA are mostly interested in promoting scientific literacy and the impact of science on the world. They compromise with the difficulty level of the content by following non-traditional techniques with no textbook, fewer topics, and by means of project work (Brooks-Gunn & Johnson, 2006; Sadler & Tai, 1997). Comparatively, teachers in India do not seem to engage in inquiry-based instructional strategies. Having a strong content knowledge in physics would not solve every sort of inadequacies if the teacher is not versatile with the research-based instructional strategies.

The learning environment, methods of instructional strategies, and student and teacher attitudes in India were found to be the same as they used to be 20 years ago (Rai & Kumar, 2018). In other words, teachers in India do not think that spending long hours on clarifying concepts using an alternative strategy other than lecturing is worth enough in teaching physics. Thereby, students fail to develop a concrete understanding of the concepts and a positive attitude toward physics (Sharma et al., 2013). The end product is construction of a group of students with misconceptions and negative attitudes toward the subject.

Indian students, in practice not in advocacy, miss the opportunity to learn on a student-centered platform using the inquiry-based approach. The curriculum mostly comprises of memorizing equations, deriving complex formulas, solving problems without the actual understanding of the underlying concepts. The lab activities are not correlated with the topics covered in classrooms and are given in a pre-determined schedule in cook-book style (NCERT, 2014). Students miss the opportunity to conduct hands-on activities while they learn a particular concept in classroom.

In the meantime, students of USA are exposed to numerous learning activities without an actual teacher involvement in clarifying concepts. The lack of thorough knowledge in content area makes them inefficient in answering many conceptual questions and solving many application-level problems (Trninic, 2018; Beichner & Saul, 2014). The “student-centered” activities become sheer learning activities for classrooms with minimal student motivation and enthusiasm. The aftermath is creating a group of students with poor conceptual knowledge and, alike their Indian counterparts, negative attitude towards physics.

Students in both India and US find it very difficult to excel in college level physics (Rai & Kumar, 2018; Sharma et al., 2013; Hoffer, Quin, & Suter,1996). In other words, the current instructional strategies they are exposed, mostly positioned around one end of the student-centered instruction and teacher-centered instruction continuum, do not seem adequate enough to develop a firm conceptual understanding in either of the groups. A better score in physics does not rule out students’ misconceptions, and their attitudes toward the subject is strongly correlated with their conceptual knowledge. This scenario made to situate the present study in an Indian as well as US setting. Based on this evidence, it is hypothesized that the attitude toward physics would be identical among students, whether in India or USA, although for varying reasons. Further, classroom visits in both countries revealed a strong urge among students for a modified instructional strategy that could improve the teaching and learning environment. This realistic circumstances make an argument against the effectiveness of both the traditional mode of teaching with a strong background in the subject matter and the research-based student-centered methods without the actual teacher participation in developing positive attitudes among students.

A thoughtful combination of teacher-centered and student-centered instructional strategies could make physics learning better. There is a need to realize the fact that teacher-centeredness and student-centeredness during instruction are not mutually exclusive, and an instructional strategy, which is in between these two extremes could provide measurable effects. Therefore this study focused on investigating the effect of integrated instruction with various extents of student-centered and teacher-centered characteristics on student attitude toward and achievement in Physics. The findings of this study could provide evidence to develop an instructional strategy in physics for students at higher secondary level regardless of differences in gender or nationality, since the effect of the instruction is measured in a natural setting.

Statement of the Problem

This study is entitled as "INFLUENCE OF INTEGRATED INSTRUCTION ON ATTITUDE TOWARD PHYSICS AND ACHIEVEMENT IN PHYSICS AMONG HIGHER SECONDARY STUDENTS OF KERALA IN INDIA AND SOUTH CAROLINA IN THE UNITED STATES".

The problem implied in the above title is to investigate whether higher secondary school physics teachers in India and United States differ in the extent of their practice of teacher-centered and student-centered strategies in classroom; and, to verify whether higher secondary students in India and United States differ on their attitude toward physics, and whether such difference, if any, varies for male and female students; and, to finally test whether the extent of integration of teacher-centered and student-centered instruction strategies by their teacher effect attitude toward physics and achievement in physics of higher secondary students, and if so, to further know if such effects of integration vary by gender, nationality and previous level of the attitude and the achievement.

Definition of Key Terms

Influence: The ability to change the development of fluctuating things like conduct or thoughts. Here, influence is the consequence measured in student attitude and achievement in physics when teachers implement integrated instruction in classrooms.

Integrated Instruction: An integration of constructivist and non-constructivist pedagogical approaches by re conceptualizing repetitive activities as an exploratory practice in which direct instructional strategies are intimately incorporated. In this study, integrated instruction is the four types of integration developed using a scheme of integration consisting Incompetent Teaching, Student-dominant Integration, Teacher-dominant Integration, and Fair Integration.

Attitude toward Physics: Attitude is defined as an individual's prevalent tendency to respond favorably or unfavorably to an object. In this study, it is the overall approach toward learning physics in terms of affect toward physics, self-defined abilities in learning physics, perception of content/personal difficulties in learning physics, and future expectations on physics.

Achievement in Physics: Student achievement in physics measures the amount of academic content a student learns in a determined amount of time. In this study, it is the conceptual understanding of Newtonian Mechanics that could be measured by mid-term of the academic year.

Higher Secondary Schools: Schools accommodating students in grades 11 and 12 for two years of formal education before entering college. In this study, Grade 11 and 12 students in the states of Kerala (India), and South Carolina (USA) are considered. Higher secondary schools are part of the 9-12 curriculum in USA and hence they are known as "high schools".

Kerala: The southernmost state in India with high population density and literacy. The quality of education is moderate and has a national curriculum and system for higher secondary schools.

South Carolina: One of the southeastern states in USA with high population density and higher secondary school graduation rate. The quality of education is moderate and follows a national curriculum, standards and system for higher secondary schools.

Objectives

This study is to test the effect of integration of student-centered and teacher-centered classroom practices by physics teachers on attitude towards physics and achievement in physics of higher secondary male and female students of Kerala (India) and South Carolina (US). The major objectives are as follows.

1. To compare Attitude toward Physics of higher secondary students in Kerala (India), and South Carolina (USA)
2. To examine whether Gender and Nationality interact on Attitude toward Physics of higher secondary students in Kerala (India), and South Carolina (USA)

3. To develop an inventory on classroom practices to measure the extent of Student-centered and Teacher-centered instructional strategies practiced by higher secondary physics teachers in Kerala (India), and South Carolina (USA)
4. To confirm if there is any difference in the extent of Student-centeredness and Teacher-centeredness in physics instruction between the teachers in Kerala (India), and South Carolina (USA)
5. To confirm if Integrated Instruction (combinations of student-centeredness and teacher-centeredness at different levels) makes a difference in Attitude toward Physics among higher secondary students in Kerala (India), and South Carolina (USA)
6. To investigate gender wise effect of Integrated Instruction on Attitude toward Physics of higher secondary students in Kerala (India), and South Carolina (USA) by their previous level of Attitude toward Physics
7. To confirm if Integrated Instruction (combinations of Student-centeredness and Teacher-centeredness at different levels) makes a difference in Achievement in Physics of higher secondary students in Kerala (India), and South Carolina (USA)
8. To investigate gender wise effect of Integrated Instruction on Achievement in Physics of higher secondary students in Kerala (India), and South Carolina (USA)by their previous level of Achievement in Physics

Research Questions

1. Do higher secondary students of Kerala (India), and South Carolina (USA) differ in their Attitude toward Physics?
2. Does Gender affect Attitude toward Physics regardless of Nationality of higher secondary students in Kerala (India) and South Carolina (USA)?

3. Do higher secondary physics teachers in Kerala (India), and South Carolina (USA) differ in the extent of Student-centeredness and Teacher-centeredness in their instruction?
4. Does Integrated Instruction in physics affect Attitude toward Physics of higher secondary school students in Kerala (India), and South Carolina (USA)?
5. Does the effect of Integrated Instruction on Attitude toward Physics among higher secondary students in Kerala (India), and South Carolina (USA) vary by Gender, and if so, to what extent?
6. Does the effect of Integrated Instruction on Attitude toward Physics higher secondary students in Kerala (India), and South Carolina (USA)vary by Nationality, and if so, to what extent?
7. Does Integrated Instruction affect Achievement in Physics of higher secondary school students in Kerala (India), and South Carolina (USA)?
8. Is there an effect of Integrated Instruction due to Gender on Achievement in Physics of higher secondary students in Kerala (India), and South Carolina (USA)?
9. Is there an effect of Integrated Instruction due to Nationality on Achievement in Physics of higher secondary students in Kerala (India), and South Carolina (USA)?

Hypotheses

1. There is no significant difference between Attitude toward Physics of higher secondary students of Kerala (India), and South Carolina (USA)
2. There is significant difference in Attitude toward Physics by Gender among higher secondary students of Kerala (India), and South Carolina (USA)

3. There exists significant difference between higher secondary physics teachers in Kerala (India), and South Carolina (USA) in the extent of
    a) Student-centeredness in instructional strategies
    b) Teacher-centeredness in instructional strategies
4. There exists significant effect of Integrated Instruction on Attitude toward Physics of higher secondary students in Kerala (India), and South Carolina (USA).
5. Gender, Nationality and Previous Attitude toward Physics significantly interact with the effect of Integrated Instruction on Attitude toward Physics among higher secondary students of Kerala (India), and South Carolina (USA).
6. There exists significant effect of Integrated Instruction on Achievement in Physics of higher secondary students of Kerala (India), and South Carolina (USA)
7. Gender, Nationality and Previous Achievement in Physics significantly interact with the effect of Integrated Instruction on Achievement in Physics among higher secondary students of Kerala (India), and South Carolina (USA).

Methodology

As the study progressed through distinct though complementary phases, a mixed methods research with an exploratory sequential design has been adopted. The initial phases required more open and flexible qualitative data which were then used to develop more structured data collection instruments and procedures appropriate for quantitative analysis. The study was mixed of qualitative and quantitative methods, which used interviews, questionnaires, scale of attitude, an inventory and achievement testing as the research instrument. Three phases in the study required multiple samples drawn by multistage sampling in a time span of three consecutive academic years. Variables for this study were divided into dependent variables, independent variables and moderator variables.

Independent Variables

There are three independent variables in the study, namely, Integrated Instruction (in phase 3), and Student-centered Instruction and Teacher-centered Instruction (in phase 2).

1) Integrated Instruction.

In phase 3 prospective ex post facto study, Integrated Instruction was measured using Physics Classroom Practices Inventory on two dimensions namely extent of student-centered strategies and the extent of teacher-centered strategies practiced by physics teachers. The level of integration has been defined for teachers from each country as

1. Teaching with minimal integration (Incompetent Teaching or IT),
2. Teaching with average integration with increased concentration on student-centered tactics (Student-dominant Integration or SI),
3. Teaching with average integration with increased concentration on teacher-centered tactics (Teacher-dominant Integration or TI)
4. Teaching with maximum and balanced integration (Fair Integration or FI).

2) Student-centered Instruction.

In phase 2, the extent of student-centeredness in teaching higher secondary physics among teachers in India and USA was studied based on the scheme of integration developed for this research.

3) Teacher-centered Instruction.

In phase 2, the extent of teacher-centeredness in teaching higher secondary physics among teachers in India and USA was studied based on the scheme of integration developed for this research.

Student Perception of Physics and Teacher Perception of Physics was considered, explored and qualitatively analyzed in phase 1 pilot study.

Dependent Variables

There are two dependent variables in the study, namely, Attitude toward Physics and Achievement in Physics.

Attitude toward Physics

In phase 1, Attitude toward Physics is studied as qualitative perception, beliefs, difficulties and preferences in learning physics. In Phase 2 student survey, the Attitude toward Physics is hypothesized as moderated by interaction of gender and nationality. Attitude toward Physics is measured in Phase 3 as the overall approach of students toward learning physics in terms of Affect toward Physics, Self-defined Abilities in learning Physics, Perception of Content/Personal Difficulties in learning Physics, and Future Expectations on Physics. These components are considered as the sub-scales.

Achievement in Physics

Achievement in Physics is measured as Achievement in Newtonian Mechanics concepts as score obtained on Force Concept Inventory (Hestenes, Wells & Swackhamer, 1992) by the end of the first semester.

Moderator Variables

Gender, Nationality, Previous level of Attitude toward Physics, and Previous level of Achievement in Physics of higher secondary students are hypothesized to modify the influence of Integrated Instruction (independent variable) on their Attitude toward Physics and Achievement in Physics at higher secondary level. In addition, phase 2 of this study tests hypothesis that Gender and Nationality of students have independent and interactive influence on Attitude toward Physics.

Research Instruments

A total of six data collection instruments and techniques were used for this study. All instruments except the Achievement Test were developed during the study. Structured Interview schedule for Students, Questionnaire on Student Attitude toward Physics, and Scale of Attitude toward Physics were used to obtain data on measures of Attitude toward Physics, one of the two major dependent variables in this study. Structured Interview schedule for Teachers, and Physics Classroom Practices Inventory were used to obtain data on measure of Integrated Instruction, the independent variable in this study. The Force Concept Inventory, which is a universally accepted test for measuring the conceptual understanding in Newtonian Mechanics was adopted to obtain data on measures of Achievement in Physics, the other major dependent variable in this study (originally developed by Hestenes, Wells & Swackhamer, 1992).

Samples Used in the Study

Higher secondary students and teachers of two countries, India and USA from the states of Kerala and South Carolina, were the selected samples for the study. Kerala (India) and South Carolina (USA) states were chosen to represent their respective countries with the assumption that they are typical yet relatively comparable states of the two nations. The teacher and student samples used in the three phases of this study are related; as the data was collected repeatedly from the same cohort of teachers and their students in these two states. Randomness was applied in choosing the districts and schools within each district.

Pilot Studies were performed among students and teachers in phase 1, on a random sample of 121 students drawn from 6 schools, 3 from one district in Kerala and the other 3 from one district in South Carolina. Teacher sample in Phase 1 consisted of 82 physics teachers randomly chosen from 57 schools from 3 districts each of Kerala and South Carolina including those from 6 schools used for pilot study among students. Surveys of students and teachers were conducted in phase 2 of this study. A total of 1368 students drawn by stratified random sampling from 4 schools each from the 3 districts (2x3x4 =24 schools) of Kerala and South Carolina. These schools were chosen from the 57 schools in phase 1 teacher sample. The teacher sample consisted of 106 teachers drawn by stratified random sampling from randomly chosen 9 districts each of Kerala and South Carolina. These 9 districts include 6 randomly selected districts and all 3 districts for pilot study among teachers. Student sample for ex post facto phase consisted of 949 students of 24 classrooms, of which 12 classrooms each in Kerala and South Carolina, taught by the select 24 teachers from the phase 2 sample of 106 teachers. Teacher sample for ex post facto phase consisted of select sample of 24 teachers (12 per nation), who were considered typical of the 4 types of integration (3 teachers for each type of integrated instruction) from Kerala and South Carolina.

Statistical Techniques Used for Analysis

1. Qualitative Analysis
2. Descriptive Statistics
3. Chi-Square Test of Homogeneity
4. One-way ANOVA
5. Factorial ANOVA
6. Test of Significance of Difference between Means
7. Exploratory and Confirmatory Factor Analyses (SPSS version 24)
8. Effect Size as Partial Eta squared

Scope and Delimitations

Scope of the Study

A cross-national study like this involving two different nations with unique educational philosophies highlights the pros and cons of instructional strategies for physics instructors.

This study indicates that there is room for developing such studies to add diversity in physics education in terms of student attributes and teaching methods by analyzing data from two different populations. The influence of integrated instruction was found equally prominent among students of two countries that are seemingly different in culture, tradition, infrastructure, and facilities. Findings of the study pave way to design physics curricular activities with adequate teacher-centered instructional practices without compromising its student-centered environment. It is worth noting critical insights on the teacher-centeredness among the US teachers and student-centeredness among the Indian teachers.

The study was performed in a natural setting with the choice of typical teacher samples for investigating the effect of Integrated Instruction. Being a status study, the findings were gathered in accepted and established educational settings in which normal educational practices are performed. In that way, the biasing has been minimized. The study has been carried out in three consecutive academic years. This could minimize the fluctuation in observation, if any, of their teaching strategies and common practices, possible in one-shot studies. The observation on teachers implementing the instructional strategies are consistent and valid.

Gender gap in physics achievement and subsequent attitude toward physics has been a topic of research for the past three decades. There are not many studies on the cultural aspect of gender gap in physics education and its outcomes. This study intended to investigate how culture affects attitude toward physics in an international context.

It was part of the research to develop a tool for measuring the students' attitude toward learning physics using the responses from students and teachers in Kerala (India) and South Carolina (USA). The scale of attitude is similar in many ways with other international tools used to measure students' attitude toward physics. Similar results were found in the literature that used the international tools in measuring student attitude toward physics. Further study is required to establish its credibility among other populations.

The study has developed another tool, an inventory in measuring the extent of student-centeredness and teacher-centeredness in classroom practices for teachers. Classroom practices of physics teachers in India and USA were analyzed in two dimensions and in two different phases. Measures were taken to confirm that the students of those teachers stayed the same throughout the study so that the investigator could relate the attitude of students toward physics with the instruction they receive. The inventory has been developed in such a way that it could be used in other science disciplines and at any level of education.

The problem was attacked in different angles and using different aspects of the major objectives. A variety of statistical techniques ranging from descriptive statistics to Four-way ANOVA have been performed in this study to examine the main and interaction effects of the independent and moderator variables on the dependent variables. An array of tools comprising both qualitative and quantitative, namely, structured interviews, questionnaire, scale, inventory, and test, were used in this mixed methods research with exploratory sequential design. Student attitude toward physics was one of the dependent variables in this study, which has been investigated in various levels and dimensions namely, structured interview, survey using questionnaire, and a scale, and cross-validated on three different samples in three different phases. Three moderator variables namely, gender, nationality and previous performance (in attitude and achievement) were included in this study.

An interaction effect of Nationality and Gender on Attitude toward Physics was revealed among higher secondary students in Kerala (India) and South Carolina (USA) in the survey phase of this study, and then reconfirmed the finding by analyzing the data in the prospective ex post facto phase. By reconfirming the result in two different samples provided more to the validity of the tool in measuring Attitude toward Physics among students.

The curriculum and instructional strategies can be modified and teachers can be trained to improve student performance and persistence in learning physics concepts through suitable pedagogical practices. Additionally, the ability in enjoying and sensing physics concepts is directly related to the ability to understand abstract ideas. The lack of enjoyment in learning physics concepts keeps students, especially the female counterparts, away from accepting careers and opportunities for higher education in related areas. For them, learning physics is to merely get qualified in other science related fields or careers during the years of their higher education. In that case, the effect of various levels of integration developed by the researcher would create a passion toward learning physics for students.

Delimitations

Samples of this study were limited from Kerala (India) and South Carolina (USA). It would be a more balanced representation of both countries if samples were considered from across India and USA. The possible inadequacy of sampling has been rectified by choosing samples for different levels of study in three consecutive years focusing on various dimensions of the objectives with various types of research instruments.

The outcome variables were limited to attitude toward physics and achievement in physics. Other outcome variable such as process skills, problem-solving ability, critical thinking skills were not explored. This study concentrated on students' attitude toward physics and achievement in physics. One of the moderator variables, previous performance (in attitude and achievement) was not measured individually, but as a continuous data. It was practically impossible to analyze the data individually as a significant portion of students displayed high attitude toward physics and achievement in physics initially without having enough room to show improvement. Therefore, the data on previous performance was collected as continuous and in groups as “high” and “low”.

Achievement test was limited to assessing conceptual understanding for the study. Generally, achievement in physics measures students’ conceptual understanding along with their problem-solving skills. There are other international tools available to measure students’ conceptual understanding and problem-solving skills in physics. The Force Concept Inventory was used in the study because of its versatility and popularity among studies conducted at higher secondary level. Additionally, based on the related literature, it is likely that students often are able to solve problems without in-depth conceptual understanding. Therefore, this study intended to measure conceptual understanding.

Nevertheless, it was possible for students to guess answers and get them right as all 30 items in the Force Concept Inventory (FCI) are Multiple-choice questions. As a result, the test scores did not completely interpret students’ conceptual understanding in this study. Investigator could have asked students to justify each of their responses during the test. Review of related literature reveals that standardized in measuring achievement in physics mostly consist of Multiple-choice questions.

The topic was limited to Newtonian Mechanics from Grade 11 syllabus in this study because investigator had to make sure that the topics covered in India and USA would be the same during the same period of the academic year. During the discussion with teachers in both countries, Newtonian Mechanics was found to be the appropriate topic for that purpose.

A wide gap has been noticed in the mean scores of students from India and USA especially in achievement. The highest mean scores of the Indian sample lay beneath the lowest mean scores of the US sample. This discrepancy was found regardless of the gender difference of the total sample. Since the major objective of this study was to investigate the effect of the integrated instruction, this inadequacy did not affect the analysis to a great extent.

Teacher samples for the Ex Post Facto study in the third phase were limited to 24, with 3 teachers for each type of integration from each country. Inclusion of more teachers in each category would increase generalizability of data for interpretation.

Chapter II

REVIEW OF RELATED LITERATURE

- *Scope and Challenges of Physics Education*
- *Disciplinary Factors Affecting Physics Education*
- *Instructional Factors Affecting Physics Education*
- *Integrated Instruction in Physics*
- *Empirical Studies on Physics Learning Outcomes*
- *Conclusion on Literature Review*

Review of Related Literature

This study investigates physics classroom practices and tests the significance of combining traditional and research-based instructional strategies for better learning outcomes for students in India and USA at higher secondary level. A systematic review on various factors affecting physics teaching-learning process globally as well as in the contexts of India and USA was conducted. The results are presented as theoretical and empirical backgrounds for the study.

The scope and challenges faced by the physics learning community is described in terms of physics learning outcomes from a cross-national perspective in the first subsection. More specifically, how students' lack of positive attitude and motivation in learning physics affects their achievement is described in this sub section. Disciplinary nature of physics, challenges faced by students in learning physics, and students' epistemological beliefs are detailed in the second subsection. The influence of instructional strategies is detailed along with different types of instructional approaches in the third subsection of instructional factors in learning physics. A thorough dissection of traditional as well as research-based instructional strategies has been provided in the latter part of the subsection with supporting literature. The drawback of implementing these strategies in their purest forms is explained in order to make a statement of the need for integrating instructional strategies. Studies indicating or proposing the need of integration, its effect in learning physics with a detailed description of the 5E Instructional Model is described in the last subsection. Strategies and methods of integrated instruction have been discussed in detail with the support of learning theories and different types and levels of integration in the latter part of this sub section. The four subsections in the Theoretical Overview: 1) Scope and Challenges of Physics

Education, 2) Disciplinary Factors Affecting Physics Education, 3) Instructional Factors Affecting Physics Education, and 4) Integrated Instruction in Physics.

The sub section of the first section explores relevant cross-national studies in physics education. Subsections of the second major section deal with empirical evidence on pros and cons of research-based instructional strategies. The third section details constructivist approaches in physics education, and indication of the relevance of inquiry-based strategies with prominent teacher immersion. Empirical studies on Attitude toward Physics and Achievement in Physics were addressed simultaneously in the review because the two variables are interconnected in nature. Hence, this subsection deals with the relationship between attitude and achievement in learning physics. Commonly used tools for measuring students' attitude and achievement in physics are also examined. Further, achievement in physics was explored in terms of problem-solving skills and conceptual understanding. Since the topic of this study whirls around integrated instruction, relevant as well as recent literature reviews were gathered on integrated instruction in physics in the last subsection, which is unique since relevant studies suggest integration of popular research-based strategies with traditional non-constructivist strategies. Finally, the literature review wraps up with a conclusion. The Empirical Studies are: 1) Cross-national Studies in Physics education, 2) Evidence on the Effect of Research-based Instructional Strategies, 3) Constructivist Approach in Physics Instruction, 4) Studies on attitude toward Physics, and 5) Integrated Instruction in Physics.

This review of related literature was drawn from peer reviewed journal articles, scientific research studies, and international policies of education available online and as hard copies. An attempt was made to incorporate several cross-national studies conducted in various parts of the world on physics education.

Scope and Challenges of Physics Education

International tests like Trends in International Mathematics and Science Study (TIMSS) and Program for International Student Assessment (PISA) and other assessments indicated the shortcomings of the existing framework on science education (PISA, 2006; TIMSS, 2015). Literature review shows that students in India and USA face the same problem of losing interest in science subjects, especially in the discipline of physics (Gafoor, 2013; Dancy & Henderson, 2010; Hazari, Sonnert, Sadler, & Shanahan, 2010). It is crucial for the science education community to investigate the basic issue of students fleeing away from science disciplines.

The major goals of science education at the secondary level include practical application of concepts and the intellectual exercises associated with those concepts (National Council for Educational Research and Training of India, 2014; National Science Teachers Association of USA, 2007). These goals, along with its vision and methods normally face difficulties in implementation. Due to the absence of a consistent vision, educators fluctuate back and forth from accentuating on content knowledge to the realization of the relevance with the real life (Rudolph & Meshoulam, 2014). Incompetence to provide emphasis on both disciplinary content and pedagogical practices often tend educators not to teach the discipline in its full fledge. This is the scenario faced by physics education in USA.

Inadequacies in educational policies, negligence and over involvement of the political parties and social organizations could also cause decline in science education. India has an intense structure of education compared to other developing countries, and a long tradition of science education in secondary and tertiary levels. However, the discipline of science has become unattractive among students recently particularly in physics (Shah, 2017). Students shift their priorities from science to non-science disciplines, especially in the basic science area (Garg & Gupta, 2003). The National Council of Applied Economic Research reports indicate that less than three percent of school children want to pursue a career in science (Bauer, Shukula & Allum, 2012). A notable portion of the students are found to lose their interest while learning the discipline (Varghese, 2008). Therefore, a thorough exploration of disciplinary and instructional factors affecting physics education becomes inevitable, especially in the Indian and US contexts in which enormous resources are being spent on science education.

Students' expectations affect their understanding of the subject (Lising & Elby, 2005; Roth & Choudhury, 1994). According to Project 2061 by AAAS (American Association for the Advancement of Science), students' learning is influenced by their existing ideas gathered through previous life experiences. Therefore, it is important to identify student perceptions in order to develop a more student-friendly approach in physics instruction to cultivate positive attitude toward the subject along with a deep conceptual understanding.

Outcomes of Learning Physics

Learning physics becomes relevant and the discipline turns into one's favorite science when physics concepts help explain many questions related to his or her real life activities. A superficial knowledge is not adequate for students to provide enough explanation on various physical phenomena around and, as a result, they become less motivated and develop a negative attitude toward physics. Physics has become the least favorite of the basic sciences among students all over the world (Potvin & Hasni, 2014; Erinosho, 2013). Recent studies reveal lack of motivation and interest in learning physics among the students in India and USA (Walper et al, 2014; Sharma, Ahluwalia, & Sharma, 2013).

What is meant by Attitude toward science or physics? How does that affect students' learning, performance and future endeavors? Is there a way to find remedial measures to retain students in science or physics classrooms? What measures need to be done to accomplish this goal? The rest of this review makes an attempt to find answers to these questions.

Attitude toward science: a global perspective. Attitudes refer to a set of emotions, beliefs, and behaviors toward a particular object, person, thing, or event. Strauss (1945) defined attitude as "a process of individual consciousness determining possible activity of the individual in the social world". The four concepts, namely attitude, belief, opinion and value are the four major parts of the cognitive-affective continuum. Attitude is a construct that has cultural, religious, traditional and ethnic bases. Attitude describes a tendency toward an object, and always includes evaluation. A person's affective and motivational aspects have been attributed to attitudes (Fishbein & Raven, 1962).

Scientific attitudes are different from attitude toward science. Scientific attitude is philosophical and cognitive whereas, the attitude toward science is evaluative. Attitude toward science is defined as a learned response evaluating students' feelings within the environment of learning science (Koballa & Glynn, 2013). A metacognitive model of attitudes developed by Cohen and Reed (2006) suggest that attitudes are associated not only with positive and/or negative evaluative tags but also with validity tags (as cited by Petty, 2006).The direct relationship of students' attitude toward school science with classroom environment and learning activities has already been a debated issue for the last few decades (Piburn, 1993; Myers & Fouts, 1992; Simpson & Oliver, 1990; Talton & Simpson, 1987).

Attitude toward Physics: current scenario. The decline in interest toward science especially toward physics occurs as students proceed from primary to secondary level. Recent studies show that the level of positive attitude and motivation was not greatly improved even though the students pursue their studies to higher level with a physics major (Sharma et al., 2013). More students choose chemistry and biology over physics and it has been considered common or normal in higher education institutions even in the developed countries (Kaya & Boyuk, 2011). Schwartz, Sadler, Sonnert, and Tai (2009) report preparedness of students in secondary and senior secondary levels as an important predictor of their attitude toward physics. What is the root cause of negative attitude toward physics among students?

Students develop negative attitude toward the subject when applying their inaccurate understanding in novel situations. These naive beliefs often affect their perception on teaching and learning physics (Hammer, 1995). There may be other factors such as personal confidence, perception on the usefulness of the subject, long-term goals, previous learning experiences, and perception on teachers' attitude affecting students' attitude. As a result, physics remains as an unpopular subject among secondary school students, and considered as more difficult than its other two pure counterparts, biology and chemistry (Seth, Fatin, & Marlina, 2007).

Students' attitudes do not seem to improve by memorizing information from textbook, writing the lab report, deriving equations, or having a superficial understanding of the concepts (Erinosho, 2013). Improved conceptual understanding improves students' attitude toward physics (Beichner & Saul, 2003). Researchers are in the process of developing effective methods to assess conceptual knowledge of students in content areas especially physics (Cahyadi, 2007). Having conceptual understanding along with a positive attitude is critical in physics education (Hammer, 2000; May & Etkina, 2002).

Students possess misconceptions in physics prior to entering classrooms that are gathered from environment. These misconceptions lead them to have incorrect mental structures that are difficult to modify just by offering traditional instructional activities (Elby, 2011). Students with difficulties in learning physics view the subject as a collection of facts, formulas, and problem solving methods; mostly disconnected from everyday thinking, and primarily as a matter of memorization. If these difficulties and misconceptions are not properly addressed, it will build negative attitude and perception towards Physics within the learners (Owen, Dickson, Stanisstreet, & Boyes, 2008).

Achievement and attitude in learning physics. Studies reveal a positive correlation between students' academic achievement and attitude in physics in various parts of the world (Ali & Awan, 2013; Narmadha & Chamundeswari, 2013; Sharma, Rosemary & Wilson, 2006; George, 2006; Guzel, 2004; Magno, 2003; Thompson, Lokan, Lamb, & Ainley, 2001). However, the relationship between attitude and achievement in physics is often controversial. There are studies that do not verify a particular relationship between attitude and achievement (Visser, 2007; Azizi, Jamaluddin, & Yusof, 2000). They claim that students achieved good grades in science without having any positive attitude towards science. Based on data reported in the Trends in International Mathematics and Science Study (TIMSS), it has been revealed that the higher the average student achievement, the less positive is their attitude toward science (Osborne & Dillon, 2008). A similar finding of negative correlation between interest and achievement has also been discovered by the Relevance of Science Education (ROSE) project (Turner & Peck, 2009). It is interesting to note that when and where education related to science and technology is the strongest, students usually possess less interest in it (Potvin & Hasni, 2014). Social desirability cannot be overruled in this scenario since students from developed countries reveal a negative attitude toward science than those from developing countries (Baram-Tsabari, Sethi, Bry, & Yarden, 2006). Similar to attitude and achievement, another critical factor that affect students' learning is the gender wise difference.

Despite the fact that the content of physics challenges every student in a high school setting, it has also been observed that female students lag even behind male students in learning and excelling physics concepts (Musasia et al., 2012). The ability of learning physics concepts by female students has been a topic of research for more than two decades. Gender-wise differences are obvious when disciplines become more specific (Potvin & Hasni, 2014). Physics has obviously and universally been preferred by boys (Buccheri, Gurber, & Bruhwiler, 2011; Drechsel, Carstensen, & Prenzel, 2011; Dawson, 2000; Jones, Howe, & Rua, 2000). Interest in physics, especially among girls, is found to be the lowest among secondary school students (Walper, Lange, Kleickmann, & Möller, 2014; Gafoor, 2013; Martin, Mullis, & Foy, 2008; Osborne, Simon, & Collins, 2003).

Among the universities and higher institutions in India, the female participation is still lower in the field of physics and engineering compared to their male counterparts (Parikh, 2004). The female participation is less than 5 percent in the Indian Institutes of Technology (IITs) all over India (India Education Profile, NCERT, 2005). This gender difference in India has also been reported nationally and state-wise that the recipients of higher ranks in the Medical and Engineering Entrance examinations are male students in which the scores in Physics often becomes critical (Sharma et al., 2013). A similar finding was revealed in USA; gender differences were noticed in career plans with males showing far more interest particularly in engineering, whereas females were more attracted to careers in health and medicine during their high school years (Hazari, Tai, and Sadler, 2007; Sadler, Sonnert, Hazari, & Tai, 2012). Is there a physiological reason to have this gender difference in learning physics?

Neuroscience reveals that there are no differences in what girls and boys can learn, but there are obvious differences in the strategies that could be used to instruct them. It is also indicated that the pedagogical factors influence male and female students differently (Gillibrand et al., 1999; Haussler & Hoffmann, 2002). Both male and female students are able to understand physics concepts; however, they differ in the way that they learn. Therefore, the strategies used for instruction must take this aspect into consideration. Since learning physics is more than just coming to understand the concepts of physics, the instructional practices should help the student to think and behave like a physicist (Beatty, Leonard, Gerace & Dufresne, 2006). Therefore it is necessary to explore physics as a discipline and its instructional factors to reduce students' negative attitude and the gender gap.

Disciplinary Factors Affecting Physics Education

Physics is the science that attempts to describe how nature works using the language of mathematics. Learning physics requires skills in logical thinking, problem solving, analyzing concepts at the abstract level, and manipulating ideas in a philosophical way with the support of visual and spatial intelligence (Redish et al., 1998). A physics student is supposed to possess excellent analytical, quantitative and problem solving skills in order to synthesize and analyze large quantities of data and present their analysis in an easily understandable form (Modini, 2006). Students find learning physics difficult because it requires a variety of skills to be applied at the same time (McDermott, 1997; Redish, 1994). Students at all levels have insufficient physics comprehension skills and contradictory cognitive interpretations for physics concepts (Obaidat & Malkawi, 2009).

Disciplinary Nature of Physics

Physics is often considered the most fundamental of all natural sciences and its theories attempt to describe the behavior of the smallest building blocks of matter, light, the Universe and everything within them. Physics has been considered as a difficult subject because it deals with physical quantities and mathematical exactitudes, which are is uninteresting, abstract, and conceptually difficult to grasp (Ogunleye, 2009). Students possess lower expectations of their ability to complete different tasks related to physics, leading to less interest in the subject (Lavonen, Meisano, Byman, Uiito, & Juiit, 2005; Ancell, Guttersrud, Henriksen, and Isnes, 2004; Watson, McEwen, & Dawson, 1994). It has been revealed that students lose interest in physics when they enter secondary level, however, their interest in biology remains the same (Gafoor, 2013; Barmby & Defty, 2006; Ancell et al., 2004). How do students themselves perceive learning physics?

Epistemological Beliefs of Students in Learning Physics

Epistemology deals with the acquisition of knowledge and different modes of attaining it. Epistemological beliefs mainly consist of the nature of knowledge and nature of knowing. Students' perception on science gets weakened due to their perception of the subject that they receive from classrooms (Zacharia & Barton, 2004). Epistemological beliefs of students on learning physics play an important role at novice level. Students learn best when they find the material relevant and understandable. Additionally, students' perception influences their understanding of the subject (Erinosho, 2013). Studies indicate that students choose a subject for further study if they find it interesting (Barmby & Defty, 2006; Lavonen et al., 2005; Williams, Stanisstreet, Spall, Boyes, & Dickson, 2003). Difficulty faced by students in learning physics has been revealed as their failure to construct meanings based on their knowledge structures (Nakleh, 1993).

Majority of students perform mathematical manipulation by rote memorization of equations without any proper grasp of the underlying concepts. Such a shallow knowledge on concepts is not adequate for students to grasp the subject at a mastery level (Johnson & Willoughby, 2018). As a result, it is found challenging for students to secure expert-like thinking and an in-depth understanding of the underlying concepts (Sharma et al., 2013; Sadler et al., 2010). The nature of knowing could be affected by the teaching/learning practices itself and can be modified depending on the nature of domain (Hammer & Elby, 2002).

Teaching physics is not just teaching facts, concepts and methods of physics, but introduce students to a complex culture with the mode of thinking and cultural code of behavior of practicing scientists. Instructors must pay attention to students' intuition and perception while teaching physics (Redish, 2010). The process through which instructional strategies affect students' epistemological beliefs and thereby their attitude toward physics and achievement in physics during teaching/learning practices is depicted in Figure 1.

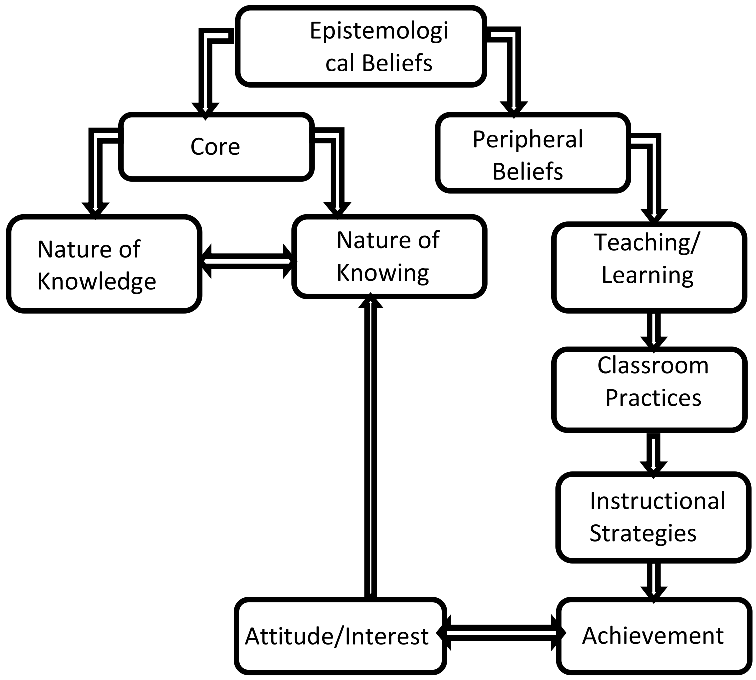

Figure 1. Effect of instructional strategies on students' epistemological beliefs

Challenges in Learning Physics

The ability in enjoying and sensing physics concepts is directly related to the ability to understand abstract ideas (Yerdelen-Damar & Elby, 2016; Redish, Saul & Steinberg, 1998). Due to the nature of Physics, students are likely to possess numerous preconceptions that are quite often incorrect. It is not possible to learn physics only by reading, listening, memorizing or problem-solving (Erinosho, 2013; McDermott, 2000). A major focus should therefore be on how students understand various concepts and how they address misconceptions. To make conceptual understanding effective, a thorough emphasis on qualitative and qualitative analyses of the situation is necessary. Learning to be a physicist is all about making concrete connections between the expert and the novice (Lombardi, 2007).

A modified curriculum can improve student performance and persistence in learning physics through suitable pedagogical practices, and thereby make students passionate about the subject. Teachers need to weigh their options thoughtfully and make decisions on strategies to make learning active and effective (Wilson & Peterson, 2006). With the acknowledgement of paradigmatic shift in the research and the role of knowledge on teaching, there is an isomorphic relationship between approaches to teaching and modes of learning (Elliot, 2018). Ebenezer and Zoller (1993) argue that necessary emphasis must be placed on science teachers' role and their teaching styles if an educational change is to be achieved in the constructivist direction.

Learning physics at higher levels is challenging if one disregards traditional practices and merely follows the prevalent student-centered strategies such as conducting experiments, providing real life examples and arranging fieldtrips. As the curriculum gets broadened and deepened in the secondary level, teaching/learning strategies tend to become more teacher-centered. Contrarily, research shows that students get more motivated and engaged while using student-centered strategies (Schwartz, Lederman, & Crawford, 2004; Hakkarainen, 2003; Chang & Mao, 1999). A sustained learning outcome through those activities is still controversial (Fagen, Crouch, & Mazur, 2002; Mottmann, 1999; Coleman, 1998; Redish et al., 1998). Students lack motivation and develop a negative attitude toward the subject, since they fail to get intellectually challenged in secondary and higher grade levels in a purely student-centered environment. Students' epistemological beliefs have greater impact on attitude and they in turn affect their learning approaches in physics since learning approaches are directly linked with conceptual understanding (Elby, 2011; Redish, 2010; Schommer, 1990). Teachers could make significant changes in their students' epistemological beliefs (Redish, Saul, & Steinberg, 1998).

Foundation of physics is the quantitative analysis of the physical world, and therefore, problem-solving is a critical element of learning physics. Nonetheless, conceptual understanding and problem-solving skills are not mutually exclusive for physics students. Students' learning outcomes become minimal when quantitative aspects of problem solving such as equations and mathematical procedures are addressed in classrooms rather than performing a qualitative analysis for selecting appropriate concepts and principles (Docktor, Strand, Mestre, & Ross, 2015). The authors in their study developed and evaluated an instructional approach called Conceptual Problem Solving. Before moving onto the equations and utilizing mathematics skills mechanically, students are practiced to identify the underlying principles, justify their use, and plan their solution in writing. The approach was implemented among high school students in USA on Mechanics topics. The students received this instruction were compared with those taught by traditional problem-solving techniques. Findings indicate improved student engagement and higher scores on both conceptual understanding and problem-solving. Teachers found the approach easy to integrate into their curricula and recognized the student performance with higher quality than before.

It is acknowledged that instructors of physics all over the world usually address students' problem-solving abilities rather than focusing on their conceptual understanding. However, physics education research focuses on the improvement in students' conceptual understanding and problem-solving skills. It has been an established finding that novice and expert learners solve problems differently (Priest and Lindsay, 1992 as cited by Fraser, Timan, Miller, Dowd, Tucker, & Mazur, 2014). Expert-like learners with improved understanding of the physics concepts approach physics problems as a model of a physical world phenomenon, whereas it is just a numerical problem for the novice-like learners where equations need to be plugged in to find the unknown variable using the given values. The strategies adopted by students are related to their levels of conceptual understanding and performances.

It has been identified that physics instructors commonly use problem-solving as a mechanism to teach physics content and to assess students' learning. Several studies concentrated directly on analysis of different approaches in improving students' problem-solving skills in physics. Shared features from different studies include heuristic scaffolding, modeling by teacher, and explicit procedures that students need to follow collectively intend toward improved problem-solving skills in physics (Taconis, Ferguson-Hessler, & Broekkamp, 2001 as cited by Fraser et al., 2014). Earlier studies in physics education focused on problem-solving concluded that improved problem-solving ability corresponded toward improved conceptual understanding. However, studies conducted among students revealed that students often did not understand the basic concepts even at the end of instruction despite the fact that they were able to solve textbook problems (Crouch & Mazur 2001 as cited by Fraser et al., 2014). According to Hull, Kuo, Gupta, & Elby (2013) the types of problem-solving rubrics currently available do not discriminate the communication during mathematical manipulations that can differentiate the expertise of students on the essential concepts. They conclude that problem-solving rubrics should be reviewed to assess problem-solving expertise more accurately.

Instructional Factors Affecting Physics Instruction

This section comprises sub-sections namely, current status of science instruction in India and USA, physics instruction in both Indian and US contexts, and exploration of current instructional strategies in physics.

Current Status of Science Instruction in India and USA

Studies show that gathering knowledge in the Indian education system is mostly theory-based rather than acquiring practical knowledge (Rai & Kumar, 2018; Sharma et al., 2013; Garg & Gupta, 2003). The Indian National Curriculum

Framework suggests adopting critical pedagogy to provide students opportunity to reflect critically on issues in terms of their political, social, economic and moral aspects (NCF, 2012). An improvement in learning outcomes is expected upon changing the teaching-learning process to enhance students' conceptual development along with the improvement of interest in the learning process. Nonetheless, a vast majority of students display lower level of conceptual understanding in the abstract form. There seems to be a strong need of revolutionizing curriculum and pedagogy to have a more activity-oriented learning environment in the Indian classrooms (Dagar & Yadav, 2016; Sharma et al., 2013; Varghese, 2008).

The goal of addressing the daily needs and interests of the learner has been the key factor of science education in USA rather than just following the abstractions of the disciplinary content. The major objective of this approach was to ignite motivation and attitude among students by gaining social justification for learning science (Brooks-Gunn & Johnson, 2006; Ross, Morrison & Lowther, 2010) and this was groundbreaking among students who wanted more relevant and practical instruction instead of having formal disciplinary studies (Rudolph, 2005b; Kliebard, 2004). However, the change was initially made by omitting the formal laboratory experiments that was originally included in the science curricula. The argument was to replace quantitative laboratory experiments by more qualitative exercises and teacher demonstrations or illustrated lectures to make the discipline of science connected with the real world of which students had direct exposure and experience (Cotter, 2009; Rudolph, 2005a). In this scenario, the science curriculum is evolved with more emphasis on its pedagogy leading to the principle of scientific inquiry through constructivist approaches. As a result, scientific literacy has been emerged as a major goal of science curriculum as a byproduct of STS (Science Technology and Society) by relating science to everyday life. Despite all these revolutionary practices, there still seems to be a decline in student interest in science and technology (Potvin & Hasni, 2014; Walper et al, 2014).

Physics Instruction at Higher Secondary Level: Indian and US contexts

A large number of students in India opt to study science subjects at higher secondary level compared to those in USA. Students in India opt for physics in grades 11 and 12, whereas physics is a mandatory science for all students in grades 11 or 12 in the United States (NCTE, 2014; NCERT, 2010). While students in India take the same physics course, the US students have the option of four different physics courses. Every student is given physics course of the same difficulty level in India no matter what their future goals are. Students in USA are allowed to choose two different physics courses (college preparatory and honors) based on difficulty level, future goals, and individual interests. In addition, ambitious students can complete two more physics courses of higher level that are administered nationally. Physics at higher secondary level is taught in two years in India, whereas the college preparatory and honors physics courses are taught in one year. Students follow a strict syllabus for the final examination. Syllabi for the college preparatory and honors level courses are flexible. A summative assessment at the end of the year determines student's final grade for Indian students, whereas summative and formative assessments given during the academic year determine student's final grade in USA. In India, lab activities are given in separate sessions usually in grade 12 with a predefined sequence, whereas they are given concurrently with the concept being taught in most physics classrooms in the US (NCTE, 2014; NCERT, 2010).

Compared to US standards of academic qualifications of physics teachers, higher secondary school teachers in India are highly qualified with a masters' degree in physics, whereas the US teachers usually have a bachelor degree in science, not necessarily in physics. A large portion of the US teachers teach subjects for which they have little education or training (Ingersoll & Smith, 2003). Student-teacher ratio in an Indian classrooms is 1:60 in most classrooms; it is just about 1:25 in most classrooms in the US. More than 50% of a typical Indian science classroom is of female students; percentage of females who opt for higher level physics courses is comparatively lower in USA. A large number of students including females in India take physics as their major in college. The number of students taking physics as major in college is low in the US; the number of females is even lower.

Generally, there is an agreement on the humanistic approach of science education in USA. The method of teaching shifted from indulging students in discipline-related lab activities toward instruction promoting student-choices and decision-making. Activities in the US classrooms consisted of argumentation, disagreement and discussion toward student engagement to generate social consciousness and willingness to make a change in the world. The American Association for the Advancement of Science later initiated for the Project 2061 in which the emphasis was given to science for all Americans. Later organizations like NSTA, and NRC put forward an age-graded version of the AAAS Benchmarks (Collins, 1998; Hanuscin & Lee, 2008). The guidelines were more supportive of the disciplinary approach rather than considering science for its social and political needs. The framework focused on two central themes, inquiry and nature of science. Inquiry was included as a method of instruction involving hands-on activities student understanding of the nature of science. However, students failed to acquire a desired level of understanding of basic science. International tests like Trends in International Mathematics and Science Study (TIMSS) and Program for

International Student Assessment (PISA) and other domestic assessments indicated the shortcomings of the existing framework on science education. A greater focus on content knowledge and testing to ensure its mastery was again emphasized as the result of the national and international assessments (Vinovskis 2008; Guskey, 2003; Toch 1991). There were mixed responses on these recent changes, the disciplinary approach was applauded on one side, whereas the narrowing down of the content toward frequent testing was criticized on the other side. The current system of science education provides students and educators two different scenarios, 1) to focus heavily on mastery of disciplinary content rather than focusing on scientific process or epistemology, and 2) to prepare students for high-stake testing by mastering a narrow area of the disciplinary content. Therefore, students lack opportunities to get exposed to inquiry-based activities toward the nature of science (Sadler et al., 2010). The bottom line is students lack both attitude and achievement due to the inadequacy of a stable and consistent science education program.

Poor conceptual understanding has been found as one of the major factors affecting the popularity of science among students of India (Rai & Kumar, 2018). The existing practices in the Indian classrooms lack an active component of student engagement in the learning process. Students complained that the teachers usually followed the traditional instructional strategies and do not seem to possess adequate knowledge on research-based instructional strategies (Sharma et al., 2013; Varghese, 2008). The National Educational Policy states that India is committed to secure the benefits acquired from acquisition and application of scientific knowledge for the welfare of its people (NEP, 2016). A recent study on the issues faced by science education in South India reveals that students were concerned about the present science education system. According to the mission of the National Council of Educational Research and Training, India has been bringing out improvement in producing quality teachers in tune with the emerging demands of the students, by achieving the goals of universalization of quality secondary education (NCERT, 2012). However, recent research shows a declining trend in the interest toward basic sciences among students at secondary and tertiary levels (Rai & Kumar, 2018; Garg & Gupta, 2003). Students complain that the achievement tests measure the rote memory at the end of the year or semester and not evaluating their conceptual understanding in depth. In addition, the instructional techniques were criticized for science students losing interest (Varghese, 2008). As a result, students lack both attitude and achievement due to the inadequacy of an efficient and science education program designed to meet the student needs of the present era. Therefore a study of student perceptions in learning physics from these two countries would help to reveal how teaching/learning strategies affect interest in physics. How effective are the existing science classroom practices?

Current Practices in Teaching-Learning Physics

Teacher characteristics affect student motivation and achievement in learning physics to a great extent (Korur & Eryilmaz, 2012). An effective teacher questions students, learns their preconceptions, and help them steering in a direction of growth (Jonassen, Davidson, Collins, Campbell & Haag, 1995). Despite the fact that inquiry-based instructional strategies have become the most popular in science education, many experts and educators still encourage more research that benefits students to have an improved achievement and to have a positive attitude in science subjects (Hanuscin & Lee, 2008, NRC 1996; AAAS 1989, 1993). While experts worldwide support inquiry as an instructional strategy, there are heated debates about various documented problems identified in relation with the inquiry-based approach such as lack of explicit association with science content, lack of evidence in its effectiveness, and lack of clarity upon employing inquiry as an instructional strategy (Bybee et al. 2008; Windschitl, Thompson, & Braaten, 2008; Settlage, 2007).

Proper guidance during instruction is required when learners do not possess sufficient prior knowledge in the subject. The specific role of teachers with a determined level of teacher-centeredness and student-centeredness has not been explored in physics education to a great extent. There have been attempts of implementing and testing a number of instructional strategies for the last few decades (do Carmo & Hönnicke, 2018; Cahyadi, 2007; Langley & Eylon, 2006; Napoli, 2004; Jonassen, 1991). However, new strategies are mostly constructed independent of existing strategies as foundation and thereby fail to be complete and successful in their pedagogical aspects. A teaching strategy that works for one situation may not be effective in another environment (Ramsden, 1992). Therefore, a debate on accepting student-centered vs. teacher-centered learning is one of the key issues among educators. What are the pros and cons of these strategies?

Major arguments against the teacher-centered instructional strategies are related to motivation, conceptual change, misconceptions and transfer of learning. Misconceptions are not rectified though traditional teaching strategies (Brown, 2003; Gunstone, 1987). The instructor is usually unable to identify misconceptions during traditional instruction and hence fails to bring in conceptual change among learners. Conceptual change occurs in the learner when content could be related to his/her cognitive level and to the interrelationships with the other content areas of understanding.

An effective transfer of learning occurs when learners get motivated upon rectification of their misconceptions. In the learning process of science, it is not possible to learn only by reading, listening, memorizing or problem-solving

(McDermott, 1996). In learning physics, it has been reported that mere problem-solving alone doesn't change misconceptions among students (Kim, 2010). As a result a strong urge for active communication between the teacher and learners has been identified.

An outbreak of researches and theories occurred in the recent years to support the active involvement of students in the learning process, of which most of them were student-centered (Schwartz et al., 2004; Hakkarainen, 2003; Chang & Mao, 1999). For implementing student-centered learning activities, researchers suggest inquiry as the platform with a constructivist approach. Students must be doing science rather than reading or being told. However, there is a lack of evidence for improved student outcome since teachers feel discomfort directing or controlling student inquiry (Kock, 2013; Hodgson, 2010). It is conceivable that an inquiry-based strategy which is both student-centered and teacher-centered in nature would be an impeccable option to provide an activity-oriented learning with ample as well as active support from the teacher. Using well-structured activities, students are able to think of the topic as a dynamic process of inquiry rather than absorbing it as a body of language.

Some students feel uncomfortable with non-traditional approaches (Fagen, 2002; Mottmann, 1999; Coleman, 1998; Redish, et al., 1998). As the disciplinary content gets complicated at the secondary level, students need more teacher-centered instruction in learning physics rather than discovering the concept through purely student-centered instructional strategies (Kirschner, Sweller & Clark, 2006). When student-centeredness and inquiry get overpowered by pure teacher-centeredness during instruction, students begin to lose interest and develop a negative attitude toward the subject.

The most popular research-based instructional strategies in physics that are both student-centered and teacher-centered are shown in Figure 2.

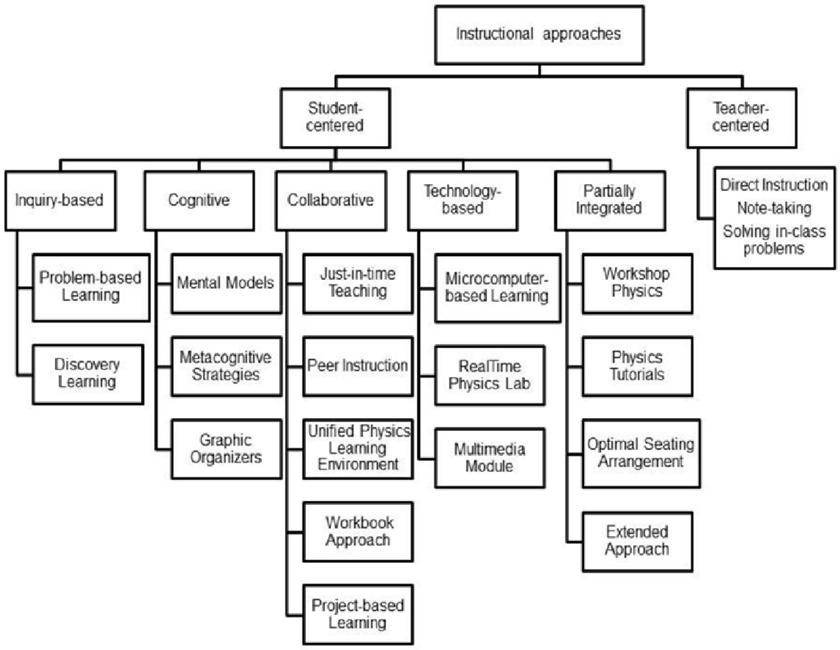

Figure 2. Major types of instructional strategies used in physics classrooms

Investigating the effect of these strategies in higher secondary school setting could have better outcomes (Elby, 2001). Inquiry-based strategies such as Problem-based and Discovery learning, and the Cognitive strategies like Mental Models, Metacognition strategies and Graphic organizers can also be adopted to teach physics in higher secondary level. The popular collaborative strategies like project-based learning, Peer Instruction and Workbook approach and popular lesson plan styles such as Learning Cycle and Legacy Cycle lesson plans can be used as an effective platform for obvious achievements and improved attitudes.

Constructivist approach in physics instruction.

According to constructivist theory Students construct their own versions of reality in a constructivist approach (Prince & Felder, 2006). Radical constructivism makes a deliberate attempt to move away from the epistemological base. It is argued that the attempt is post epistemological, which denies the philosophy that knowledge has to be a representation of reality. As opposed to the realistic view, there is no indication of attaining the absolute truth in constructivism. According to this philosophy, knowledge is attained in a constructive activity and it cannot be transferred to a passive learner. However, this philosophy has no relationship with reality. Moreover, the inadequacies incorporated with this philosophy restrict its potential and applicability on a universal scale, especially in science education.

The most important aspect of constructivist approach is to engage students with tasks and activities in which students develop their own ideas by constructing knowledge and awareness of the underlying principles. The more students know, the more they can further learn. Learners' perception must be made accountable during the learning process (Morrison, Ross & Kemp, 2001). Additionally, instructional practices become more critical when teachers have difficulty in responding to multitude of student interests due to lack of resources available in a constructivist environment (Boethel & Dimock, 2000).Being more open-ended in expectation, constructivism and hence results of instruction and even the methods of learning are often found inconsistent with each learner and not easily measured (Gafoor, Farooque, & Munavvir, 2013).

In a realistic approach, the teacher is able to explain what the actual reality of the universe is. However, science should not be taught as a list of known facts to be memorized. Learners need to experience and realize the phenomena around them through viable experiences and experiments, but without proper guidance, acquiring knowledge by themselves may lead to misconception or incorrect conceptual understanding. They face many obstacles to master the concepts due to the complexities of human learning and the nature of the subject.

Role of Instructional Strategies in Improving Attitude and Achievement. Instructional strategy is an external factor that can impact the internal factors like attitude, achievement and acquisition of knowledge (Carbone, Hurst, Mitchell, & Gunstone, 2009). There are numerous research studies to develop curricular and pedagogical practices to improve students' attitude and conceptual understanding in physics (Redish, 2003; McDermott & Redish, 1999). However, the impact of such studies on effective physics instruction is not so evident. It has been revealed that the lack of effectiveness could be due to the mode of administering the research-based approaches in classrooms. Instructors often modify or discontinue the use of these strategies significantly, resulting in the absence of a major change in the actual classroom practice (Dancy & Henderson, 2010). This scenario calls for a model that accounts for this complex nature of the actual classroom change by establishing a novel methodology in classrooms to have improved attitude and achievement in learning physics.

Insufficient attitude toward science could lead to alternative pedagogical considerations. The idea of how science is taught could be more important than what is taught. Adapting pedagogical interventions has been suggested in many studies worldwide (Potvin & Hasni, 2014). Many of the research studies on improving student attitude do not provide results of experiments, but rather concentrates on declarations made by students. Among studies with positive results are interesting and could inspire instructional practices to develop favorable attitude toward learning science subjects. However, it is worth mentioning that they are essentially the products of students' declarations, and possibly their desires for comfort, novelty, or simple enjoyment. Since it is important to favor learning along with attitude, those research findings should be further investigated.

There is no one right way to teach well. Every teacher needs a repertoire of instructional strategies. Teachers are supposed to bridge the ideology or methodology by being elective without complete rejection or acceptance of one. Although traditional approach remains the most prevailing method in science education worldwide, there are many research findings that support alternative types of instructional strategies for improved outcomes (Beichner et al., 2007; Froyd, 2007; Knight & Wood, 2005; Crouch & Mazur, 2001). Instructional strategies vary from open inquiry to radically traditional in nature and implementation. According to radical constructivists teachers must never "teach" students; all knowledge must be constructed independently through their experience and interaction with the environment (von Glasersfeld, 2006). Science instruction could be ineffective when students construct inaccurate knowledge without the appropriate interference from the instructor. In this scenario, teachers, beyond becoming "facilitators", are required to design multiple possibilities for their students to create favorable results in achievement and attitude (Sliško, 2016). The role of teachers in effective learning is a controversial issue in the modern era of education as the relationship between teaching and learning is complex. There is no single method to deliver the nature of science. A spectrum of various methods can be implemented in generating some understanding on how practices of science legitimizes its knowledge claims. Based on how knowledge is attained, there are constructivist and non-constructivist epistemologies.

Physics instruction with minimal guidance. Kirschner, Sweller and Clark (2006) has done a thorough analysis of why instruction with minimal guidance does not work toward conceptual understanding in classrooms. The authors presented ample reasoning and descriptions about the scarcity of empirical evidences on purely discover learning strategies that are constructivist and inquiry-based. In addition, they provide explanation to why experienced and efficient instructor are reluctant in using purely inquiry-based instructional strategies in classrooms. The justifications presented by the authors are supported by the brain-based learning theories.

Brain-based teaching approach is found effective in improving attitude and achievement in physics (Saleh, 2012). Brain-Based Education is the purposeful engagement of strategies that apply to how our brain works in the context of education. Therefore, knowledge on working of brain during the learning process is necessary to develop suitable instructional strategies for subjects like physics.

Lachman (1997) defines learning as the process by which a stable modification is developed in the stimulus-response relation as a result of functional environmental interaction through senses. A change in long-term memory of the learner occurs during the learning process. Minimally guided instruction does not appear to proceed with respect to working memory or long-term memory.

Working memory has limitation in its duration and capacity when processing novel information (Cowan, 2001). Inquiry-based instructional strategies affect the working memory of human brain adversely when introduced without proper guidance to novice learners. In other words, any instructional strategy that ignores the limitation of human brain upon dealing with new information is likely to be ineffective (Kirschner, Sweller & Clark, 2006).

Physics curriculum development has been frequently adopting teaching-learning theories in the secondary and post-secondary levels. However, a proper way of propagating these ideas do not occur in classrooms even though the instructors have been exposed to a variety of research-based instructional strategies as pre-service and in-service (Dancy & Henderson, 2010).

Promoting change in instructional practices is complicated and poorly understood. It is often neglected that the development of suitable instructional practices benefits from a thorough modification of effective curriculum and pedagogies. This study attempts to measure the effect of classroom teaching practices at various levels and find if a combination of student- and teacher-centered instructional strategies can provide a positive impact on physics learning outcomes.

Integrated Instruction in Physics

Students need efficient instructional strategies and credible reasoning to create a connection between their pre-existing mental images and newly learned concepts (Hammer, 1996). Teaching practices aimed explicitly addressing student beliefs about physics can have clearly measurable effects (Adams, 2006). An integrated approach comprising teacher-centered as well as student-centered strategies makes learning physics more efficient and meaningful, as suggested by the Biological Sciences Curriculum Study (Bybee et al., 2006). An integrated approach of various science process skills can be an appropriate strategy to form models, conduct experiments and to make inferences (Akinbobola, 2009). Such integrated approaches, if judiciously planned and meticulously carried out may lead to true comprehension of scientific principles as well as their application in a real world scenario (Davison, Miller & Metheny, 1995).

This section mainly addresses the need of integrating instructional strategies in science classrooms, and relevance of integration in physics classrooms. The significant role of teachers in an integrated learning environment has been further explored with the 5E Instructional Model as a possible framework.

Research shows that a large proportion of students favor a combination of learning styles (Langley & Eylon, 2006).This section details on the logic of integration by discussing the advantages and disadvantages of both teacher-centered and student-centered instructional strategies, and the concept of integration with the support of learning theories. A thorough analysis of the pros and cons of both types of strategies has also been carried out to build a platform for the major argument of integration.

Teacher-centered and Student-centered are not simply strategies or methods. Teacher-centered strategy is more traditional in nature whereas student-centered is the newly developed strategy to make learning more effective and enjoyable. In an explicitly teacher-centered classroom, teachers serve as the center of knowledge whereas students are considered as empty vessels to receive knowledge. Students' prior knowledge is usually not explored. Teaching is mainly carried out without taking students' individual pacing or knowledge level into consideration. In the meantime, teachers are advised to make transition from teacher-centered to student-centered without providing ample guidance without its technical and practical obstacles. Irrespective of theoretical arguments, the practice of student-centered classroom is still a matter of dispute. A large group of educators believe that they carry out student-centered activities in their classrooms without grasping the actual meaning of student-centeredness. As a result, they would engage students in some pair work or having them present their work without any clear instructions. In addition, pure student-centered strategies are neither effective in all subject areas nor an optimal way of learning for all types of learners (Napoli, 2004). Clearly, both student-centered and teacher-centered classrooms have their own pros and cons. The advantages and disadvantages of both student-centered and teacher-centered strategies can be drawn in order to gather support for the need for integrating the strengths of both the practices.

Novice learners irrespective of the stage education require more facilitation. As far as the learning outcomes are concerned, in a student-centered learning environment, there is an emphasis on the multiple aspects of the acquired knowledge through a multidisciplinary window. Students receive vigorous enforcement of higher order thinking skills. In the meantime, the teacher-centered strategies provide discipline-specific oral information, lower order thinking skills such as recall, identify or define, and encourage memorization of abstract and isolated information (Napoli, 2004). Therefore, designing suitable activities that involve combination of both teacher-centered and learner-centered approaches, it can undoubtedly be argued, can pave the pathway from a firm basic understanding toward kindling the higher order thinking skills in the content. Such an integrated strategy requires enormous amounts of preparation, thought, energy and creativity from the instructor.

Based on the human cognitive architecture, researches do not encourage instruction with minimal guidance. Although the minimally guided instructional approaches are very popular and appealing, empirical evidences for the past five decades indicate that minimally guided instructional approaches are less effective in the student learning process. However, minimal guidance is sufficient when students acquire prior knowledge during the learning process. Recent developments in instructional research emphasize guidance during instruction (Kirschner, Sweller & Clark, 2006). There has been a long lasting dispute about the level of guidance to be given to learners during instruction process for more than five decades (Mayer, 2004; Shulman & Keisler, 1966; Ausubel, 1964). It has been hypothesized that learners must construct essential information in a minimally guided environment (Glasersfeld, 2006; Steffe & Gale, 1995; Bruner, 1961). However, numerous studies oppose this notion arguing that novice learners should not be left to discover information by themselves, but receive direct instructional guidance on concepts and procedures (Klahr & Nigam, 2004; Mayer, 2004; Cronbach & Snow, 1977; Shulman & Keisler, 1966).

Teacher has a significant role in facilitation. According to the American Association for the Advancement of Science, teachers bear a conscientious role in the learning process of their students, especially in learning science, mathematics and technology. To understand various subject areas, students should be able to consider them as ways of thinking and doing, and as bodies of knowledge. In order to develop such thoughts in students, teachers must be cautious and accountable in engaging their students in the learning process by providing ample evidence that are more natural. Teachers should also make sure that students get opportunity to express clearly in a team approach, not to separate knowing from finding out, and to de-emphasize memorization of technical vocabulary. The techniques mentioned above are mostly used in student-centered instructional strategies; however, the role of teachers to make them happen in classrooms has been confirmed with much emphasis (AAAS, 1989). The Association further details that:

> "Teachers should recognize that for many students, the learning of mathematics and science involves feelings of severe anxiety and fear of failure. No doubt this results partly from what is taught and the way it is taught, and partly from attitudes picked up incidentally very early in schooling from parents and teachers who are themselves ill at ease with science and mathematics. Far from dismissing math and science anxiety as groundless, though, teachers should assure students that they understand the problem and will work with them to overcome it. Teachers can take such measures on Build on Success, Provide Abundant Experience in Using Tools, and Emphasize Group Learning."

Significant role of teacher in a student-centered environment. Since the part of the teacher is significant in the learning process, an argument is made for an integrated approach by combining teacher-centered strategy in a student-centered environment. Traditionally, by integration educators mean that the knowledge from different branches is connected together as the subject matter of knowledge is fundamentally united (Resnick & Collins, 1996). In higher education, the term “integration” is used to describe the idea of applying learning in multiple contexts. Integration of learning is a more intimate process in which ideas as well as individuals come together rather than simply interacting (Barber, 2009). The term “integration” denotes creating an effective teaching-learning environment by combining both teacher-centered and student-centered instructional strategies. Through the purposeful integration of the instructional strategies, the common goal of conceptual understanding in the content area of physics can be met.

Conceptual change occurs among learners due to real-life and active engagement. Traditionally formal learning was conceived mostly as a passive process from the learner’s point of view, in which the learner acquires knowledge from the instructor to have predictable and measurable outcomes. This conception of learning does not specify prior conditions of the learner or the context in which learning occurs. It provides no reference to other individuals like teachers, peers, or facilitators and their roles in the learning process. The definition for learning has been restated as an active process in which the learner relates new experience to existing, and interprets the modified information into new ideas (Wentzel & Watkins, 2002). Effective instruction paves pathway for effective learning and should be able to make conceptual change among learners. The aspect of effective learning is connected to real-life examples in which learners make sense of their environment cognitively with an active mental engagement (McDermott, 1996).

Conceptual understanding in physics. Attaining accurate conceptions has always been an issue in science education. Preconceived notions on various physical phenomena can have a significant effect on students' performance in physics. A conceptual change is often possible through appropriate learning process (Kokkonen, 2017). However, studies show that students fail to learn fundamental concepts during the transfer of learning process when teachers adopt traditional instructional strategies (Tebabal & Kahssay, 2011).

With the emphasis of constructivist, student-centered and activity-oriented instructional practices, science curriculum has been emerged as an epitome of inquiry-based learning activities with the teacher's role as a facilitator (Walper et al, 2014). Instructional strategies become significantly effective when the teacher's role become significant as a facilitator (Tebabal & Kahssay, 2011). Traditional instructional strategies help students learn concepts to an extent, but the level of understanding is on a rise when students are able to make predictions of an outcome in an inquiry-based learning atmosphere (Crouch & Heines, 2004) A variety of student-centered and inquiry-based classroom strategies were developed during the past couple of decades (Beichner, 2009).

There has been extensive research in science education especially in physics education to improve students' conceptual understanding for the last few decades (Foote, Neumeyer, Henderson, Dancy, & Beichner, 2014). Studies agree that the research-based strategies can be adopted by teachers in their classrooms to replicate the results (Sharma et al., 2010). However, the secondary implementation of the strategies seldom obtain the same results (Henderson & Dancy, 2006). As a result, researchers are often confused to state and amplify the advantages of these research-based strategies. There are several proposals to increase the conceptual understanding in the literature ranging from Peer Instruction to Interactive Animations (Beichner et al., 2007).

Conceptual understanding as transfer of learning. The basic idea of complex learning involves integration of knowledge skills and attitude to transfer learning in life scenarios. Transfer of Learning is described in several studies as a theory for learning science concepts. Transfer of learning is the application of skills and knowledge acquired in one context to a novel context. According to cognitive theory, the transfer of learning ceases to happen if there are no shared features between the source of knowledge and the new context. Transfer of learning in physics is often challenging due to the absence of this shared features. Storing the conceptual understanding in the abstract level helps students de-contextualize their learning (Singh, 2005). Preconceived notions on various physical phenomena can have a significant effect on students' transfer of learning physics and on their performance. Students do not have an effective transfer of learning of fundamental concepts in classrooms with traditional instructional strategies. Therefore, an interactive platform is required for better understanding and contextualization of physics concepts in different situations (Ellis & Turner, 2002).

Integrated instructional strategy

Researchers were in search of a suitable methodology for science instruction by re-examining the enduring assertion of the limitations of direct instruction and the advantages of discovery methods. As a result of a very detailed and thorough study, integrated instructional models such as the Science Curriculum Improvement Study (SCIS) learning cycle (Karplus & Thier, 1967) and the Biological Sciences Curriculum Study (BSCS) 5E instructional model were developed. These models were not limited by the constraints of many researches that impose on direct instruction. On the contrary, both SCIS cycle and the BSCS 5E instructional model incorporate direct instruction in one phase in an integrated instructional model. Many other studies characterized direct instruction and discovery learning approaches as separate, as opposed to possibly being integrated, has done a disservice to both approaches. Using this scenario as the background principle, integration of instructional strategies are considered as the base theory in this study. Therefore, the rationale for integration has been developed from the 5E instructional model as a platform.

Rationale of integration. The major objectives of this study are to highlight the strength of integrative approach in teaching physics rather than implementing either student-centered or teacher-centered instructional strategy alone, to emphasize that teacher-centered and student-centered instructional strategies are not mutually exclusive; they constitute a continuum, and to reinstate the role of the instructor in a student-centered learning environment with the support of major learning theories. Instructional strategies whether teacher-centered or student-centered are not simply strategies; rather they are models based on various learning theories to reflect various views on the nature of teaching, learning and knowledge (Napoli, 2004). A firm understanding of the learning processes of students is inevitable to ensure effective learning. Although students claim attaining knowledge through teacher-centered activities, they realize the effectiveness of more independent, investigative, and task-oriented learning activities in constructing concrete knowledge.

Inductive approaches consisting mainly of student-centered and inquiry-based learning activities are supported universally by empirical research studies including brain research. Inductive instructional strategies often become less effective because of the lack of preparedness of the instructors, leading to inferior learning outcomes. Therefore, instructors following inductive methods should get familiarized themselves with best practices along with providing adequate amount of guidance and support to learners. Teaching through inductive method neither avoid teacher-centered strategies completely nor rely on self-discovery. In other words, the instructor has an important role in facilitating learning by guiding, clarifying and even lecturing in an inductive method (Prince & Felder, 2006). It has been discovered that "teaching by telling" extremely effective in science and engineering classrooms after the introduction of the concept in an inductive way (Bransford, Brown, Cocking, 2000).

Relevance of 5E Instructional Model in Integration

A learning cycle approach can benefit learners with retention of concepts and improved attitude toward science in a constructivist learning environment (Abraham, Grzybowski, Renner & Mark, 1992). Students view subject with a positive attitude when they develop self-confidence through an interactive learning environment with 5Es. Attitude affect learning the subject like physics since it is correlated with achievement (Soomro, Qaisrani & Uqaili, 2011).

The Learning Cycle Lesson Plan model or the BSCS 5E Instructional model has been in ubiquitous use in science education since the 1980's. The model consists of five phases: Engagement, Exploration, Explanation, Elaboration, and Evaluation. Each of these phases enhances the teaching-learning atmosphere by providing a sequence and organization of concepts, lessons or units. The model is flexible so that teachers are able to make necessary modifications by making instantaneous decisions during the classroom activities, which makes it student-friendly and teacher-friendly at the same time. In an environment of integrating student-centered and teacher-centered instructional activities, the 5E model can be more efficient and effective on conceptual understanding (Bybee et al., 2006).

The historical models used in developing the 5E instruction model include the ones by Johann Herbart and John Dewey. Herbart proposes two ideas as foundations for teaching: interest and conceptual understanding. Herbart's instructional model is one of the first methodical approaches to teaching and has been used in various forms by educators worldwide for more than 100 years. According to Herbart, the first principle of effective instruction consists of the students' interest in the subject, which is of two types, one based on direct experiences with the natural world and the other on social interactions. In science instruction, teachers can use objects from the natural world to help students accumulate and capitalize on the curiosity (Bybee et al., 2006). In his principle of social aspect, an instructional model should incorporate opportunities for social interaction among students and between students and the teacher. According to Herbart (1901), the best pedagogy allows students to discover the relationships among experiences in which teachers become systematic direct instructor as well as an efficient facilitator in making students demonstrate their understanding by applying the concepts to new situations. This theory was supported by Dewey's model of reflective thinking (Heiss, Obourn, & Hoffman, 1950). In his model based on reflective thinking, John Dewey implies an instructional approach in science that must be minds-on rather than being just hands-on activities. His model of reflective thinking describes thoroughly on the role of teacher in encouraging his/her students in reflective thinking.

The philosophical and psychological detail for a model presented by Atkin and Karplus as the foundation for the 5E instructional model. Robert Karplus designed instructional materials for science to help children explore and explain natural phenomena by connecting the developmental psychology of Jean Piaget. Myron Atkin shared Karplus's ideas about teaching science, and collaborated on a model of *guided discovery* in instructional materials (Atkin & Karplus, 1962). Later, Karplus put greater clarity and a curricular context by described the three phases of their model for science teaching: preliminary exploration, invention, and discovery (Karplus & Thier, 1967). These three phases became the sequence of the Science Curriculum Improvement Study (SCIS) learning cycle. Later, there were some modifications in the terminology of these terms, however, the conceptual foundation of the learning cycle remained essentially the same.

The constant use of an effective, research-based instructional model can help students learn fundamental concepts in science and other domains. Consistent use of such an instructional model could have the desired effect on teaching and learning. (Bransford & Donovan, 2005; Bransford, Brown & Cocking, 2000). The review of related literature provided the historical background of several learning theories of which the 5E instructional model has been found as the most appropriate as possible for the research objective of this study. The five phases create an effective way to help learners enjoy and understand the science content.

Inductive instructional strategies are inquiry-based learning strategies that are mostly student-centered such as case-based, discovery learning, problem-based, peer instruction, just-in-time teaching etc. These research-based strategies are found at least equal to and generally more effective compared to traditional methods that are deductive. In an inductive approach, a topic is taught by helping students to discover it only after its relevance has been established (Prince & Felder, 2006). Deductive approaches are the most traditional in nature in which student acquire knowledge as passive learners though direct teaching.

However, the process of teaching and learning is not purely inductive or deductive in practice. In a classroom adopting the integrated instruction using the

5E Instructional Model, the components of Engagement and Exploration help students recognize the relevance of the topic through inductive activities, whereas they receive additional knowledge and support in the Explanation phase from the instructor trough a deductive manner.

5E instructional model for teaching-learning physics.

During the development of the 5E instructional model, the BSCS began with the SCIS learning cycle model to develop the five phases: engagement, exploration, explanation, elaboration, and evaluation. The middle three elements of the BSCS model are fundamentally equivalent to the three phases of the SCIS learning cycle. A summary of each phase is shown in Table 1.

Table 1

Summary of the Five Phases in the 5E Instructional Model (Bybee et al., 2006)

Phase	Summary
Engagement	The teacher is able to access the learners' prior knowledge and direct them to get engaged in a new concept through the use of short activities that promote curiosity and elicit prior knowledge. Activities such as providing a lab experience, conducting a discussion forum, watching a video clip, or completing a short quiz are some examples for this phase to help students make connections between past and present learning experiences. The role of a teacher as an effective facilitator is crucial in this phase.
Exploration	Exploration experiences provide students with a common base of activities within which current concepts (i.e., misconceptions), processes, and skills are identified and conceptual change is facilitated. This phase is critical since teacher's involvement becomes critical in this phase for eliminating the common misconceptions in physics. Teacher is expected to raise from being a facilitator to an expert to direct the learners from developing incorrect conceptual understanding. The students could begin an investigation by designing and performing suitable lab activities.

Phase	Summary
Explanation	The explanation phase focuses students' attention on a particular aspect of their engagement and exploration experiences and provides chances to demonstrate their conceptual understanding, process skills, or behaviors. Teachers receive occasions to directly introduce a concept, process, or skill. An effective teacher-centered learning atmosphere could eliminate the students' misconceptions and establish proper understanding in this phase. Explanation from the teacher guides students toward a deeper understanding, which is a critical part of this phase.
Elaboration	In this phase, teacher's role becomes critical as an excellent facilitator. Student-centered instructional strategies become extremely useful for this phase. Students receive new experiences to develop deeper and broader understanding of the concept and to apply their knowledge in novel situations. Teachers receive opportunities to challenge and extend the learner's conceptual understanding and related skills.
Evaluation	In the present scenario, the evaluation phase is mostly traditional in nature. Both student-centered and teacher centered classroom practices are used in this phase with the major goal of encouraging students to assess their understanding and Abilities. With the help of the established objectives and grading rubrics, teachers could evaluate student progress.

Strategies and Methods of Integration

Teacher-centered and Student-centered learning are not mutually exclusive. They constitute a continuum in the learning environment. In the present scenario of teaching/learning, there is hardly a single strategy adopted by teachers that is explicitly one way or the other. In every activity there used to be an element of integration though it is not done intentionally (Kirschner, Sweller & Clark, 2006). Applying any individual strategy in its radical form is practically impossible. This section comprises the major categories and levels of integration during the learning process. A detailed investigation is done on possible ways of integrating curriculum, academic standards, teaching/learning goals, instructional strategies and modes of evaluation.

Integration can be categorized into integrative practice, interdisciplinary approaches and integration of learning. Integrative practice is the broadest of the three and functions as an umbrella term for structures, strategies and activities that connect various stages in the educational scenario (Klein, 2005). Integration depends on a combination of factors such as student needs, teacher skills, and available facilities. During such integration or transition educators should focus on how and why to teach rather than considering what to teach (Curriculum Council, Govt. of Western Australia, 2004).

Learning theories suggest integrative methods. Even as most of the popular learning theories mainly focus on solving the learning difficulties among students, there is not a common theory to describe the learning process. Behavioral, cognitive and social-cognitive are the most prominent theories of which the cognitive perspective of learning describes the mental processes of the learner that occur as a result of various experiences. Learners modify their mental structures created from their experiences with the external world (Resnick, & Collins, 1996). They carry out the process of constructing knowledge through social interactions (Vygotsky, 1978). Learning happens when learners attain knowledge by disrupting the cognitive equilibrium (Piaget, 1963). The most important aspect of learning is the knowledge construction. The process of knowledge construction can be influenced by interactions with other people, which constitute the essence of socio-cultural theory of cognitive development (Vygotsky, 1978). Most of the learning theories derived from the educational contexts are integrative in nature and more integrative than the psychological theories (Dewey, & Small, 1897; Hannon, 2002).

Learners look for connections while receiving information with their existing knowledge structures. To invest time and effort on a new material the learner must be intrinsically motivated in order to continuously practice with the possibility of further explanation. Therefore the need to reiterate the classroom environment that supports intrinsic motivation is important in improving learning processes (McCord & Matusovich, 2013). With the proper implementation of instructional strategies, the instructor could establish a transparent rapport with the learner in measuring their knowledge and the level of understanding. According to the socio-cultural theory of cognitive development, the process of knowledge construction can be influenced by the interactions with other people when learning takes place (Vygotsky, 1978).

Students acknowledge the value of activities that require higher cognitive skills over drill-type exercises. Expanding the range of learning activities can develop more sophisticated epistemologies in students. A student's epistemology plays a major role in defining his/ her attitude toward the subject like physics. A good pedagogy must essentially be a judicious mix of approaches. A large proportion of students favor a combination of learning styles and instructional strategies (Langley & Eylon, 2006). For example, direct instruction which is primarily teacher-centered can be made relevant and meaningful if the teacher is an expert in the content area. It can be used for well-structured topics. Direct instruction really works well in a wide range of situations as long as the teacher employs a variety of pedagogical techniques (Cotton, 1991). In other words, the distance between the student and teacher can be bridged by selecting appropriate teaching strategies.

Types and levels of integration. There are different ways for curriculum integration, focusing on combination of subjects, relationships among concepts in the same content area, emphasis of projects or other similar tasks into the learning activities, flexible student scheduling or grouping, use of authentic sources other than textbooks, and design of activities based on student needs or interests (Fogarty & Stoehr, 1995). An effective level of integration can be achieved by integrating the teacher-centered and student-centered strategies since students appreciate a balance between the role of teacher in communicating at their level and at the same time present the content with confidence (Mulholland & Turnock, 2012).

Inadvertent vs. purposeful integration. There usually occurs an unintentional integration of student-centered and teacher-centered strategies in a learning environment. Nevertheless, instructors are also able to integrate these two strategies on purpose based on the type of content, teaching/learning goals, prior knowledge or the learning level of the students. Instead of simply making the two types of strategies mechanically interact in a given scenario, instructors as well as students can come together with a variety of ideas and concepts toward assimilating them in a more efficient manner by integrating strategies on purpose. The logic of integrating the instructional strategies is shown in Figure 3.

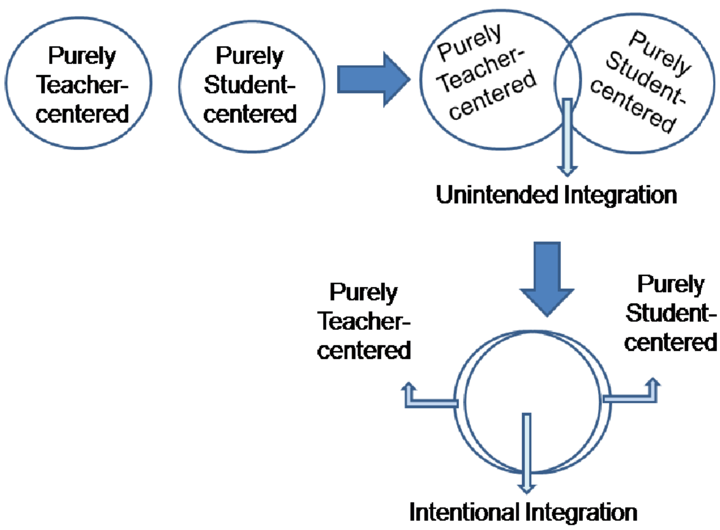

Figure 3. The transition of integrated instructional strategy

There seems to be little emphasis in the literature on decisively integrating the teaching strategies for effective learning. Although there occurs accidental mixing up of both strategies during instruction, there is not much evidence in integrating them on purpose. Although integration can occur on any of the aspects such as curriculum, academic standards, teaching/learning goals, and the methods of evaluation during the learning process, they are hardly combinations of student-centered and teacher-centered activities. In usual practices, the integration is mostly done in the curriculum and rarely on evaluation. The hierarchy of the order by which integration is usually found among classroom practices is mentioned in Figure 4.

Figure 4. Levels of educational practices that can be integrated

Empirical Studies on Physics Learning Outcomes

This section presents a methodical review of empirical studies conducted on major outcomes of physics education mainly during the last two decades (2000-2018). It is divided into seven subsections namely, cross-national studies in physic education, evidence on the effect of research-based instructional strategies, inquiry-based strategies with prominent teacher involvement, student attitude and achievement in physics education, measuring student attitude toward physics, measuring achievement in physics, and gender wise difference in learning physics. A brief conclusion has been provided at the end of the major section.

Cross-national Studies in Physics Education

In this section, studies that have been conducted in physics education as cross-national during the past couple of decades are included. These studies describe various ways to strengthen physics education in a variety of populations all over the world.

Diversity has been identified as a critical factor for the success of education (Frazer, 2017). The author in this study, emphasizes the multifaceted role of diversity in physics education, but it is broadly defined in the physics education research. There are numerous studies conducted on diversity, specifically with respect to gender. However, studies on diverse groups of students, interactions between student attributes, and teaching methods are not very common in physics education research. Author indicates that there is room for developing such studies. Cross-national studies add to this diversity in physics education in terms of student attributes and teaching methods.

Chai, Friedler, Wolff, Li and Rhea (2015) conducted a study among the students of East China and USA to compare the achievement in calculus using pre- and posttests. The study raised the issue of math learning and teaching at the university level. The interactive pedagogical practices and formal assessment at the university in USA were compared with the traditional way of instruction in China. The findings were in favor of the Chinese students, though the students in USA revealed a larger gain and normalized gain. The study did not claim on the effect of teaching method alone; authors indicate that there could be an effect for a particular instructional strategy on a specific culture. However, they concluded with a statement of the advantage of conducting cross-national studies in the field of education as the educator community all over the world receive information on alternative strategies, and feedback on existing approaches.

Ramsey, Nemeth, and Haberkorn (2013) conducted study on the effect of different teaching styles in physics among high school students of different ethnicities. The major objective was to compare the effectiveness of the teaching styles among students from different demographics. A survey was sent out to teachers on student preparation, pedagogical practices, assessment techniques and professional development. Authors reveal that there were differences in practices related to all faces of teaching and learning based on demographics. However, there were a few predominant teaching practices like lecturing with demonstration and hands-on activities were commonly used by the teachers regardless of the demographic differences.

Sharma et al. (2013) explores expectations and beliefs of students in India in learning physics at the secondary and tertiary levels. Maryland Physics Expectation survey was used to measure students' epistemological beliefs, expectations and learning physics. The data was then compared with those in four other countries namely, Philippines, Thailand, Turkey, and USA. Comparison of the pre-post instruction reveals that the difference between the attitudes of students at higher secondary, undergraduate, and graduate level in India is similar to those in Philippines, Thailand and Turkey. Nonetheless, authors noticed a dissimilarity between the U.S. students and those of the other three countries and also between U.S. experts and Indian teachers. In all countries except USA, the basic trend of expectation from pre to posttest remained the same, with a deterioration observed in all levels of students except the graduate level Indian students. A significant difference was observed in the expectations of U.S. experts and Indian teachers. The score of favorable views of Indian higher secondary and undergraduate students was observed to be less than U.S. students in many clusters of the Survey.

A similar study was conducted on the teaching and learning of mathematics among students of China and USA by Vistro-Yu (2013). This cross-national study compared student performance in mathematics and compared it between the Eastern and Western hemispheres. Authors claim that such studies can focus on what countries with diverse culture and tradition can learn from each other. They add that learning does not end in articulating similarities and differences between cultures but adopting the best practices that these cultures offer. With the help of more cross-national studies, countries are able to collaborate effectively to understand, appreciate each country's uniqueness and work for improving the teaching and learning environment for all. Cross-national studies conducted in science education are not different in establishing their ultimate objectives.

Reddy (2010) stated the need of discussing the potential of cross-national studies particularly on student achievement in science education. In his study, the topic was discussed through a critical reflection on South Africa's participation in the Trends in International Mathematics and Science Study (TIMSS). The author confirms the effectiveness of such studies for designing improved strategies for assessing the progress across nationalities. However, the limitations of many of such studies are recognized along with fruitful suggestions to improve them. Effect of teaching style was tested in USA on diverse groups of students would have a similar effect as that of studies conducted on different nationalities.

Evidence on the Effect of Research-based Strategies in Physics

Recent development of various instructional strategies in Physics Education Research (PER), strengthened physics instruction at secondary and tertiary levels internationally. These revolutionary strategies and related activities became a wakeup call for Educators all over the world to begin debating on weighing out traditional practices with these innovative strategies. In this section, effectiveness of popular research-based strategies in physics, namely, Inquiry-based (Problem-Based Learning), Cognitive (Modeling Instruction), Cooperative (Peer Instruction), and Partially Integrated (Interactive Lecturing with Demonstrations) are described with empirical evidence.

Georgiou and Sharma (2014) examined the claim of active learning through Interactive learning Demonstrations. The study was conducted in an Australian University. Four parallel streams of Thermodynamics unit were investigated, two with Interactive learning Demonstrations and the other two with traditional approach in two consecutive academic years on 500 students. A validated survey, the thermal concepts survey, was used as pre-test and post-test to measure learning gains while surveys and interviews provided insights into what the 'active learning' meant from student experiences. The authors analyzed lecture recordings to capture the time devoted to different activities in a lecture, including interactivity during data collection. The learning gains were in the 'high gain' range for the Interactive learning Demonstrations streams and 'medium gain' for the other streams. The analysis of the lecture recordings revealed that the Interactive learning Demonstrations streams spent significantly more time for interactivity while surveys and interviews showed that students in the Interactive learning Demonstrations streams were thinking in deep ways. The study concluded that Interactive learning Demonstrations can improve students' conceptual understanding and their experiences extensively by investing in active learning to enhance lectures.

Fredlund, Linder, Airey, and Linder (2014) explored the disciplinary knowledge provided qualitatively by different physics representations in terms of disciplinary affordances. Authors argue that due to the restructuring of representations in physics, students have limited access to disciplinary knowledge. As a result, these reorganized representations pose learning challenges for students though they are powerful tools for communication from the disciplinary point of view. Authors report this issue by analyzing a qualitative study using responses from student discussion in the physics laboratory on a physics topic. It is indicated that students appreciate disciplinary affordances only when more attention is given during their knowledge transfer. They need help to be aware of critical aspects of physics concepts, which are too easily taken for granted during these representations. The authors conclude that teacher plays a vital role in unfolding students' disciplinary affordances. This article poses a genuine concern about the facilitator role of teachers in many of the research-based instructional approaches.

Modeling Instruction has been proved as one of the effective research-based strategies in physics education recently. Brewe, Sawtelle, Kramer, O'Brien, Rodriguez, and Pamelá (2010) implemented the Modeling Instruction (MI), which is found to be another efficient way of instructing physics. The study has been conducted at undergraduate level in USA. Authors report the results of a five year evaluation of introductory calculus-based physics by implementation of Modeling Instruction (MI) to the university students. The students participated were form various ethnicities that are under-represented in physics education research. The data was analyzed from a participationist perspective of learning of various aspects, namely, conceptually based instruction, cooperative learning, and culturally sensitive instruction. Force Concept Inventory was used to measure students' conceptual understanding. The findings reveal student success 6 times greater than that from traditional lecturing. The results indicate that ethnically under-represented students narrow the gap in the overall conceptual understanding compared to majority students, indicating a movement toward greater equity in introductory physics.

Students' conceptual understanding in physics and their beliefs about physics and physics learning physics were investigated in Turkey (Sahin, 2010). Participants were 124 university students (PBL = 55, traditional = 69) selected from introductory level calculus-based physics classes. The conceptual understanding of Newtonian Mechanics was assessed by the Force Concept Inventory (FCI) and the beliefs about physics and physics learning was evaluated by using the Colorado Learning Attitudes about Science Survey (CLASS). The experimental group received instruction through Problem-based learning (PBL), whereas the control group received traditional instruction. As expected, the group exposed to the inquiry-based approach (PBL) showed gain in conceptual understanding compared to those received traditional instruction. However the PBL approach did not have significant influence on student beliefs as both groups revealed similar beliefs about physics and physics learning. The study also indicated a positive correlation between students' beliefs and conceptual understanding. Students with expert-like beliefs in the beginning of the semester had higher level of conceptual understanding by the end of the semester.

Folashade and Akinbobola (2009) investigated the effects of constructivist Problem-based Learning (PBL) strategy on the academic achievement of physics students with low ability levels in Nigeria secondary schools. Pre-test-Post-test control group design was adopted for the study. A total of 105 physics students were used for the study. 51 students were used for the study in problem-based learning technique while 54 were used for conventional learning method respectively in their intact classes. The achievement and ability tests for physics developed by authors were used for measuring student learning outcomes. The Problem-based Learning strategy was implemented for a unit of waves. Analysis of data showed that Problem-based learning technique is more effective in teaching and learning of physics and science subjects in particular than the conventional method. Additionally, problem-based learning technique exposed to students more to realities of life and tend to work as scientist and acquire knowledge by themselves which the teacher only correct their misconceptions. A narrowed gender gap was also noticed on the performances of students when they are taught with problem-based learning technique.

Problem-based Learning strategies in physics at secondary level provide favorable results in the improvement of students' attitude toward the subject. Erdemir (2009) made a recent study on the effect of Problem-based Learning in physics on students' attitude toward physics has been explored in Turkey. Participants were 270 high school students from various parts of Turkey. Findings indicate that students in the experimental group (PBL) made more positive improvement in attitude toward physics compared to the control group. The study suggests that teachers may integrate problem-based strategies in their regular teaching practices to improve their positive attitude toward physics, and thereby students could have better conceptual understanding.

Jackson, Dukerich, and Hestenes, (2008) conducted their study as a series of professional development workshops for high school teachers in USA. Teachers were trained to develop students' abilities using Modeling Instruction. Student data came from three major high school course types: regular and introductory physics, honors level physics, and advanced placement physics. The study consisted of several evaluations from multiple sites and years. Pre-post measures using Force Concept Inventory were used for analysis. The extent of implementation of the modeling methods and their impact on student learning were investigated. There were repeated findings that greater extents of implementing modeling methods were associated with larger student gains. Authors also commented that the repeated findings refuted the possibility of student improvements from motivated teachers. The Modeling Instruction in High School Physics students surpassed the performance of the comparison groups by margins by two standard deviations.

Hänze and Berger (2007) investigated the effects of cooperative learning and direct instruction among one hundred and thirty-seven 12th grade students in Germany. Cooperative instruction has been compared with direct instruction method in this quasi-experimental study. Four aspects of students' personal learning characteristics were examined through path analysis in terms of previous knowledge, academic self-concept in physics, academic goal orientation, and uncertainty orientation. Despite the fact that there is no difference in the achievement gain for the experimental and control groups, the findings revealed differences in students' experience based on the elements of self-determination theory of learning. Feelings of competence with cooperative learning were found associated with better performance in physics, but direct instruction revealed a facilitating effect upon controlling for competence. Cooperative instruction benefited students with low academic self-concept than those received direct instruction because of the feeling of greater competence.

Inquiry-based Strategies with Prominent Teacher Involvement

Science literacy has become a milestone for all science learners but the learning activities fail to consider the critical assumptions that the educators bring into classrooms. It is not considered significant in today's inquiry-based classrooms that teacher's role is critical in ensuring that students understand basic scientific concepts (Glaze, 2018).

Since inquiry-based strategies are mostly student-centered, students get the opportunity to get acquainted with information on their own, which makes them more creative and accountable for what they gather. After the activity, students take the responsibility of reaching a conclusion by suitable experimentation that they design and accept or reject the prediction. In an inquiry-based classroom, students understand the need of finding the right answer, but to seek solutions to questions and issues.

Malik et al. (2018) studied students' critical thinking skills with the use of inquiry-based instructional strategies. They use High Order Thinking Laboratory also known as HOT-Lab to enhance critical thinking skills of 60 preservice teachers in Indonesia. Teacher encourages students by introducing a puzzling situation and evokes the responses in students. Students get motivated and engaged so that teacher is able to control the inquiry-based student activities. The study adopted a quasi-experimental design with pretest-posttest control group. The normalized gain was calculated and analyzed statistically. Findings reveal that students begin to develop their critical thinking skills rather than just absorbing information the way it is presented to them.

Adorno, Pizzolato, and Fazio (2018) investigated the global robustness of open-inquiry approach in achieving long-term stability of physics instruction. The study was done as a continuation of a research project started four years ago with a sample of 30 engineering undergraduate students in Italy. Students attending traditional instruction in physics were exposed to a six-week long experience of open-inquiry research activities within the topics of thermodynamics and mechanics.

The outcomes were analyzed in three phases of preinstruction, post instruction, and after four years. Their responses were categorized into three epistemological profiles. Findings reveal the robustness of open-inquiry, which has been confirmed statistically with the control group. However, authors seek for more investigations to further analyze some changes observed and discussed based on students' responses.

Erinosho (2013) made an attempt to identify the areas of physics that students considered difficult to grasp. A questionnaire was administered to 830 final year secondary school students in science class and 52 physics teachers purposively drawn from secondary schools in Nigeria. The findings showed three major sources of difficulty that are related to nature of subject, teaching/teacher factors and curriculum/assessment. Students revealed difficulty in understanding specific topics that are usually characterized as lacking concrete examples and requiring a lot of mathematical manipulations or visualization. Based on the findings, author implies that designing interventions and identifying pedagogical techniques could help students overcome the difficulty that hinders quality learning. It is also shown in the study that students do not show willingness in asking questions or answer questions in class. Author notices this student behavior as critical and suggests teacher's role in modifying the situation. It is suggested in the study that teachers could emphasize active teaching methods like group work, cooperative learning and presentations that could initiate quality interactions between the students and teacher.

Abrahamson and Chase (2015) studied primary and high school students in Switzerland who participated individually in tutorial interviews centered on a problem-solving activity designed for learning basic algebra. Participants were randomly assigned to experimental and control groups, who were exposed to Discovery and Non-Discovery learning environment, respectively. Analysis of data reveals that the Discovery group exhibited significant gain in learning the concept. However, follow up studies on the findings based on a heuristic activity architecture for technology-based guided-discovery learning (Chase & Abrahamson 2015) reveal a series of interrelated inferential constraints that learners iteratively calibrate as they refine and reflect on their evolving models. The authors further investigated the emergence of these constraints by analyzing annotated transcriptions of two case-study student sessions and argue for their constituting role in conceptual development. Findings reveal that the participants in the Discovery group were obliged themselves to intuit, infer, determine, construct, and inter-calibrate features of the mathematical system, which could be detrimental without proper guidance.

These different types of inquiry-based and student-centered strategies based on constructivist learning theory make a significant impact on the educational system in the recent decades. These methods connect student learning with a real life situation (do Carmo & Hönnicke, 2018). They are intended for the development and retention of knowledge in students, supports learning in an actively engaging environment, evokes curiosity, motivation, and creativity among the learners.

However, a lack of explicit association of inquiry has been revealed with science content in a few recent studies. Carrying out inquiry tasks without detailed instructions is difficult for students to obtain conceptual understanding. According to Settlage (2007), implementing inquiry in its purest form in a regular basis is practically impossible as there is lack of evidence.

Arsal (2017) studied the impact of inquiry-based learning on critical thinking skills of preservice teachers. The sample of the study consisted of 56 preservice teachers in the teacher education program at a university in the north Turkey. The participants were majoring in science education. The findings reveal that the experimental group did not show statistically significant advancement in terms of critical thinking dispositions than the control group. The author suggests that teacher educators should consider the drawback of inquiry-based learning, which could not be effective to improve pre-service teachers' critical thinking temperaments in pedagogical courses. The results of this study are discussed in relation to potential impact on science teacher education and implications for future research by the author.

A study done in learning mathematics, Trninic (2018) claims that direct instruction and discovery learning are not opposite but complimentary which could be repeated by exploratory practices. He suggests that reconceptualization of repetitive activities as an exploratory practice in which direct instruction strategies are intimately integrated by using a case study in Martial Arts. Following the case study of a martial arts pedagogy, the author explains the method using Bernstein's ideas (Bernstein, 1996), which was then developed through Vygotsky's discussion of kinesthetic sensations (Vygotsky 1997), and later through the contemporary perspective of embodied cognition. The author of this study considers parallels of this case study in mathematics, thinking through a present-day classroom activity where students discover certain features of rational numbers revealed by the practice of the division algorithm.

Lehtinen (2017) provides evidence of the inefficiency of using inquiry-based instructional strategies in their purest form among pre-service primary teachers in Finland. Forty preservice teachers majoring in Special education with a minor of primary teacher studies were the participants for this study. The result reveals the unique role of the teacher in science instruction in providing adequate guidance to support inquiry-based learning. Author explains that a proper distribution of guidance is important to ensure that inquiry-based learning is guided in a way that it maximizes learning. Additionally, the major argument of the study is that providing guidance is not just to benefit conceptual understanding, but also to provide meaningful connections between students' views with the scientific view.

Hofer, Schumacher, Rubin, and Stern (2018) studied the effectiveness of evidence-based cognitively activating methods in teaching physics secondary school students in Switzerland. The method was designed to develop conceptual understanding along with quantitative problem-solving performance. In addition, the authors stressed the importance of acquiring solid conceptual understanding in physics and reduction of gender gap. Their teaching method integrated several methods of classroom practices to help students acquire meaningful knowledge. A unit in Newtonian Mechanics has been developed. Students were taught according to this unit developed a better understanding of major concepts than those who were taught by the same teachers in a traditional way. In particular, female students improved their conceptual understanding while having instruction in this integrated manner. The findings of the study show that the method of evidence-based cognitively activating physics instruction can be successfully implemented by regular in-service teachers, for improved conceptual understanding, quantitative problem-solving ability and for reduced gender gap.

Bøe, Henriksen, and Angell (2018) determined the importance of integrated instruction in learning physics. As a part of the innovative teaching methods for increased focus on qualitative understanding, and history and philosophy of science aspects. The study was conducted among the secondary physics students in Norway. The experience of physics students was analyzed by providing instruction in traditional style and with the innovative approach. The findings suggest that student found it difficult to monitor their progress in the classroom with the innovative approach. Students found visualization of concepts in the innovative approach useful in constructing conceptual understanding. Authors reveal the need of better alignment of different learning activities, learning goals and assessment innovations and explicit expectations in order to make students learn physics in its full-fledged manner.

A combination of student-centered and teacher-centered strategies were found to be effective in achieving conceptual understanding in physics concepts and developing a positive attitude (Kaur et al., 2017). The study was conducted among 9^{th} grade students in Western Australia. They were undergone the program designed by the authors for two consecutive years. The retention test undertaken after three years revealed that the students retained their conceptual understanding. The findings also showed that students' attitude toward physics has been improved regardless of the difference in gender. Authors of this study claim that students' attitude and achievement in physics could be maintained throughout the academic year and beyond, through simple but appropriate teaching strategies. This study emphasized the role of teacher in a student-centered classroom for improved attitude and achievement in physics.

Another study conducted in Nigerian senior secondary schools by Akinbobola (2015) proposed an integrated instruction for improved transfer of knowledge in physics. The efficiency of transfer of knowledge in physics using effective teaching strategies, namely, guided discovery, demonstration and expository teaching strategies was assessed. The tool for collecting data on transfer of knowledge was developed with a high internal consistency. The data was collected with a non-randomized pretest-posttest control group design. The data was analyzed statistically and the results reveal that guided discovery was the most effective in enabling students' transfer of knowledge in physics. There was no effect of gender on transfer of knowledge in any of the instructional strategies. The study suggested that student-centered teaching strategies with an active teacher involvement.

According to the author, it is advantageous for students if the physics teacher could emphasize procedures, techniques and application of knowledge during instruction.

In order to develop mastery in physics, students should have a thorough understanding of concepts, process, and nature of the subject, which could be made possible through appropriate experiences. Lack of sufficient preparedness of instructors has been found as one of the major issues in spite of implementing various inquiry-based strategies. The need of teachers with proper content knowledge and sufficient understanding of research-based pedagogical practices are equally important in shaping the new generation of physics students with proper conceptual understanding and positive attitude in physics (Foote et al., 2014).In an environment of modified instruction in which students and teacher share the responsibilities, students build new information on their prior knowledge and motivate themselves to have a positive attitude toward the subject.

Student Attitude and Achievement in Physics Education

This subsection deals with attitude toward science in general and attitude toward physics in particular. Special attention has been given to studies conducted among secondary and post-secondary students. The most widely used tools to measure student attitude toward science and physics are described as a separate section. Studies conducted in different demographic locations including India and USA have been included though such studies are not very common in the Indian setting. A total of 10 different studies with empirical evidence are described in this section.

A study conducted by Al-Mutawah and Fateel (2018) in the Middle East among secondary school students aims to see the relationship between attitude and achievement in mathematics and science. According to their findings, there is a positive and significant correlation between attitude toward science and achievement. Based on the details of their data, students see the importance of excelling in science as they value the subject. The findings also reveal that at least 40% of the students find science as one of the hardest subjects. The authors suggest that teachers' active role and involvement toward improving interest in mathematics and science in order to build a positive attitude toward the subjects. However, some other studies do not find the teaching method as a significant factor in developing positive attitude among students.

Sheldrake, Mujtaba, and Reiss (2017) analyzed data from PISA 2006 and PISA 2015 on samples of students in England. They found that student attitude toward science was more related to their perception on utility of science and career aspirations than the effect of teaching approaches. It is noteworthy that teaching approaches had smaller or no effect on student attitude. Authors suggest that conveying wider relevance of science to everyday life may help students to develop an interest in science and its perceived utility. Additionally, they reveal that teaching the applications of science is the only teaching approach which consistently and positively associated with student's interest in science. This study indicates the relevance of inquiry-based teaching strategies in developing connections with the nature of science and science, technology, and society (STS).

Student attitude and motivation toward physics has been the topic of research performed in Czech Republic (Snetinová, Kácovský, & Machalická, 2018). They compared interest in physics among upper secondary students at a university in Prague by introducing hands-on experimental work in the interactive physics laboratory to one group, whereas the other group watched physics demonstrations conducted by an instructor. In addition to assessing students' interest using Intrinsic Motivation Inventory, authors studied students' understanding of selected physics concepts qualitatively. Results showed that there was no significant difference in students' interest and perceived usefulness between the inquiry-based and traditional teaching practices. However, students sensed the need for more effort and experienced more pressure in the interactive laboratory. Additionally, student achievement was a significant predictor in assessing the projects; those who had better grades assessed the projects positively. A gender difference has been found on student attitude in terms of interest and pleasure.

In a recent study conducted in Turkey, Kişoğlu (2018) revealed that the student motivation has a positive impact on attitude. The sub dimension of intrinsic motivation has been found more specifically related to the sub dimensions of interest and pleasure on the attitude scale. The study was conducted among the high school science students toward learning biology. Two scales, one for measuring motivation and the other for measuring attitude were used. In addition, the author reports that the sub dimensions of attitude and motivation scales are significantly different in different levels of class and with gender. Female students are found to have higher attitude in terms of interest and pleasure in comparison with their male counterparts.

A pseudo longitudinal study conducted by Bates, Galloway, Loptson, and Slaughter (2011) in UK studies the attitudes and beliefs about physics. They used different cohort groups ranging from final year high school students to physics faculty. The Colorado Learning Attitudes about Science Survey (CLASS) was used for measuring the overall degree of expert-like thinking. Significant differences were observed in the overall CLASS scores and the degree of expert-like thinking at the entry and exit points, and it remained unchanged during the duration of the undergraduate program. Among the high school students, those who intend to major in physics at the university level displayed more expert-like views. A similar change was observed among the undergraduate students who were about to pursue a postgraduate research degree in physics. The authors suggest that the attitude could be reproducible elsewhere. In other words, student attitude is positively correlated to their future aspirations.

Cahill, McDaniel, Frey, Hynes, Repice, Zhao, and Trousil (2018) tested the relationship between student attitude and learning before and after a semester of learning physics. The study was conducted during six consecutive semesters of four introductory physics courses at the university level in USA. The prior knowledge of students was controlled in the beginning of semester using an assessment of conceptual understanding. The results suggested that the relationship between attitude and learning is positive but weak and inconsistent. In three of the four courses, attitudes of students significantly determined the learning but with a small amount of variance. The authors argue that the inconsistency may be either due to the modest relationship between the attitude and learning, or due to the inadequacy of the measurement tool to establish the relationship. They call for further research to see the relationship across various learning contexts.

Craker (2006) analyzed students' attitudes toward science enrolled in entry level general education science courses at a university in USA in the areas of personal confidence, usefulness of the subject, perception of the subject as a male domain, and perception of the teacher's attitude. A total of 389 introductory level science student were the participants in the study. A modified version of Fennema-Sherman Attitude in the form of a Likert scale was used to measure the attitude. Four subscales within the scale include measuring personal confidence about the subject matter, usefulness of the subject's content, perception of science as a male domain, and perception of teacher's attitudes. Male students were found to have more confidence than females, whereas females perceive science as a male domain more than men. A strong correlation between achievement and attitude toward science was revealed in this study. The number of science and math courses taken in high school has a direct impact on a student's attitude toward science.

Sharma et al. (2013) conducted a study among the Indian students and teachers on teaching and learning physics at secondary and tertiary levels. A total of 265 students at higher secondary, undergraduate and graduate levels from India were the participants for the study. Maryland Physics Expectation (MPEX) survey was used to measure the correlation among students in higher secondary, undergraduate and graduate levels. A deterioration has been observed on expectations among the students in higher secondary and undergraduate levels, but an improved or expert like expectations among the master's degree students. Authors specify that this decline on expectations would affect their motivation and success in future. No gender was observed among the Indian students on their expectations. Finding also indicate that the Indian students continue to be novice like even after the instruction in physics.

Measuring Student Attitude toward Physics

Maryland Physics Expectations (MPEX) survey by Redish et al. (1998), the Colorado Learning Attitudes about Science Survey (CLASS)by Adams et al. (2006), Test of Science Related Attitudes (TOSRA)] by Fraser 1981 are the most widely used internationally used research tool in measuring student attitude toward science. In addition to these most widely used measuring tools for attitude toward physics, researchers from China developed a Physics Attitude Scale (Kaur & Zhao, 2017). The scale was developed after conducting extensive interviews with experts as well as students, reviewing with experts and pilot testing.

Kaur and Zhao (2017) used the Physics Attitude Scale (PAS) to test students in India. Validity and reliability coefficients were established prior to testing. The final version of the scale consisted of 60 items after the item analysis measuring five dimensions namely, Enthusiasm toward Physics, Physics Learning, Physics as a Process, Physics Teacher, and Physics as a Future Vocation. The factor correlation matrix explains the dimension of Enthusiasm toward Physics has a positive correlations with Physics Learning, Physics as a Process, and Physics as a Future Vocation. The dimension of Physics Teacher is positively correlated to Physics Learning.

Schiepe-Tiska, Roczen, Müller, Prenzel, and Osborne (2016) indicate the importance of having a positive attitude toward science along with attaining achievement. The recent shortage in the area of skilled professionals in the field of science and technology could be mainly due to the lack of interest in science. Authors lists interest in science, enjoyment of science, instrumental motivation, self-concept, self-efficacy, perceived value of science, self-regulation strategies, epistemological beliefs, technology- and environment-related attitudes, career aspirations as the outcomes of science education. However, it is practically impossible to include all these elements in large-scale assessments that are performed internationally. According to this study, the selection criteria of a particular assessment depends on its characteristic features. Based on that assumption authors of this study, selected constructs for the Program for International Student Assessment (PISA) 2015 have been analyzed. This study is informative for this research because the researcher could get acquainted with all dimensions that might have affected the students' attitude toward physics.

A comparative study (Zhang & Ding, 2013) was done among High school students, from 8^{th} through 12^{th} grade, in China. Students' epistemological beliefs about physics were measured using the Colorado Learning Attitudes about Science Survey (CLASS), by using the Mandarin version. It was administered to students from all five grade levels as a pencil-and-paper in class survey. The results reveal that students' epistemological beliefs turn into less expert-like if receiving more years of traditional instruction. In the beginning years, there occurs a positive shift in students' beliefs, views about the conceptual nature of physics and problem-solving sophistication. Authors hypothesize both pedagogical and non-pedagogical factors contributed to the positive changes. Additionally, the findings are in good agreement with many other studies about the complex nature of traditional instruction and students' epistemological beliefs.

Zwickl, Hirokawa, Finkelstein, and Lewandowski (2014) deal with the development of a newer tool to assess students' epistemologies and expectations on perceiving the nature of physics experiments in the contexts of usual laboratory courses and the professional research laboratory. The Colorado Learning Attitudes about Science Survey for Experimental Physics or E-CLASS can be used to evaluate students' epistemology at the beginning and end of a semester. By the end of the semester, the E-CLASS adds another dimension to the assessment. The third dimension assesses students' reflections on their course expectations for good grades. Authors present the development, evidence of validation and results of the initial formative assessments results in this article on a sample consisting 45 class sections at 20 different institutions in USA. The authors of this study claim that the tool could be used as an assessment tool for undergraduate level physics courses. With minor modifications this tool could be used for high school physics students as well.

Balta, Mason, and Singh (2016) investigates how students' attitudes and approaches impact problem-solving by using Attitude and Approaches to Problem

Solving survey has been administered among the high school and university students in Turkey. Administration of this survey has already indicated differences between students' expertise when administered among the physics and astronomy students in USA. Authors in study used the Turkish version of the survey after validation. Analysis of student responses revealed no statistical differences between students of different grade levels, school type and gender. The statistical analyses showed that university students possessed more expert-like attitudes and approaches in metacognition, whereas high school students demonstrated expert-like attitudes and approaches on role of equations and formulas in problem solving. Comparison of the results with that of the US students indicated that students in USA demonstrated more expert-like attitude and approaches on average. A thorough analysis of the curriculum, instructional strategies, and assessment techniques of both countries might provide more input on the significant difference in attitude and approaches between students of Turkey and USA.

Measuring Achievement in Physics

The effect of traditional instruction has been found ineffective in USA and other western countries with the administration of different standardized tests. The results of those studies indicated that students' conceptual understanding on introductory physics is quite poor. The improvement in understanding concepts is relatively lower in classrooms with traditional style of instruction compared to those adopting other research-based and interactive teaching strategies. In this study, Emarat, Arayathanitkul, Soankwan, Chitaree, and Johnston (2012) investigated the performance of undergraduate students receiving traditional instruction in Thailand. The Force and Motion Conceptual Evaluation (FMCE) was used to assess students' understanding. The pre- and posttest results were compared and the gain was again compared with that received by students in western countries. The results indicate that students receiving traditional instruction show similar gain in conceptual understanding irrespective of their nationalities.

Students' conceptual understanding in physics was investigated among the undergraduates in Cyprus (Zacharia & Constantinou, 2008). A pre-posttest comparison was performed between two classrooms adopting guided inquiry and traditional with virtual manipulatives approaches, respectively. The curriculum, method of instruction and resources were explicitly controlled for the group receiving traditional approach. Tests were administered to evaluate students' conceptual understanding before, during, and after the instruction. The findings indicate that both approaches were equally effective in enhancing conceptual understanding among students. Students were advantageous from physical and virtual manipulates during these two types of instructional approach.

Ding (2014) studies the causal influences of reasoning skills and epistemology on students' conceptual learning in physics. The variable used were students' pre-instructional reasoning skills, pre- and post-epistemological views, and pre-and post-performance. The pre-instructional reasoning skills were measured by the Classroom Test of Scientific Reasoning, epistemological views by using the Colorado Learning Attitudes about Science Survey, and performance was measured on Newtonian concepts by the Force Concept Inventory. The study was conducted on introductory level physics students in USA. The findings reveal that pre-instructional reasoning skills and epistemological views influence students' conceptual understanding, whereas the post-epistemological beliefs have little influence. This finding is in good agreement with other studies that teaching approaches make little influence on epistemological beliefs, but does not quite agree with the finding that conceptual understanding is not affected by instruction.

Interactive engagement improves student learning outcomes which is already established in the research related to physics education. This study reveals that certain representations used in physics help students learn in such learning environments. Fredlund, Airey, and Linder (2012) conducted a case study in which some persistent representations such as equations, graphs and diagrams were used to assess the potential for sharing disciplinary knowledge. Findings reveal that appropriate persistent representations are required to create an interactive engagement. Through an appropriate interactive engagement, students are able to avoid misconceptions and develop accurate conceptual understanding.

Several diagnostic tests have been developed during the past two decades to investigate students' understanding and misconceptions of physics concepts. These tests consist mostly multiple choice questions in which the correct answer is purposefully embedded among easily misleading false choices. The wrong options are developed based on students' common misconceptions identified through earlier researches. The most widely used physics achievement tests in the area of Mechanics are the Force Concept Inventory (Hestenes, Wells, & Swackhamer 1992); the Test for Understanding Graphs in Kinematics (Beichner 1994); and the Force and Motion Conceptual Evaluation (Thornton & Sokoloff, 1998). Many physics education researchers have evaluated these tests on their reliability and validity. It has been proven that these tests can be used among students of various grade levels and performance levels. Emarat, Arayathanitkul, Soankwan, Chitaree, and Johnston (2012) used the Force and Motion Conceptual Evaluation (FMCE) to figure out if the test could be used among students in Thailand to replicate the same result obtained by the western countries.

Docktor et al. (2016) developed and tested a rubric to assess the written solutions to problems among the undergraduate students in USA. According to the authors, student performance is often measured by the percentage of problems answered correctly by explicitly checking their numerical skills. These assessments usually provide an inadequate description of students' problem-solving skills due to the lack of characters to distinguish experts from novices. An assessment of the expertness on solving problems should focus on the reasoning quality leading to the solution. In their study, the need of practical tools to differentiate between novice and expert problem-solving performance during instruction. Evidence for validity, reliability and utility of the instrument is detailed in the study. The rubric identifies the dimensions of approach, specific application, and logical progression of physics concepts involved during problem-solving. Authors claim that teachers can easily adopt the rubrics of this instrument toward an improved student learning outcome.

Gender wise Difference in Learning Physics

Lorenzo, Crouch, and Mazur (2006) investigated the gender gap in conceptual understanding of introductory physics students at university level in USA. Authors' major goal was to narrow the gender gap by using interactive engagement methods that promote interaction between student and teacher by collaboration, reduce competition, and emphasize conceptual understanding. The data was collected from students who study physics as non-major for their undergraduate program. The groups receiving traditional instruction were compared to those using different degrees of interactive engagement. Finding reveal that students taught with certain interactive strategies had increased conceptual understanding regardless of gender. The pre-instruction gender gap was closed in classrooms that are the most interactive in nature. Authors found that while both males and females benefit from the interactive engagement, females improve their performance most. The researchers claim that by adopting a collaborative environment in which the level of interactivity is maximum students improve their understanding of physics concepts with a narrow gender gap. However, a similar study conducted in a larger university in USA provides finding that are contradictory.

Pollock, Finkelstein, and Kost (2007) describe that the use of interactive engagement techniques does not necessarily reduce the gender gap in a large research university. Despite the use of interactive classroom techniques, a significant gender gap is found in learning gains. The study was conducted among students in a large university in USA. Female students outscore their male counterparts on homework and participation scores; whereas the males perform better on the exams, in a fashion consistent with the gender gap observed on the conceptual surveys. The finding of this study indicate that engaging students in interactive learning environments is not sufficient to reduce the gender gap in learning physics. Additionally, the authors indicate that there are both student and instructor effects that impact gender gap. The study reminds that it is crucial to examine how these interactive techniques are enacted by students and instructors, and understand the broader class culture that structures the practices.

Hazari, Tai, and Sadler (2007) studied the difference in persistence of male and female students when studying physics. Authors notice that the most significant drop in females studying physics happens between high school and college. They indicate that this stage is critical for female students because they make important decisions on future career plans in physics at this stage. The study seeks the best high school physics curriculum, instruction, and affective factors to predict female and male introductory university physics performance after controlling for university course, demographic, and academic background variables. Data from 1973 surveys completed by introductory physics students at undergraduate level from various parts of USA. Students' demographic and academic background characteristics were used as control. Findings of the study reveal that performance of male and female students are predicted differently by their affective experiences. One of the major issues raised by this study is that female high school physics pedagogy does not positively influence students' future performance to a great extent. Learning experiences often negatively impact students toward pursuing physics for high studies because these activities often create confusion and lack clarity. Hazari et al. continues:

> High school teachers have the onus of striking the balance between preparing their students for success in a university course as well as providing them with "good" physics instruction whether that instruction helps them in university or not.

Conclusion on Literature Review

The following inconclusive provisional but suggestive premises were reached during the review of related literature, which paved way for pursuing this study.

1. ***Physics is difficult and unpopular among students***

Physics remains as an unpopular and difficult subject than the other sciences (Seth, Fatin, & Marlina, 2007). Students at all levels have insufficient comprehension skills and contradictory cognitive interpretations in various levels of their schooling ranging from elementary, middle, and higher secondary (Baran, 2016; Walper et al., 2014; Gafoor, 2013; Sharma et al, 2013; Wulf, Mayhew & Finkelstein, 2010; Hazari et al., 2010; Malkawi & Obaidat, 2009; Pollock, Finkelstein & Kost, 2007; Trumper, 2006). A superficial knowledge is not adequate for students to provide enough explanation on various physical phenomena around and, as a result, they become less motivated and develop a negative attitude toward physics (Potvin & Hasni, 2014; Erinosho, 2013). Therefore it is necessary to explore physics as a discipline and its instructional factors to reduce students' negative attitude and the gender gap (Beatty, Leonard, Gerace & Dufresne, 2006).

2. ***Science classroom practices and student attitudes are related***

The direct relationship of students' attitude toward school science with classroom environment and learning activities has already been a debated issue for the last few decades (Piburn, 1993; Myers & Fouts, 1992; Simpson & Oliver, 1990; Talton & Simpson, 1987).The current system of science education provides students and educators with two different scenarios, 1) to focus heavily on mastery of disciplinary content rather than focusing on scientific process or epistemology, and 2) to prepare students for high-stake testing by mastering a narrow area of the disciplinary content (Vinovskis 2015; Guskey, 2003).Studies reveal that decline in interest toward physics is most likely connected to classroom experiences (Elster, 2007; Shaw, 2004).

According to Sharma et al. (2013), the instruction strategies adopted by teachers in India and USA are methodically different. During the pilot study, students from both countries revealed that they prefer student-centered instructional strategies with a strong emphasis on teacher participation and guidance, to modify their preconceptions and to develop concrete understanding. This finding is in agreement with studies conducted in USA, Germany, Australia and India that the instructional practices have a major role in triggering difficulty in physics learning among the secondary school students (Walper et al., 2014; Sharma et al., 2013; Hazari et al., 2010; Logan & Skamp, 2008; Sadler & Tai, 1997).

3. ***Instructional practices become more critical when teachers face multitude of student interests***

The nature of knowing could be affected by the teaching and learning practices itself and can be modified depending on the nature of domain (Hammer & Elby, 2002).There is an isomorphic relationship between approaches to teaching and modes of learning (Elliot, 2018).The idea of how science is taught could be more important than what is taught. Adapting pedagogical interventions has been suggested in many studies worldwide (Potvin & Hasni, 2014). Studies with positive results are interesting and could inspire instructional practices to develop favorable attitude toward learning science subjects.

However, it is worth mentioning that they are essentially the products of students' declarations, and possibly their desires for comfort, novelty, or simple enjoyment (Prince & Felder, 2006). The inadequacies incorporated with constructivist philosophy restrict its potential and applicability on a universal scale, especially in science education. Additionally, instructional practices become more critical when teachers have difficulty in responding to multitude of student interests due to lack of resources available in a constructivist environment (Boethel & Dimock, 2000).

4. ***Pure student-centered strategies are not effective in physics learning***

Difficulty with science results partly from what is taught and the way it is taught, and partly from attitudes picked up incidentally very early in schooling (AAAS, 1989). Studies conducted in different parts of the world state that students show positive attitudes to student-centered activities (Adorno, Pizzolato, & Fazio, 2018; Galloway, 2018; Kay, Hardy, & Kokkonen, 2017; Agbaje & Alake, 2014; Bennett, 2003).Learning physics at higher levels is challenging if one disregards traditional practices and merely follows the prevalent student-centered strategies such as conducting experiments, providing real life examples and arranging fieldtrips. As the curriculum gets broadened and deepened in the secondary level, teaching/learning strategies tend to become more teacher-centered. In addition pure student-centered strategies are neither effective in all subject areas nor an optimal way of learning for all types of learners (Napoli, 2004).

Contrarily, research shows that students get more motivated and engaged while using student-centered strategies (Schwartz, Lederman, & Crawford, 2004; Hakkarainen, 2003; Chang & Mao, 1999). A sustained learning outcome through those activities is still controversial (Fagen, Crouch, & Mazur, 2002; Mottmann, 1999; Coleman, 1998; Redish et al., 1998). Students lack motivation and develop a negative attitude toward the subject, since they fail to get intellectually challenged in secondary and higher grade levels in a purely student-centered environment.

5. ***Research based strategies are seldom in practice.***

Educators all over the world mostly depend on traditional strategies without even trying to implement alternative strategies at least once. There seems to be a wide gap between research and practice. Deslauriers, Schelew and Wieman (2011) reveal the hesitation of physics faculty to adopt interactive teaching strategies proposed by the vast majority of researches in physics education. They often find it difficult to implement because of time constraint, student-interest, facilities, and other concerns of applicability. In addition, it is widely known that inquiry-based strategies are time consuming and are comparatively difficult to implement under a structured school curriculum.

6. ***While minimally guided instructional approaches are popular they can be ineffective***

Despite the fact that inquiry-based instructional strategies have become the most popular in science education, many experts and educators still encourage more research that benefits students to have an improved achievement and to have a positive attitude in science subjects (; Hanuscin & Lee, 2008; NRC 1996; AAAS 1989, 1993).Minimal guidance is sufficient when students acquire prior knowledge during the learning process. Recent developments in instructional research emphasize guidance during instruction (Kirschner, Sweller & Clark, 2006).

Although the minimally guided instructional approaches are very popular and appealing, empirical evidences for the past five decades indicate that minimally guided instructional approaches are less effective in the student learning process. (Kirschner, Sweller & Clark, 2006).It has been revealed that the lack of effectiveness could be due to the mode of administering the research-based approaches in classrooms. Instructors often modify or discontinue the use of these strategies significantly, resulting in the absence of a major change in the actual classroom practice (Dancy & Henderson, 2010).

7. ***Combination of learning strategies are better***

Erdemir (2009) observed that Problem-based Learning strategies in physics at secondary level provide favorable results in the improvement of students' attitude toward the subject. The study suggested that teachers may integrate problem-based strategies in their regular teaching practices to improve their positive attitude toward physics, and thereby students could have better conceptual understanding. A modified curriculum can improve student performance and persistence in learning physics through suitable pedagogical practices, (Wilson & Peterson, 2006).

Beichner (1996) suggested two decades ago that students of physics must have a variety of ways to be involved with the content in an interactive way for improved conceptual understanding and attitude. Research shows that a large proportion of students favor a combination of learning styles (Langley & Eylon, 2006).Bøe, Henriksen, and Angell (2018) reveal the need of better alignment of different learning activities, learning goals and assessment innovations and explicit expectations in order to make students learn physics in its full-fledged manner.

8. ***A change in science education requires an active teacher involvement***

According to the American Association for the Advancement of Science, **teachers bear a conscientious role in the learning process** of their students, especially in learning science, mathematics and technology (1989). Ebenezer and Zoller (1993) argue that necessary emphasis must be placed on science teachers' role and their teaching styles if an educational change is to be achieved in the constructivist direction.

Carrying out inquiry tasks without **detailed instructions** is difficult for students to obtain conceptual understanding. According to Settlage (2007), implementing inquiry in its purest form in a regular basis is practically impossible as there is lack of evidence. Akinbobola (2015) suggested that student-centered teaching strategies are incomplete without an active teacher involvement.

Emarat, Arayathanitkul, Soankwan, Chitaree, and Johnston (2012) report that the improvement in understanding concepts is relatively lower in classrooms with traditional style of instruction compared to those adopting other research-based and interactive teaching strategies. A change in long-term memory of the learner is required during the learning process, but seldom occurs in minimally guided instruction. In other words, inquiry-based instructional strategies affect the working memory of human brain adversely when introduced without proper guidance to novice learners (Kirschner, Sweller & Clark, 2006).However, a proper way of propagating these ideas do not occur in classrooms even though the instructors have been exposed to a variety of research-based instructional strategies as pre-service and in-service (Dancy & Henderson, 2010).

9. ***Combination of student-centered and teacher-centered strategies are suggested for physics instruction***

The notion of integrated instruction has been evolved from historical models of Johann Herbart and John Dewey during the development of the 5E instructional model by BSCS. (Bybee, 2006; Heiss, Obourn, & Hoffman, 1950). Although integration can occur on any of the aspects such as curriculum, academic standards, teaching/learning goals, and the methods of evaluation during the learning process, they are hardly combinations of student-centered and teacher-centered activities.

A combination of student-centered and teacher-centered strategies were found to be effective in achieving conceptual understanding in physics concepts and developing a positive attitude (Kaur et al., 2017). This study emphasized the role of teacher in a student-centered classroom for improved attitude and achievement in physics. Another study conducted in Nigerian senior secondary schools by Akinbobola (2015) proposed an integrated instruction for improved transfer of knowledge in physics.

10. ***Higher secondary stage is critical in physics learning especially for female students***

Hazari, Tai, and Sadler (2007) studied the difference in persistence of male and female students when studying physics. Authors notice that the most significant drop in females studying physics happens between high school and college. They indicate that this stage is critical for female students because they make important decisions on future career plans in physics at this stage.

Neuroscience reveals no differences in what girls and boys can learn. However as pedagogical factors influence male and female students differently there are obvious differences in the strategies that could be used to instruct them (Gillibrand et al., 1999; Haussler & Hoffmann, 2002).

Lorenzo, Crouch, and Mazur (2006) indicated that pre-instruction gender gap was closed in classrooms that are the most interactive in nature. Authors found that while both males and females benefit from the interactive engagement, females improve their performance most. The researchers claim that by adopting a collaborative environment in which the level of interactivity is maximum students improve their understanding of physics concepts with a narrow gender gap.

However, Pollock, Finkelstein, and Kost (2007) indicate that engaging students in interactive learning environments is not sufficient to reduce the gender gap in learning physics. Additionally, the authors indicate that there are both student and instructor effects that impact gender gap.

11. ***Effect of instructional strategies may be culture specific***

A lack of positive attitude and low achievement among students in higher secondary physics was observed among students of India and USA albeit the differences in instructional strategies that they are usually exposed to (Siddiqui & Khan, 2016; Singh & Immam, 2014; Sadler & Tai, 2007; Sonnert, Sadler, & Shanahan, 2010).

Vistro-Yu (2013) articulate similarities and differences between cultures but adopting the best practices that these cultures offer. It is important to appreciate each country's uniqueness and work for improving the teaching and learning environment for all. Reddy (2010) studies for designing improved strategies for assessing the progress across nationalities.

Chai, Friedler, Wolff, Li and Rhea (2015) indicate that there could be an effect for a particular instructional strategy on a specific culture. However, they concluded with a statement of the advantage of conducting cross-national studies in the field of education as the educator community all over the world receive information on alternative strategies, and feedback on existing approaches.

Ramsey, Nemeth, and Haberkorn (2013) suggested that there were differences in practices related to all faces of teaching and learning based on demographics. However, there were a few predominant teaching practices like lecturing with demonstration and hands-on activities were commonly used by the teachers regardless of the demographic differences.

12. ***Dissimilarity in student perception and instructional practices between India and US is indicated***

Studies show that gathering knowledge in the Indian education system is mostly theory-based rather than acquiring practical knowledge (Rai & Kumar, 2018; Sharma et al., 2013; Garg & Gupta, 2003). Poor conceptual understanding has been found as one of the major factors affecting the popularity of science among students of India (Rai & Kumar, 2018).

Sharma et al. (2013) explores expectations and beliefs of students in India in learning physics at the secondary and tertiary levels. Nonetheless, authors noticed a dissimilarity between the U.S. students and those of the other three countries and also between U.S. experts and Indian teachers.

In essence, promoting change in instructional practices is complicated and poorly understood. It is often neglected that the development of suitable instructional practices benefits from a thorough modification of effective curriculum and pedagogies (Dancy and Henderson 2010). Therefore, this study attempts to measure the effect of classroom teaching practices at various levels and find if a combination of student- and teacher-centered instructional strategies can provide a positive impact on physics learning outcomes.

Chapter III

METHODOLOGY

- *Design and Phases of the Study*
- *Variables for the Study*
- *Research Instruments and Techniques*
- *Samples used in the Study*
- *Data Collection Procedure and Data Preparation*
- *Statistical Tools used for the Analysis*

Methodology

The major objective of this study was to investigate the effectiveness of Integrated Instruction among the higher secondary students of Kerala(India) and South Carolina (USA). Initially, Attitude toward Physics among male and female higher secondary students and extent of integration of teacher-centeredness and student-centeredness in classroom practices of their teachers were explored. Then, four types of integration were identified based on a scheme developed with high/low levels each on teacher-centered and student-centered classroom practices and the teachers were grouped accordingly. Finally, in the next academic year, Attitude toward Physics and Achievement in Physics of students of physics teachers identified as typical of the four types of integration were pretested and post tested. The influence of Integrated Instruction on posttest scores of Attitude toward Physics and Achievement in Physics was studied after controlling for their level on Previous Attitude toward Physics and Achievement in Physics in pretest.

Design and Phases of the Study

As the study progressed through distinct though complementary phases, a mixed methods research with an exploratory sequential design has been adopted. The initial phases required more open and flexible qualitative data which were then used to develop more structured data collection instruments and procedures appropriate for quantitative analysis. The study was mixed of qualitative and quantitative methods including interviews, questionnaires, attitude scaling, an inventory and achievement testing. Three phases in the study required multiple samples drawn by multiphase-multistage sampling in a time span of three consecutive academic years. As Creswell, Hanson, Plano and Morales (2007) advocated, this study started with a broader question, of students' Attitude toward Physics in an international perspective. The initial part of the study has adopted the qualitative approach to gather information from students and teachers of physics on perception of and difficulties in learning physics which were used for developing the research instruments for the more quantitative prospective ex post facto study.

Three Phases of the Study

This study was conducted in three phases: 1) Structured interviews for students and teachers as pilot study, 2) Surveys of Attitude toward physics among students, and Physics Classroom Practices Inventory among Teachers, and 3) Prospective Ex Post Facto Study of Influence of integrated instruction in classrooms on Attitude toward Physics and Achievement in Physics. These phases of study used both inductive and deductive approaches to draw conclusion. As the initial part of phase 1, a pilot study was conducted to gather information on interest and difficulties in learning physics, and preference for physics teaching practices by interviewing Grade 11 and 12 students in Kerala (India) and South Carolina (USA). A structured interview was conducted among higher secondary school physics teachers in the states of Kerala (India) and South Carolina (USA) to gather information on their preferred and currently implemented classroom practices, and related difficulties in physics instruction in the latter part of phase 1. A questionnaire on perception, beliefs, attitude, and preferences of practices in learning physics was then developed for students in phase 2 by incorporating the interview responses. The extents of student-centeredness and teacher-centeredness of the classroom practices, known from the literature and recognized in responses obtained from the interview of teachers, were further investigated using a more exactly designed classroom practices inventory. In phase 3 prospective ex post facto study, methodically sampled teachers and their students from India and USA were used to investigate the influence of Integrated Instruction on student Attitude toward Physics and Achievement in Physics. The data from the three phases were analyzed using descriptive and inferential statistical techniques. An outline of the methodology used in this study in total is given in Figure 5.

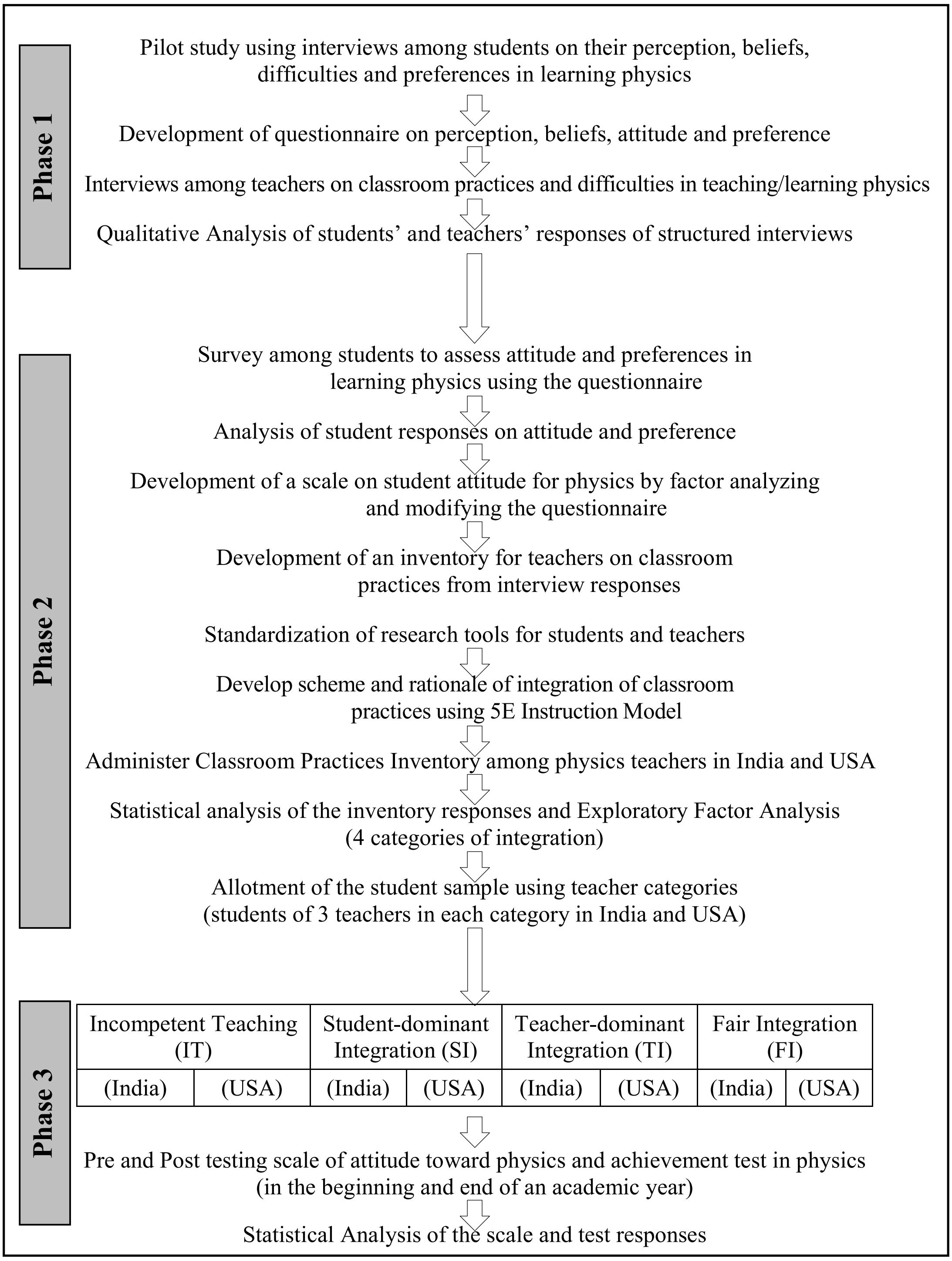

Figure 5. An outline of the study

Design of the Study

A mixed methods research with an exploratory sequential design is adopted for this study. Exploratory sequential design is helped in a thorough assimilation of data, from a qualitative approach in the initial part to quantitative approach as a follow up. The qualitative method of this design was to confirm students' and teachers' views on the extent of teacher-centeredness and student-centeredness. Analysis of this method provided indication of increased Attitude toward Physics with the integration of student-centered and teacher-centered instructional strategies. Findings of the qualitative method in this design led to the development of research tools for the follow-up quantitative method. Analyses and findings of the quantitative method were then used to confirm the findings from the qualitative method of the design (Creswell et al., 2007). An overview of the mixed methods research design used in this study is provided in Figure 6.

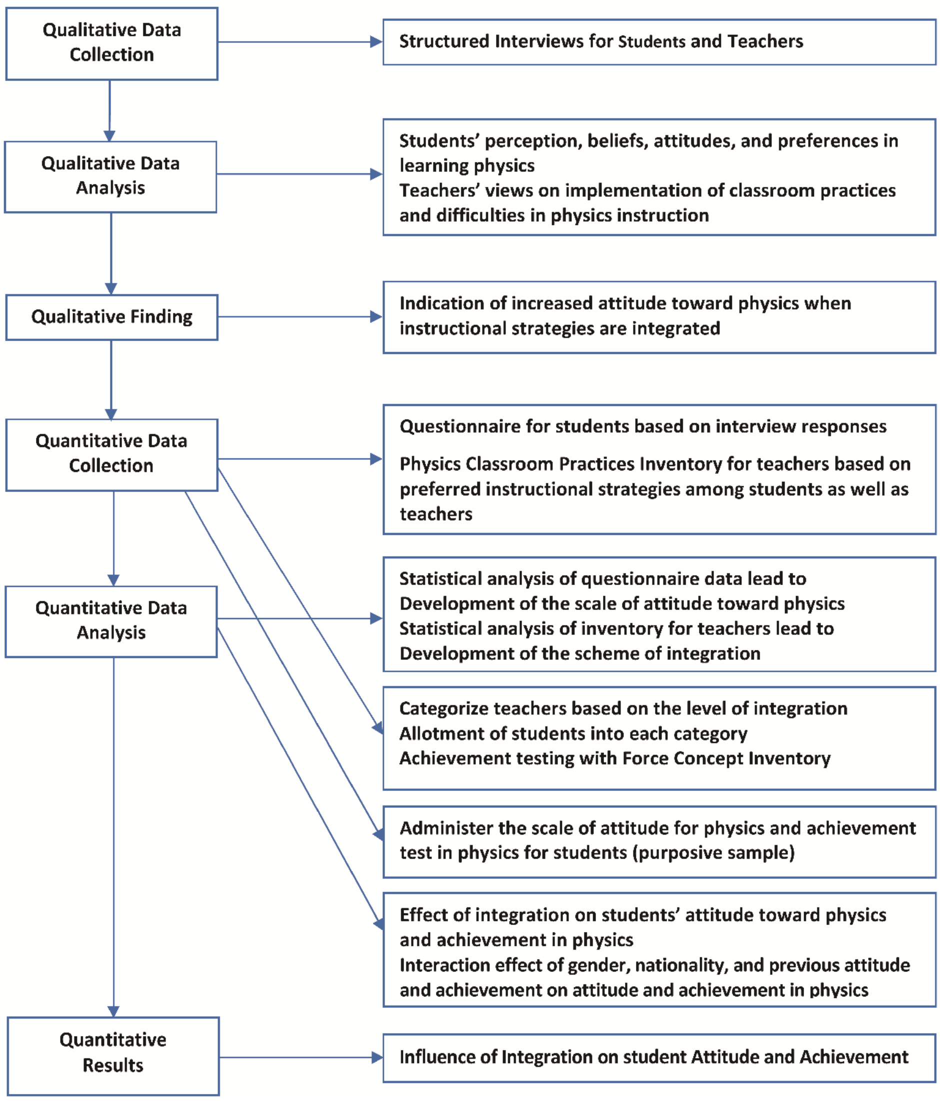

Figure 6. An overview of the research design

Prospective Ex Post Facto design

A factorial design was adopted within the prospective category of the ex post facto research method for the third phase of this research (Montero & Leon, 2007). Ex post facto method also known as the causal comparative method is a rigorous type of design to examine a possible cause and effect relationship between the existing variables (Campbell & Stanley, 1963; Crowl, 1993). It is ideal for conducting social research when manipulation of participants becomes impossible, but the basic logic of inquiry is similar to an experimental research. In this experimental research in reverse, participants have been selected in advance using a particular combination of characteristics that have originally been decided (Kerlinger & Rint, 1986).

For this study, the prospective category of the ex post facto method was found to be a legitimate design since it could attain information and seek solution through an effective data analysis (Johnston, 2008). A prospective category initially registers an independent variable and then measures the dependent variable. The action of the independent variable takes place during the interval between these two registrations. In addition, since this study registers more than one independent/ moderator variable, the four levels of integration along with nationality, gender, previous achievement/attitude in physics, were registered, the research design becomes factorial (Montero & Leon, 2007). During the data analysis, the subjects were matched in order to rule out the possibility of attributing difference to sampling. Matched pairs of teachers were chosen from each country using the scheme of integration, and then the student sample was selected accordingly in the final phase. This matching process could satisfy the drawback of the lack of control of the independent variable in this ex post facto study to a great extent.

Variables for the Study

The independent, dependent and moderator variables used in this research are listed for each of the phases in Table 2.

Table 2.

Summary of Phase wise Description of Variables used in the Study

Variables	Phase 1. Pilot Study	Phase 2. Survey (Students & Teachers)	Phase 3. Ex Post Facto
Independent Variable	Student Perception of Physics	1. Gender 2. Nationality	Integrated Instruction with 4 levels ▪ Incompetent Teaching (IT) ▪ Student-dominant Integration (SI) ▪ Teacher-dominant Integration (TI) ▪ Fair Integration (FI)
Dependent Variables	Teacher Perception of Physics	1. Attitude toward Physics 2. Student- centered Instruction 3. Teacher-centered Instruction	1. Attitude toward Physics 2. Achievement in Physics
Moderator Variables			1. Gender 2. Nationality 3. Previous Attitude 4. Previous Achievement

Independent Variables

There are three independent variables in the study, namely, Integrated Instruction (in phase 3), and Student-centered Instruction and Teacher-centered Instruction (in phase 2).

1) Integrated Instruction.

In phase 3 prospective ex post facto study, Integrated Instruction, is measured by Physics Classroom Practices Inventory on the two dimensions namely extent of student-centered strategies and the extent of teacher-centered strategies practiced by physics teachers. The level of integration has been defined for teachers from each country as

1. Teaching with minimal integration (Incompetent Teaching or IT),
2. Teaching with average integration with increased concentration on student-centered tactics (Student-dominant Integration or SI),
3. Teaching with average integration with increased concentration on teacher-centered tactics (Teacher-dominant Integration or TI)
4. Teaching with maximum and balanced integration (Fair Integration or FI).

These four levels of integration of student-centered and teacher-centered strategies are hypothesized to influence Attitude towards Physics and Achievement in Physics.

However, as part of better understanding this independent variable, phase 2 of this study examines whether incidence of four types of integration varies by nationality, and examines if there is significant difference in the extents of student-centeredness and teacher-centeredness by teachers in Kerala (India), and South Carolina (USA).

2) Student-centered Instruction.

In phase 2, the extent of student-centeredness in teaching higher secondary physics among teachers in India and USA was studied based on the scheme of integration developed for this research.

3) Teacher-centered Instruction.

In phase 2, the extent of teacher-centeredness in teaching higher secondary physics among teachers in India and USA was studied based on the scheme of integration developed for this research.

Student Perception of Physics and Teacher Perception of Physics were also considered, explored and qualitatively analyzed in phase 1 pilot study.

Dependent Variables

There are two dependent variables in the study, namely, Attitude toward Physics and Achievement in Physics.

1) Attitude toward Physics

In phase 3 prospective ex post facto study, Attitude toward Physics is hypothesized as influenced by Integrated Instruction and hence is considered as a dependent variable. It is measured as the overall approach of students toward learning physics in terms of affect toward physics, self-defined abilities in learning physics, perception of content/personal difficulties in learning physics, and future expectations on physics, which are considered as the sub variables. These sub variables were emerged from an exploratory factor analysis of data obtained in phase 2 of the study on a questionnaire on Attitude toward Physics. In the phase 2 student survey, the Attitude toward Physics is hypothesized as moderated by interaction of gender and nationality. In phase 1, Attitude toward Physics is studied as qualitative perception, beliefs, difficulties and preferences in learning physics revealed through open ended questions used in the structured interview.

2) Achievement in Physics

In phase 3 prospective ex post facto study, Achievement in physics is an index of amount of higher secondary school physics content learnt by the student as demonstrated through the performance in a grade appropriate standardized achievement test. Since the common physics content that has been instructed in both India and USA by the time of data collection was limited, for this study Achievement in Physics is measured as Achievement in Newtonian Mechanics concepts as score obtained on Force Concept Inventory (Hestenes, Wells & Swackhamer, 1992) by the end of the first semester.

Moderator Variables

Gender, Nationality, Previous level of Attitude toward Physics, and Previous level of Achievement in Physics of higher secondary students are hypothesized to modify the influence of Integrated Instruction (independent variable) on their Attitude toward Physics and Achievement in Physics. In addition, phase 2 of this study tests hypothesis that Gender and Nationality of students have independent and interactive influence on Attitude toward Physics.

1) Gender

Students' Attitude toward Physics was investigated by gender. Gender in the student sample for this study was acknowledged as "Male" and "Female". Participants of any other gender were not identified during data collection.

2) Nationality

Students in India and USA were used as the sample to determine the effect of Integrated Instruction, who differ in social, geographic, ethnic, and infrastructural and pedagogical factors. In spite of having these differences, these students share some similarities with respect to physics instruction. Both countries follow the similar thought of educational psychology, physics curriculum, and learning outcomes. Since this study focused on students' physics outcomes, the researcher considered this sample appropriate. In addition, literature review suggests that demographic variables showed little influence on student beliefs and attitudes in physics education (Sadler & Tai, 2007).

In phase 2 of this study, Students' Attitude toward Physics was investigated based on the difference in nationality. Nationality in the student sample for this study was acknowledged as "India" and "USA".

The extents of student-centeredness and teacher-centeredness were investigated based on the difference in nationality of teacher. Nationality in the teacher sample for this study was acknowledged as “India” and “USA”.

3) Previous Attitude toward Physics

In phase 3 of this study, level of Previous Attitude toward Physics along with Gender, and Nationality is hypothesized as modifying the influence of integrated instruction on Attitude toward Physics of higher secondary school students. It is measured by administering the Scale of Attitude in the beginning of the semester. Based on the median score, the sample was categorized into “Low” and “High” groups.

4) Previous Achievement in Physics

In phase 3 of this study, level of Previous Achievement in Physics along with gender and nationality is hypothesized as modifying the influence of integrated instruction on Achievement in Physics of higher secondary school students. The Previous Achievement in Physics was measured by administering the Achievement Test in the beginning of the semester. Based on the median score, the sample was categorized into “Low” and “High” groups.

The interrelationships between independent, dependent, and moderator variables used in this research are for each of the phases as shown as a flowchart in Figure 7.

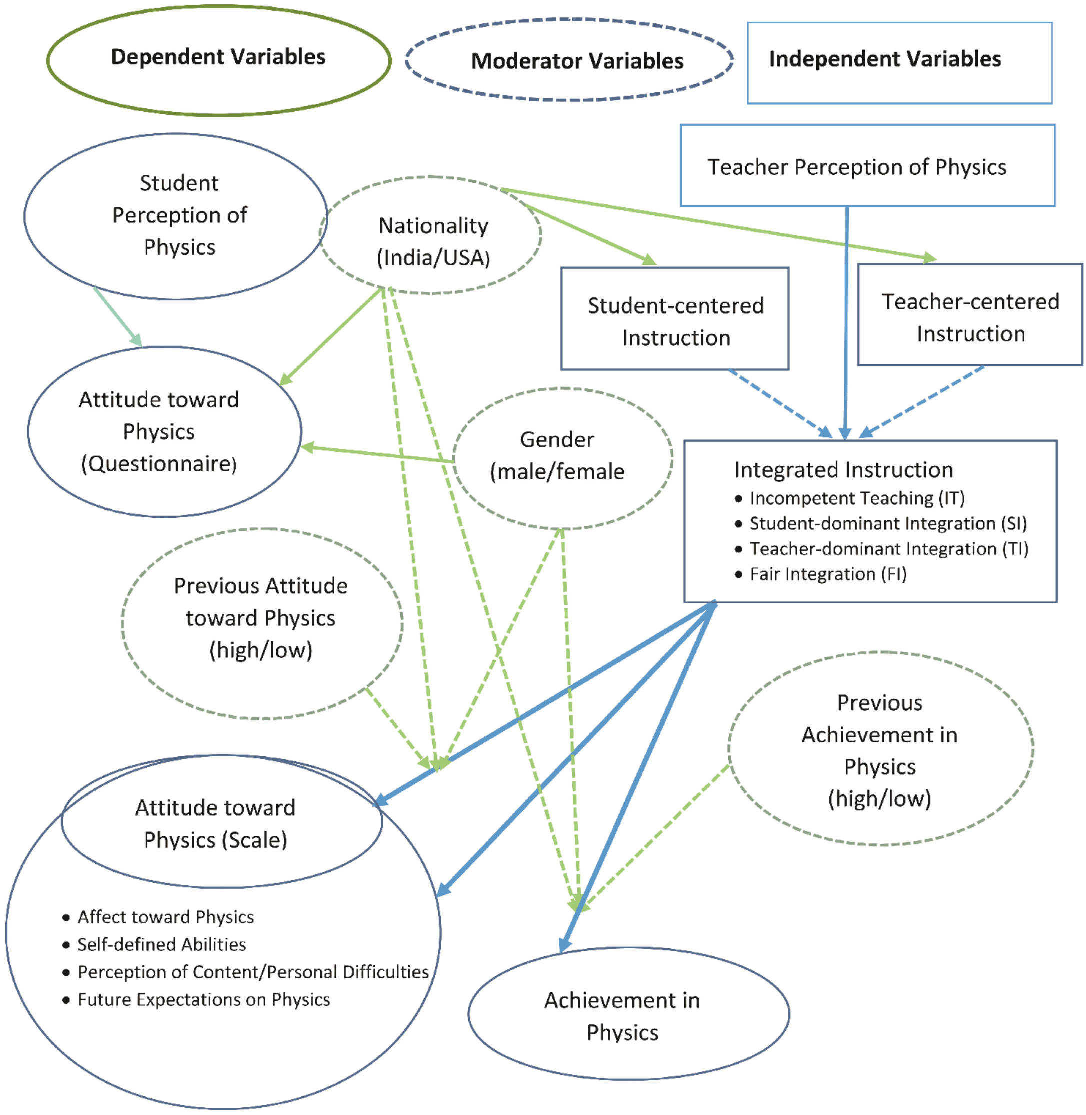

Figure 7. Summary and interrelationships of variables used in the study

Research Instruments and Techniques

A total of six data collection instruments and techniques were used for this study. All instruments except the Achievement Test were developed during the study. Structured Interview schedule for Students, Questionnaire on Student Attitude toward Physics, and Scale of Attitude toward Physics were used to obtain data on measures of Attitude toward Physics, one of the two major dependent variables in this study. Structured Interview schedule for Teachers, and Physics Classroom Practices Inventory were used to obtain data on measure of Integrated

Instruction, the independent variable in this study. The Force Concept Inventory(originally developed by Hestenes, Wells & Swackhamer, 1992), which is a universally accepted test for measuring the conceptual understanding in Newtonian Mechanics was adopted to obtain data on measures of Achievement in Physics, the other major dependent variable in this study.

Measures of Students' Attitude towards Physics

In order to obtain simple to administer, reliable, and valid measures of Students' Attitude toward Physics relevant to the cross-national context of this study a scale of Attitude toward Physics was developed. For this purpose, first, self-reports from students of how they perceive physics and its learning was obtained through interviews which helped to identify the different dimensions of teaching, learning, assessment practices, and future use that impact student attitude toward the subject. Then, the major elements of the attitude identified from the interview were field tested through another self-report using an attitude questionnaire on a wider sample. The data from the questionnaire survey were factor analyzed to identify the factors underlying students' Attitude toward Physics in the international context, which were finally modified into a more precise Likert type attitude scale. These orderly phases of developing the measure of Attitude toward Physics are here under.

Structured Interview for Students

A structured interview on perception, beliefs, difficulties and preferences in learning physics has been carried out for students in phase 1 of the study. The objective was to explore students' like/dislike of science, interest toward physics, discernment of difference between physics and other sciences, ways to make learning physics interesting, and major physics learning difficulties. The open ended questions used in the structured interview evoked responses that are meaningful, rich, exploratory, and culturally salient as participants respond to questions in their own words (Mack, Woodsong, MacQueen, Guest, & Namey, 2005). Questions focused on their experience, opinion, feeling and input with interpretative and naturalistic methodology in a natural setting (Denzin & Lincoln, 2011). This exploratory approach helped discover ideas and insights (Garg & Kothari, 2014) and the case study approach in eliciting detailed responses allowed an in depth analysis of the situations in both countries and their causal relations. The analytical mode of generalization in a case study could lead to a theory from which one can understand other similar cases (Best & Kahn, 2012).

Student responses were collected in the form of a questionnaire as shown in Appendix A. Findings of the analyses were incorporated in developing a questionnaire on Attitude toward Physics for students.

Questionnaire on Student Attitude toward Physics

This questionnaire was used in order to substantiate if there was any difference in Attitude toward Physics between the higher secondary school students of India and USA, and to investigate if the Attitude toward Physics was affected by Gender and/or Nationality in phase 2.

Planning. The Questionnaire on Student Attitude toward Physics was developed based on the student responses from phase 1 structured interview.

Item writing and editing. Based on the findings from the qualitative and quantitative analyses of the student interview responses, various factors were identified for the Questionnaire on Student Attitude toward Physics. The factors and corresponding items were then finalized after making thorough corrections with the help of the research supervisor and peer group members. The first part (part A) of the questionnaire items measured factors namely, General Perception, Metacognitive and Learning-related Beliefs, Negative Attitude, and Positive Attitude, and the second part

(part B) measured Perception and Preference on classroom practices. Part B responses were utilized in construction of classroom practices inventory for teachers.

The measurement tool comprised of 62 dichotomous items (42 in part A and 20 in part B) which were prepared carefully to address the above mentioned factors. The instrument was developed in dichotomous scale as the researcher was not sure about the way students from both countries would respond to the items. The instrument was then administered to students from Kerala (India) and South Carolina (USA). A total of 1368 complete responses were obtained. The English and Malayalam versions of parts A and B of the questionnaire draft are as shown in Appendices B1 and B2.

Sample illustrative items for its corresponding variable in Part A of the questionnaire are given below; all items were dichotomous

1) General Perception: *My perception on Physics has been changed negatively since I started learning the subject.*
2) Learning-related Belief: *I would learn Physics better if the lab activities are done parallel to the lectures.*
3) Metacognitive Belief: *I think a lab activity done with clear objectives can make a concept thorough.*
4) Negative Attitude: *I hate Physics because I never get the right answers when solving problems.*
5) Positive Attitude: *I will be able to know the world around me by learning Physics.*

Item Selection (Exploratory and Confirmatory Factor Analyses). Factor analysis is a multivariate statistical approach used in social science researches. It is a critical tool used in the development and evaluation of measures, scales and tests. It is commonly considered as the best method for interpreting self-reporting questionnaires

(Byrant, Yarnold, & Michelson, 1999 as cited by Williams, Onsman, & Brown, 2010). The major advantages in using factor analysis are that it reduces a large number of variables into smaller number of variables known as factors, and it establishes relationship between measured variables and latent constructs. Factor analysis provides the construct validity evidence for scales that are self-reported Gorsuch (1983) as cited by Williams, Onsman, & Brown, 2010). Nunnally (1978) describes that factor analysis is closely involved with validity.

The appropriate sample size for factor analysis is found different in various researches. Comrey and Lee (2013) suggest that sample sizes of 100 as poor, 200 as fair, 300 as good, 500 as very good, and 1000 or more as excellent. However, with higher factor loadings, smaller sample sizes are accepted (Henson & Roberts, 2006). Hair, Anderson, Tatham, and Black (1995)suggest that factor loadings less than 0.30 are minimal, less than 0.40 are important, and the ones greater than 0.50 are considered practically significant. In addition to sample size and factor loadings, the sampling adequacy is an important parameter considered in factor analysis. It is calculated by the Kaiser-Meyer-Olkin (KMO) test. The KMO measure of sampling adequacy 0.50 and higher is considered suitable for factor analysis (Hair et al., 1995).

A total of 23 items describing the attitude toward physics in general were carefully chosen as the Questionnaire on Student Attitude toward Physics from the 42-item questionnaire for analysis. Prior to begin analysis, Discriminative Power of each of the 23 items were calculated by performing an Item Analysis to further confirm validity. Two items were found with low Discrimination Power during the item analysis and therefore discarded from the questionnaire. As a result, the Questionnaire on Student Attitude toward Physics with 21 items was used for further analysis. The summary of item analysis for the Questionnaire is shown in Tables 3.

Table 3

Discrimination Power of the Responses of Each Item of the Questionnaire on Student Attitude toward Physics

Item No.	T	L	DP
1	25.00	18.00	0.28
2	25.00	12.00	0.52
3	25.00	4.00	0.84
4	25.00	5.00	0.80
5	22.00	2.00	0.80
6	24.00	15.00	0.36
7	24.00	12.00	0.48
8	20.00	1.00	0.76
9	24.00	15.00	0.36
10	21.00	12.00	0.36
11	21.00	13.00	0.32
12	20.00	14.00	0.24
13	13.00	0.00	0.52
14	24.00	5.00	0.76
15	24.00	5.00	0.76
16*	4.00	12.00	0.12
17	21.00	4.00	0.68
18	24.00	9.00	0.60
19	25.00	3.00	0.88
20	25.00	9.00	0.64
21	23.00	5.00	0.72
22	24.00	8.00	0.64
23*	23.00	19.00	0.16

* denotes rejected items

When an Exploratory Factor analysis (EFA) is performed, the investigator does not have any expectations on the number or nature of the variables, whereas it lets the investigator explore the dimensions to generate a theory. Confirmatory Factor Analysis (CFA) is used to see how exactly the measured variables represent the constructs. It is used to examine the relationships between variables, with hypothesized patterns of loadings based on a strong underlying theory (Long, 1983). In this study CFA is used to test whether measure on Attitude toward Physics are consistent with its nature through factor loadings.

The 21 items were then factor analyzed using Confirmatory Factor Analysis for Attitude toward Physics. The KMO test value of .87 for sampling adequacy was found acceptable for the sample size (Hair et al., 1995; Samuels, 2016). The factor loadings of the Questionnaire on Student Attitude toward Physics is shown in Table 4. The final versions of the Questionnaire on Student Attitude toward Physics in English and Malayalam are provided in Appendices B3 and B4.

Table 4.

Factor Loadings of Items in the Questionnaire on Student Attitude toward Physics

Variable		Measurement Items	Loading
Attitude toward Physics	1	Physics is filled with tough equations that are difficult to memorize.	0.747
	2	I would learn Physics better if the lab activities are done parallel to the lectures.	0.713
	3	Physics is filled with confusing derivations and their mathematical aspects.	0.657
	4	I never get the right answers when solving physics problems.	0.654
	5	Physics topics are filled with many difficult concepts that are crunched together.	0.647
	6	All sciences are my favorite, whereas Physics is the least favorite of all of them.	0.628
	7	Learning Physics would improve my skill in solving real world problems.	0.627
	8	I love discussing physics concepts outside my classroom.	0.61
	9	I try to hammer many physics concepts onto my brain without any clear understanding.	0.607
	10	I am passionate about understanding physics concepts.	0.596
	11	Learning Physics would improve my thinking skills.	0.584
	12	I think a lab activity done with clear objectives can make a concept thorough.	0.567
	13	Learning Physics would help me perform better in my future endeavors.	0.561
	14	I will be able to know the world around me by learning Physics.	0.554
	15	I think introducing Physics in earlier grade levels would help understand it better.	0.521
	16	I would never study Physics in my life though I receive excellent grades.	0.476
	17	I think I have to improve my reasoning skills to better understand Physics concepts.	0.441
	18	I notice the application of Physics concepts in my daily activities.	0.438
	19	I would learn physics concepts better if my teacher uses a variety of teaching methods.	0.404
	20	I can utilize my aptitude in Mathematics in learning physics.	0.378
	21	I am aware of the relevance of learning physics.	0.352

Scoring. The data was collected from Grade 11 and 12 students in Kerala (India) and South Carolina (USA) in a dichotomous scale. In order to balance the difference in reading comprehension skills between students in India and USA, the survey was distributed in English and Malayalam versions. A response of “Yes/Agree” was scored as “1” and “No/Disagree” as “0”. The negative items were coded in the reverse direction. The factor loadings were grouped into six different clusters, which were further modified toward the tool development in the latter phase. The total score of items that measured Attitude toward Physics for each student was calculated and analyzed for attitude toward physics.

Validity. Validity emphasizes the accuracy of the content in a research tool (Tavakol & Dennick, 2011). Gorsuch (1983) as cited by Williams, Onsman, & Brown (2010), describes that factor analysis provides the construct validity evidence for scales that are self-reported. Therefore, construct validity of the Questionnaire on Student Attitude toward Physics was verified from the high factorloadings.

Reliability. Cronbach’s Alpha value is widely and prominently used as the internal consistency coefficient, whereas the test-retest reliability is a more direct measure of reliability in addressing the stability of the scores. (Henson, 2001).

The reliability related to the internal consistency of the Questionnaire on Student Attitude toward Physics was calculated (Cronbach’s alpha = .85) indicating a high interrelatedness of the items in the measurement tool. Test-retest reliability was calculated as .79 on a sample of 78 Grade 12 students from Charleston, USA before and after a period of two weeks and found reliable (Vaz, Falkmer, Passmore, Parsons, & Andreou, 2013).

Scale of Attitude toward Physics

This instrument is used in phase 3 as a 5-Point Likert scale in measuring students' Attitude toward Physics.

Planning. The Scale of Attitude toward Physics was developed using the 21 items in the final version of the Questionnaire items on Student Attitude toward Physics (Part A) in Phase 2. The items from the Questionnaire on Student Attitude toward Physics were further modified after a thorough analysis with respect to its sub-scales. Sentence construction and use of language were revised for items for which students seemed confused in Phase 2. The items were distributed to experts to gather suggestions for further modification.

Item writing and editing. The four factors (variables) indicated by the confirmatory factor analysis of the Questionnaire on Student Attitude toward Physics in phase 2 were modified, with 24 items. The draft versions of the Scale of Attitude toward Physics in English and Malayalam are provided as Appendix C1 and C2.

A few sample items that have been modified are shown below with the original and modified factor names in parenthesis:

Sample 1.

Initial version: *My perception on Physics has been changed negatively since I started learning the subject.(General Perception)*

Modified Version: *I started disliking Physics when I started learning it(Affect toward Physics)*

Sample 2.

Initial version: *I hate Physics because many topics filled with a number of difficult concepts that are crunched together. (Negative Attitude)*

Modified version: *Many physics topics are filled with a number of difficult ideas crunched together. (Content/Personal Difficulties)*

Item Selection. The Scale of Attitude toward Physics was developed as a 5-point Likert type and administered in a sample of 949 students. Since the 24 items in four sub-scales of Affect toward Physics, Self-defined Abilities in learning Physics, Perception of Content/Personal Difficulties in learning Physics, and Future Expectations Physics, cumulatively measured a single construct of Student Attitude toward Physics, Critical Ratios of the items were calculated in order to further establish their discriminating power prior to performing analysis of the findings. The critical ratios of the items are provided in Table 5.

Table 5

Critical Ratios of each Item of the Scale of Attitude toward Physics

Item No.	Critical Ratio	Item No.	Critical Ratio
1	4.93	13	1.99
2	3.79	14	2.68
3	3.97	15	2.07
4*	0.24	16	3.31
5	2.98	17	3.87
6	2.66	18	4.34
7	4.39	19	3.99
8	4.45	20	4.87
9	4.72	21	4.36
10	2.95	22	3.98
11*	0.15	23	2.58
12	2.68	24	4.13

* denotes rejected items

The discriminative power of each item is provided as critical ratio using the equation:

$$\frac{M_{H-M_L}}{\sqrt{\frac{\sigma H^2}{N_H}+\frac{\sigma L^2}{N_L}}}$$

where M_H and M_L are the means σ_H and σ_L are the standard deviations, N_H and N_L are the number of sample considered for the higher and lower groups, respectively. The 22 item scale after excluding items #4 and 11, due to their low critical ratios, are shown in Tables 6.

An exploratory factor analysis was performed on the data to separate items into different factors. The 22 items on the Scale of Attitude were exactly loaded into the four redefined factors (variables) namely, Affect toward Physics, Self-defined Abilities in learning Physics, Perception of Content/Personal Difficulties in learning Physics, and Future Expectations on Physics. The KMO value for the Scale of Attitude toward Physics has been calculated as 0.90 which is exceptionally desirable. The factor loadings of the scale of attitude toward physics using the exploratory factor analysis are shown in Table 6.

Table 6

Factor Loadings of Measurement Items of the Scale of Attitude toward Physics with Corresponding Variables

Variables		Measurement Items	Loading
Affect toward Physics	1	Physics is my favorite subject.	0.768
	2	I am passionate about understanding big ideas in Physics.	0.673
	3	I love discussing main ideas in Physics outside my classroom.	0.615
	4	Physics is my least favorite of all of science subjects.	0.604
	5	I love conducting experiments in physics.	0.572
Self-defined Abilities	6	I would learn big ideas better if my teacher uses different teaching tactics.	0.705
	7	I would learn Physics better if we had lab activities related to the lectures.	0.556
	8	Introducing Physics in earlier grade levels would help me understand big ideas better.	0.544
	9	I can utilize my aptitude in Mathematics in learning physics.	0.47
	10	I need to improve my reasoning skills to better understand Physics concepts.	0.536
Perception of Content/ Personal Difficulty	11	Physics is filled with confusing derivations and their mathematical aspects.	0.75
	12	Many topics filled with a number of difficult ideas are crunched together.	0.735
	13	Physics is full of tough equations that are difficult to memorize.	0.709
	14	I never get the right answers when solving problems.	0.643
	15	I try to memorize major ideas in Physics without any clear understanding.	0.605
	16	I would never study Physics in my life even though I receive an excellent grade.	0.382
Future Expectations on Physics	17	Learning Physics would improve my skill in solving real world problems.	0.733
	18	Learning Physics would improve my thinking skills.	0.744
	19	Learning Physics would help me perform better in my future endeavors.	0.688
	20	I will be able to know the world around me by learning Physics.	0.64
	21	I am aware of the relevance of learning physics.	0.667
	22	I notice the application of Physics concepts in my daily activities.	0.601

Scoring. As mentioned above, the Scale of Attitude toward Physics was developed with a 5-point Likert type with the options of Strongly Disagree=1; Disagree=2; Neutral=3; Agree=4; Strongly Agree=5. The negative items were scored in the reverse order. Students were encouraged to have an opinion on each of the items in the Scale and to avoid being "Neutral" as much as possible. The score for attitude was calculated from the sub-scores of the four variables of Affect toward Physics, Self-defined Abilities, Content/Personal Difficulties, and Future Expectations consisting 22 items. The tool has been standardized by figuring out its validity and reliability, which are the two fundamental elements in evaluating a measuring instrument. The final versions of the Scale of Attitude in English and Malayalam are provided as Appendices C3 and C4.

Validity. Validity emphasizes the accuracy of the content (Tavakol & Dennick, 2011). In this study, loadings of the items into distinct factors on Attitude toward physics clearly explained the construct validity of the scale. In order to establish the content and face validities, the scale was given to professors of physics at the University of Charleston and higher secondary physics teachers in Charleston. Suggestions and comments from the faculty were incorporated into the final version of the scale.

In order to provide supporting evidence for the construct validity of the scale, a single item in the sub-scale of Self-defined Abilities has been used for samples in Phases 2 and 3. The Chi-square analysis of student samples (random and purposive) showed that student attitude toward physics was improved by integration of instructional strategies. The finding indicated that students' self-defined abilities enhanced their Attitude toward Physics through integrated instruction regardless of Nationality and Gender.

Reliability. A Cronbach's alpha value of .81 was calculated indicating a high interrelatedness of the items in the measurement tool. Test-retest reliability was calculated as .75 on a sample of 114 Grade 11 and 12 students from Charleston, USA with an interval of two weeks two weeks and found reliable (Vaz et al., 2013).

Measure of Teacher-entered and Student-centered Practices and Integrated Instruction

In order to first identify extents of various student-centered and teacher-centered classroom practices in Indian (Kerala) and US (south Carolina) classrooms of physics, the first phase of the study employed a Structured Interview for Teachers, the responses from which along with review of literature lead to development of a Physics Classroom Practices Inventory which provided the extent of student-centeredness/teacher-centeredness of higher secondary teachers in teaching physics, which were finally plotted as a scatter plot of which the four quadrants were identified as four types of Integrated Instruction, representing minimal instruction to highest extent of integration of both student-centered and teacher-centered strategies.

Structured Interview for Teachers

An exploratory approach has been adopted for interviewing physics teachers at the higher secondary level in India and USA. The questions were so structured that they could focus on experience, opinion, feeling and input of physics teachers from the chosen schools. There were 6 open-ended questions and 2 yes/no questions as shown in Appendix D. The major objective was to collect information on current practices, preferences, difficulties, personal opinions on physics instruction. Responses from teachers were qualitatively analyzed and finding were incorporated in developing a classroom practices inventory.

Physics Classroom Practices Inventory

This research instrument was developed to obtain the extent of student-centeredness and teacher-centeredness of higher secondary teachers in teaching physics. The extent of teacher-centeredness and student-centeredness, was then used to categorize teachers four different categories (types of integration), namely, teaching with minimal integration (Incompetent Teaching or IT), teaching with average integration with increased concentration on student-centered tactics (Student-dominant Integration or SI), teaching with average integration with increased concentration on teacher-centered tactics (Teacher-dominant Integration or TI) and teaching with maximum and balanced integration (Fair Integration or FI).

Planning. A theory has been developed on the effectiveness of the integrated instructional strategies in teaching and learning physics at the higher secondary level based on the responses from students and teachers in India and USA. The Physics Classroom Practices Inventory items were developed using the theory. As described in the literature review, there are different types of inquiry such as Open or Full Inquiry, Guided or Coupled Inquiry, and Structured Inquiry based on the role of teachers during instruction (Martin-Hansen, 2002). With this theoretical background of the different types of inquiry, and the components of the 5E Instructional Model (Bybee, 1987), a scheme has been developed to distinguish and combine inquiry and instruction that are teacher-centered as well as student-centered.

With the help of the scheme and theory on Integrated Instruction, responses from Structured Interview for Teachers were qualitatively analyzed and the findings were also used for developing the inventory. Student responses collected on classroom practices in physics as the second part (Part B) of the Questionnaire on Student attitude toward Physics in Phase 1, were also incorporated in developing the inventory (Appendices B1 & B2). The Physics Classroom Practices Inventory was thus developed by cross-checking the interview responses of both teachers and students in India and USA collected during the pilot study.

As mentioned above, physics classroom practices were identified and the items were constructed to match with the components of the 5E Instructional Model. The 5E model, which is an efficient model to promote constructivism was developed by the Biological Science Curriculum Study (Bybee, 1987). The items were categorized according to the 5E components such as Engage, Explore, Explain, Elaborate and Evaluate. The rationale for using the 5E's in this study is that they work well in an inquiry-based learning environment. In the meantime, it has a strong component of "Explain" in which teachers play a major role in clarifying the concepts and making students create connections between their prior knowledge and newly learned ideas in an environment of integrated instructional strategies. A scheme for integration on classroom tactics was developed based on the five components of this model on an inquiry-based platform.

Item writing and editing. A common thread of preferred classroom practices was originated upon analyzing the responses from both students and teachers. Items for the inventory were then developed by compiling the preferred classroom practices by students and teachers for higher secondary physics. In addition, information gathered from the review of literature and researcher's own experience as a physics teacher was also incorporated in the development of this instrument. Practices basically consisted of collaborative learning, cooperative learning, open inquiry, guided inquiry, hands-on learning, problem-based learning, technology-based, project-based learning, and traditional instruction techniques.

The items were initially divided into clusters such as teacher-centered in their purest form (TP), student-centered in their purest form (SP), and integrated with more student-centered activities and teacher-centered activities (SI & TI).Based on the five components of the Learning Cycle (5E) lesson plan, during the validation process, the items were thus categorized into three clusters such as Engage/Explore with/without teacher involvement, Explain with/without student participation, and Elaboration with/without student involvement. More teacher-centered activities are included in the "Explain" component to make the integration more effective for students. Student-centered practices are equally included in the component of "Elaboration" to make the integration more persuasive. The "Evaluation" component has been developed with practices that are more student-centered and technology-based.

The instructional strategy wise and classroom practice wise categorizations with logical explanations have been provided in chart form (Appendices E1 and E2), and a sample of classroom practices with different levels of integration in Appendix E3. An inventory with 32 items was finalized after verifying the items with a group of physics teachers at the higher secondary and college levels. The final version of the inventory with a 5-point Likert type is provided in Appendix E4. The 5-point Likert scale gave participants options of Never=1; Rarely=2; Sometimes=3; Often=4; Always=5. The inventory was administered to 106 teachers in Kerala (India) and South Carolina (USA).

Sample illustrative item for each factor of the inventory is given below:

1) Explain/Teacher-centered: *Provide pre-prepared directions on conducting experiments.*
2) Explain/Student-centered: *Provide students opportunity to test the accuracy of a problem.*

3) Explore/Teacher-centered: *Use web-based resources for problems and graphical analyses.*

4) Explore/Student-centered: *Let students explore concepts online or use books prior to covering them in class.*

5) Elaborate/Teacher-centered: *Introduce and brainstorm rubrics for group projects.*

6) Elaborate/Student-centered: *Let students work in groups on designing experiments for lab activities.*

Item Selection (Exploratory Factor Analysis). This study adopted the Exploratory Factor Analysis rather than using the customary Item Analysis as the physics classroom practices inventory contained a total of 32 items and addressed several variables. In order to finalize and reduce the number of variables, factor analysis was preferred over the item analysis.

The responses during exploratory factor analysis were loaded into six distinct factors (variables) namely, Engage/Explore/Teacher-centered, Engage/ Explore/Student-centered, Explain/Teacher-centered, Explain/Student-centered, Elaborate/Evaluate/Teacher-centered, and Elaborate/Evaluate/Student-centered were made. Varimax rotation was performed and the factor loadings greater than 0.4 were considered for further analysis as the sample size was 106 (Streiner, 1994). Factor loadings ranging from 0.411 to 0.864 and most of them were well above 0.50 (Samuels, 2016). The KMO value (0.637) was found acceptable for the sample size (McCallum, 2007). The factor loadings of the Physics Classroom Practices Inventory with the corresponding variables is shown in Table 7.

Table 7

Factor Loadings of Measurement Items in the Physics Classroom Practices Inventory with Corresponding Variables

Variables	Measurement Items	Loading
Explain/Teacher-centered	Conduct quizzes and tests in a traditional manner.	0.863
	Provide explanations and examples orally and in writing.	0.73
	Introduce major concepts using electronic slides and handouts.	0.525
	Provide pre-prepared directions on conducting experiments.	0.823
	Indicate quantities and variables for testing during lab.	0.692
	Solve textbook problems of various difficulty levels in class.	0.64
	Provide ample examples during lectures to avoid student misconceptions.	0.853
Explain/Student-centered	Let students work on lab in groups with teacher supervision.	0.777
	Supervise and assist when students work in small groups.	0.605
	Provide students opportunity to test the accuracy of a problem.	0.586
	Facilitate discussions to come up with problems having real-life applications.	0.557
	Assist students to analyze results and reach conclusions.	0.534
Engage/Explore/ Teacher-centered	Use alternative assessment techniques available online.	0.77
	Introduce major concepts using videos and animations.	0.71
	Provide in-class demonstrations to reinforce concepts.	0.642
	Use web-based resources for problems and graphical analyses.	0.558
Engage/Explore/Student-centered	Let students demonstrate problem-solving steps using web resources.	0.864
	Let students find resources and related information for projects.	0.749
	Let students explore concepts online or use books prior to covering them in class.	0.703
	Let students work in small groups on problems and difficult concepts.	0.811
	Let students work in groups to realize the underlying concept of a problem.	0.645
	Let students explore and get familiar with major concepts during lab.	0.578
Elaborate/Evaluate/Teacher-centered	Make students present their work public before experts in the relative fields.	0.79
	Assist students in finding resources and applying information.	0.706
	Introduce and brainstorm rubrics for group projects.	0.554
	Introduce a project by a challenging problem during in-class discussions.	0.519
	Introduce and evaluate using the rubric for group projects.	0.813
	Let students brainstorm on the rubric for group projects with teacher involvement.	0.736
Elaborate/Evaluate/Student-centered	Let students work in groups on designing experiments for lab activities.	0.754
	Let students prepare lab reports by analyzing results obtained.	0.68
	Let students brainstorm on the rubric for group projects.	0.649
	Let students work in groups and brainstorm the teacher-made lab procedure.	0.411

Scoring. Teacher responses on the Classroom Practices Inventory analyzed using exploratory factor analysis were primarily teacher-centered and student-centered. These primary categories were further classified into three sub-divisions, Explain, Engage-Explore, and Elaborate-Evaluate based on the 5E components. Responses under these components were therefore categorized as two major categories, Student-centered Instruction and Teacher-centered Instruction. The progression of the combination effect of the major categories of the instructional strategies lead to the levels of integration.

The total scores for Teacher-centered Instruction (TCI) and Student-centered Instruction (SCI) for Indian and US teachers were compared. The scores were plotted (TCI vs. SCI) on the X-Y plane in all four quadrants. Using descriptive statistics, the median for TCI and SCI were calculated, and the scores were interpreted. Hence, teachers were categorized into four different levels of Integrated Instruction namely, Incompetent Teaching (IT) with less student-centered and teacher-centered classroom practices, Student-dominant Integration (SI) with more student-centered classroom practices, Teacher-dominant Integration (TI) with more teacher-centered classroom practices and Fair Integration (FI) with an ample combination of student-centered and teacher-centered classroom practices.

Validity. In this study, construct validity of the inventory was verified using the exploratory factor analysis. The six distinct factor loadings undoubtedly explicate its construct validity. Content and face validities were substantiated by the physics faculty at university and higher secondary levels upon finalizing the tool with 32 items. The construct validity was further established from categorization of the matched responses provided by teachers and students.

Reliability. The test-retest reliability for the Physics Classroom Practices Inventory was confirmed as .89 by administering the tool to 33 physics instructors at the university and higher secondary level in Charleston, USA with an interval of two weeks to establish consistency in scores over time (Vaz et al., 2013).Reliability for internal consistency was not calculated for this instrument as it did not have item homogeneity. In other words, the items in the inventory did not designate one single construct from the six different factors.

Achievement Test (Force Concept Inventory)

The objective behind the adoption of this instrument is to measure students' Achievement in Physics. The Force Concept Inventory (FCI) originally developed by Hestenes, Wells and Swackhamer, (1992) was adapted as the tool for measuring students' achievement in the area of Newtonian Mechanics. Students' conceptual understanding in Mechanics has been determined by this tool for achievement test. This 30-item inventory measures student achievement in the areas-

Newton's Second Law free fall, no air resistance

Newton's Second Law (impulse)

Newton's Second Law (a=0)

Newton's Second Law (a is non-zero)

Circular motion or circular to linear motion

Projectile motion

Newton's Third Law

Constant and changing velocity particles (Kinematics)

The Force Concept Inventory (FCI) is widely accepted multiple-choice test that provides useful instruments to probe students' difficulties in comprehending and mastering Newtonian Mechanics concepts on a large scale (Bao & Redish, 2001).

It is an influential instrument to many researchers in developing a variety of pedagogical activities (Lasry, Rosenfield, Dedic, Dahan, & Reshef, 2011). The FCI has been developed by experts in physics education with the observation that students make inconsistent reasoning on physical problems. Therefore, this instrument can mainly be used to evaluate the effectiveness of instruction (Hestenes & Halloun, 1995).

In this study, the researcher decided to use this concept inventory due to its ability to evaluate the effectiveness of instruction. Since this inventory consists of questions based on everyday life activities and is appropriate to develop effective pedagogical activities, this research instrument has been found convincing to the researcher due to the nature of her research. The major topics covered is Newtonian Mechanics, therefore the researcher found it suitable for administering in India and USA approximately at the same time of the academic year. Additionally, the topic was identical for students in Grade 11 in India with those in USA in their first semester. The major concepts covered in FCI are Kinematics, Newton's Laws of Motion, Superposition Principle of vectors, and Force (Hestenes & Halloun, 1995), which has been broken down into items as shown in Table 8.

Table 8

Breakdown of FCI Questions

Newton's Second Law free fall, no air resistance	1, 3, 13
Newton's Second Law (impulse)	8
Newton's Second Law (a=0)	9-11, 17, 23, 24, 25, 29
Newton's Second Law (a is non-zero)	21, 22, 26, 27, 29, 30
Circular motion or circular to linear motion	5-7, 18
Projectile motion	2, 12, 14
Newton's Third Law	4, 15, 16, 28
Constant and changing velocity particles (Kinematics)	19, 20

Force Concept Inventory (FCI) is an internationally recognized research tool in physics education research (Bao & Redish, 2001). The items were in the form of Multiple Choice questions with 5 options. It has already been validated for its content and face by researchers and educators at higher secondary and college levels. The FCI is one of the most commonly used concept inventories, intended to measure the effectiveness of your teaching by assessing, on average, what your students learned in the course, and it follows that the results of the class as a whole are more important than individual students' scores. FCI has made a significant impact on physics education reform for the last three decades. Results obtained by using this instrument have inspired many physics instructors in radically changing their teaching methods from traditional lecture to more inquiry-based and interactive.

The reliability for internal consistency has also been established and verified universally. FCI had the Cronbach's alpha value of 0.90for a sample of 111 introductory physics students from Montreal, Canada (Larsy et al., 2011). In this study, the 30-item inventory was distributed to 114 higher secondary physics students in Charleston, USA before and after duration of two weeks. The test-retest reliability was determined as .83.

Samples Used in the Study

Higher secondary students and teachers of two countries, India and USA from the states of Kerala and South Carolina, respectively, were the selected populations for the study. Kerala (India) and South Carolina (USA) states were chosen to represent their respective countries with the assumption that they are typical yet relatively comparable states of the two nations. The teacher and student samples used in the three phases of this study are related; as the data was collected repeatedly from the same cohort of teachers and their students in these two states. Randomness was applied in choosing the districts and schools within each district.

As mentioned in the introductory part of this study, there are several features that are comparable between these two states of Kerala (India) and South Carolina (USA). The multistage (at the level of districts and schools and teachers) and multiphase sampling (for repeated data collection in subsequent phases) used for this study provided multiple yet related samples of the same population. By adopting the multi-site approach researcher tried to avoid 'radical particularism' of a single in-depth case study (Firestone & Herriott, 1984). The heterogeneous settings were hypothetically more useful for increased generalizability (Schofield, 1993).

Since the average number of students in a sampled classroom in Kerala (India) is about 56, and that in a classroom of South Carolina (USA) is 26, the number of students in the US sample is lower than that of the Indian sample. The phase-wise sample depiction is provided for better understanding the sample and sequential nature of the samples in the three phases in Figure 8.

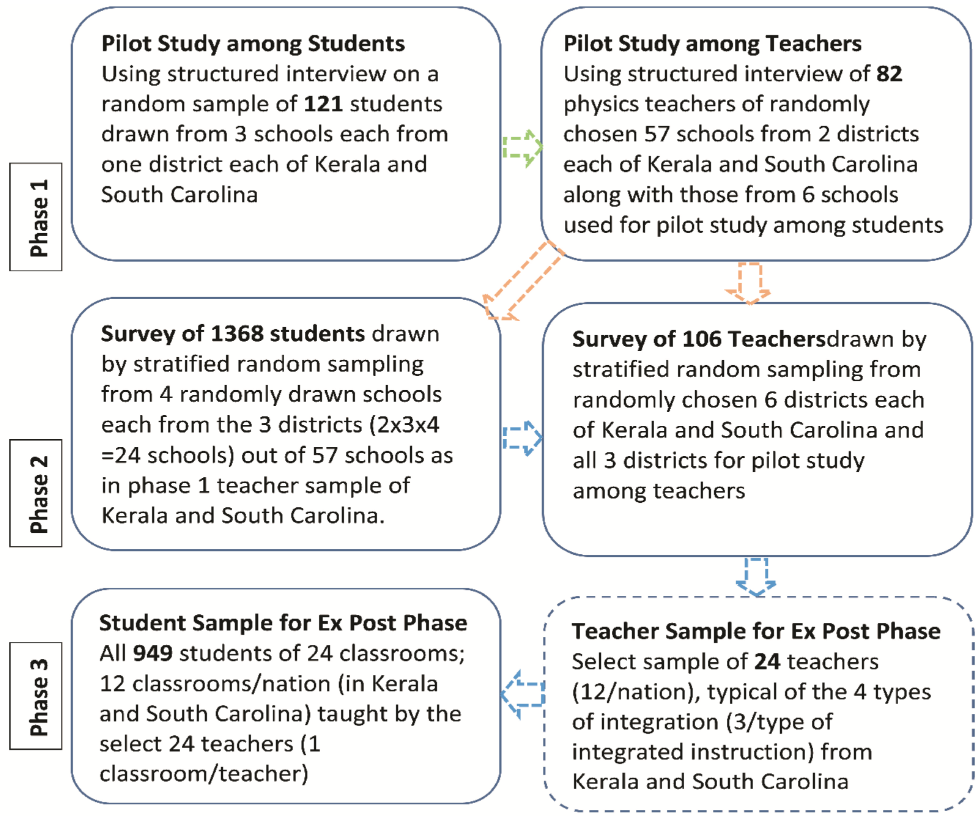

Figure 8. Flowchart showing the procedure, techniques and the relation among the samples used for the three phases of the study

Sample used for phase 1 Pilot Study among Students and Teachers

The US sample for the pilot study consisted of students from randomly chosen three schools from the district of Charleston in South Carolina and the Indian sample was from the district of Kannur in Kerala. There were a total of 121 students of which 76 students (32 males and 44 females) were from Kerala, India and 45 students (28 males and 17 females) belonged to South Carolina, USA. The pilot study conducted for teachers consisted of 82 teachers of which randomly selected 58 teachers from the districts of Trivandrum, Thrissur, and Kannur in the state of Kerala consisted of the Indian sample, whereas, randomly selected 24 teachers from three different districts (Charleston, Berkeley, and Dorchester) in South Carolina were the US sample.

Sample used in phase 2 Survey of Students and Teachers

The US sample of student survey in the second phase were from randomly chosen twelve high schools from districts of Charleston, Berkeley, and Dorchester in the state of South Carolina, and the Indian sample was also from randomly chosen twelve higher secondary schools from the districts of Trivandrum, Thrissur, and Kannur in the state of Kerala. A total of 1368 students comprising 953 students (386 males and 567 females) from India and 415 students (273 males and 142 females) from USA was used as the sample for the questionnaire survey on attitude and preference.

A total of 106 randomly selected teachers from 10 districts each in India and USA were the participants to complete the classroom practices inventory in Phase 2. There were randomly selected 55 teachers from the districts of Trivandrum, Alappuzha, Pathanamthitta, Ernakulam, Palakkad, Thrissur, Malappuram, Kozhikkode, Wayanad, and Kannur in the state of Kerala, India and randomly selected 51 teachers from counties of Charleston, Berkeley, Dorchester, Lexington, Richland, Horry, Chester, Greenville, Spartanburg, and Pickens in the state of South Carolina, USA. Twelve teachers each from each country were selected using a Scheme of Integration for allotting the student sample for the next phase.

Sample used in Ex Post Facto Study Phase

In Phase 3, a total of 949 students from classrooms of the 24 teachers in India and USA were used as the sample. These 24 teachers were selected by identifying 3 teachers from each country as typically representing each of the four types of integration at the end of phase 2. There were 576 students (226 males and 350 females) from India and 373 students (213 males and 160 females) from USA. Description and size of the samples are provided for each phase with the help of a flow chart as shown in Figure 9.

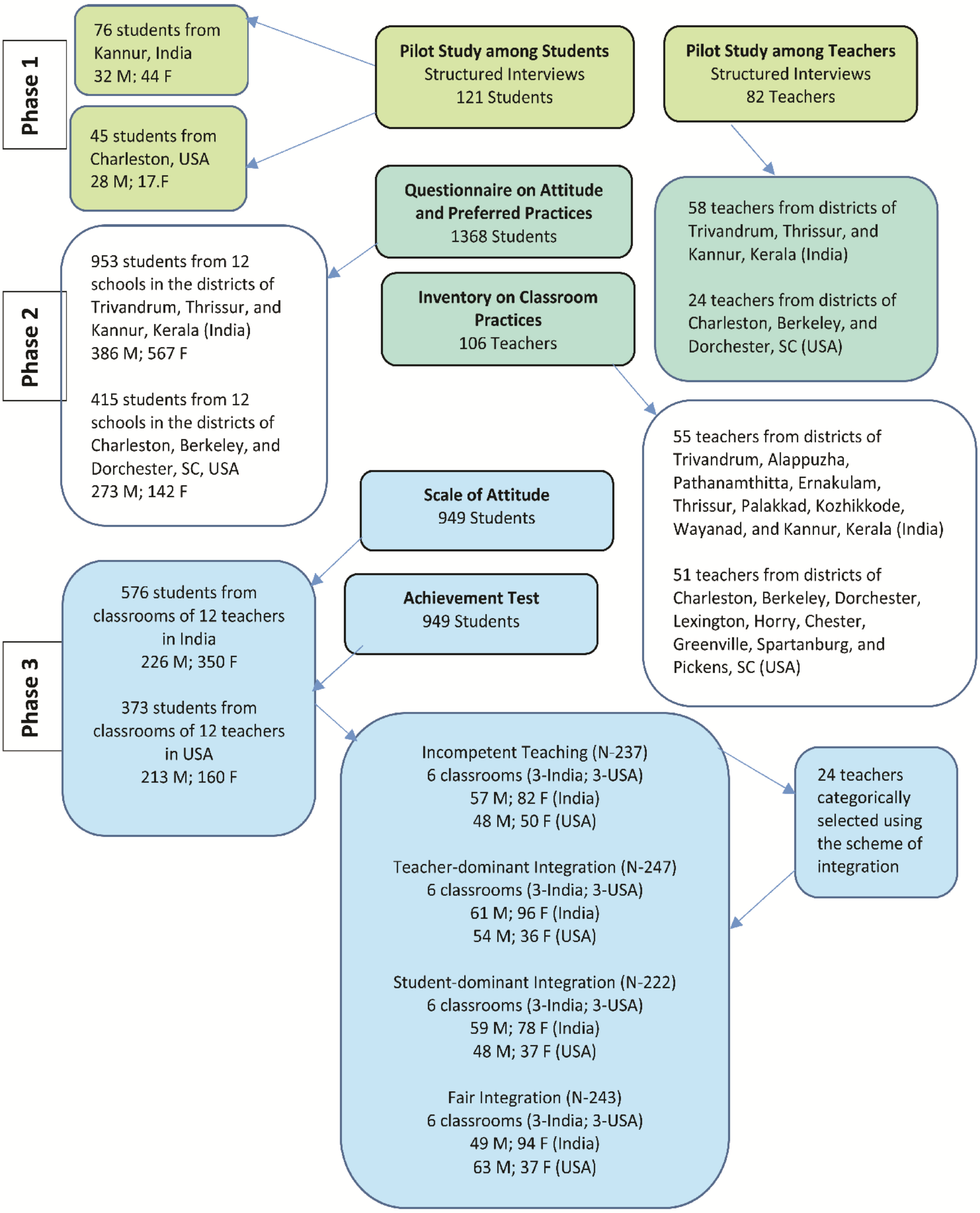

Figure 9. Nation wise and Gender wise description of student and teacher samples used in each phase of the study

In the initial part of the third phase, the samples from India and USA were also divided based on their previous performance. By using the moderator variables, Previous Attitude toward Physics and Previous Achievement in Physics, students were categorized as “Low” and “High”.

Data Collection Procedure and Data Preparation

The data collection has been carried out during 2014-15, 2015-16, and 2017-18 academic years. Since the samples involved in this study were from two different geographically different territories, each stage of the data collection required 3-4 months to complete.

During Phase 1 of this study, structured interviews were carried out as a pilot study to gather information from students as well as teachers during visits to classrooms in both countries in September-October, 2014 with prior permission from the Higher Secondary Directorate (Kerala) In USA, permission was obtained from the School District Offices and Principals after approving the parent consent letter format and research proposal. A sample copy of the parent consent letter is provided as Appendix G.

The data was collected in the form of a questionnaire from both Indian and US samples. Responses to both open-ended and yes/no questions were recorded by the investigator. Teachers were to complete a structured interview in the form of a questionnaire. Teachers were approached personally and via email for completing during the 2014-15 academic year. The investigator personally visited the schools in India to meet with the teachers, and to make request to complete the questionnaire during their leisure periods. Majority of the completed responses were collected on the day of visits and the rest was collected by post. Teachers voluntarily agreed to send the questionnaire to the department address of the investigator. Teachers in USA were given the questionnaire by the investigator in person and the completed responses were collected via email as an attachment in pdf format. Complete responses were analyzed and compared with the findings of the students' interview responses. The data was compiled and analyzed qualitatively.

A dichotomous questionnaire survey on perception, beliefs, attitude, and preferences on pedagogical practices has been carried out during the following stage of the study in January-April, 2016). Along with the data, students' demographic information such as gender, grade level, and name of the school was also collected. Since the formalities were completed during the initial data collection period, the investigator was able to approach the principals directly for collecting data in Phase 2. The parent consent letters were sent out prior to conduct the survey as the student population was different in the 2015-16 academic year. The data was collected as dichotomous responses and compiled as an Excel file for further analysis.

During the second phase, higher secondary physics teachers from India and USA completed an inventory on classroom practices. The Surveys were distributed online using the software Qualtrics to the teachers in USA. Researcher scheduled personal meetings with each of the teachers in India and distributed survey in the printed version. Teachers who required more time to complete the inventory returned the completed inventories via mail. Eighteen responses collected from the Indian teachers were excluded as the information gathered from personal interviews during pilot study was found contradictory to their responses for the inventory.

The responses were recorded in an Excel file and analyzed using Exploratory Factor Analysis with SPSS (Version 24) to figure out different factors within the classroom practices. Four major categories were developed after incorporating the responses with the components of the 5E Instructional Model namely, Engage, Explore, Explain, Elaborate and Evaluate. By carefully combining these component with Student-centered and Teacher-centered Instruction, two major categories were created.

Categorization of teachers by type of integrated instruction. The scores for Student-centered Instruction (SCI) and Teacher-centered Instruction (TCI) were calculated initially to categorize the teachers based on their extent of student-centeredness and teacher-centeredness. By plotting the scores for SCI and TCI, a scatterplot was created (TCI vs. SCI).Teachers were categorized into four different groups as teaching with minimal integration (Incompetent Teaching), teaching with average integration with more concentration on student-centered tactics (Student-dominant Integration), teaching with average integration with more concentration on teacher-centered tactics (Teacher-dominant Integration), and teaching with maximum or balanced integration (Fair Integration). The level of integration was figured out from the scatter plot for each teacher's score and placement within the plot. The advancement of integration is conceived in the order of IT-SI-TI-FI as shown in Figure 10.

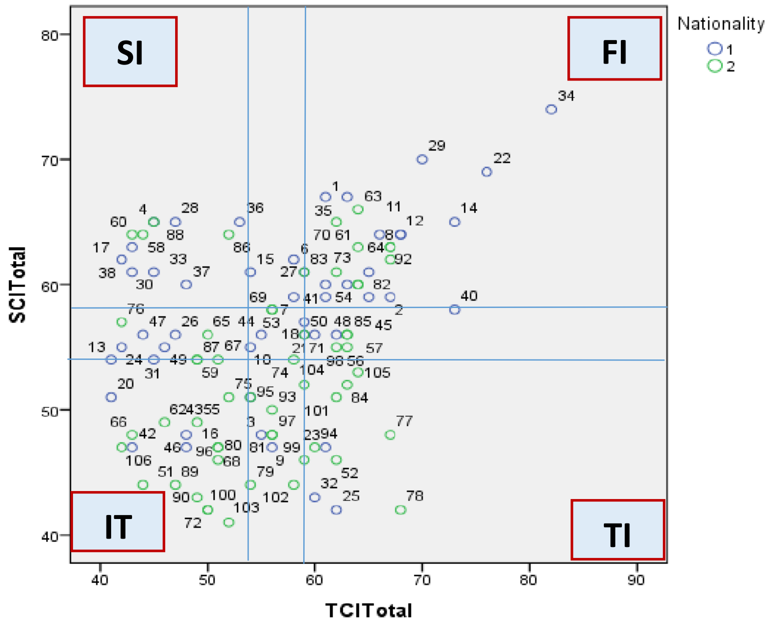

Figure 10. Categorization of the extent of teacher-centeredness and student-centeredness of the higher secondary physics teachers in 1) India and 2) USA based on the responses on the classroom practices inventory

As a precaution and to decrease the margin of error, the cut points were calculated for 40th and 60th percentiles for TCI (54 and 59) and SCI (54 and 58), respectively. The sample below the 40th percentile was considered low on student-centeredness/teacher-centeredness and that above the 60th percentile as high on student-centeredness/teacher-centeredness. After establishing the categories of integration, three teachers from each category from India and USA were randomly selected for allotting the student sample for the next phase. Student sample from each of these 12 teachers was chosen for investigating the effect of different types of integration on students' Attitude toward Physics and Achievement in Physics.

An Ex Post Facto study was performed in the last phase of the research, in which the Scale of Attitude and Achievement Test were administered twice to a sample of students from India and USA. All students participated were students from classrooms of the 24 teachers specifically chosen based on a scheme and rationale for integration. All students studied the same topics are being covered in both countries during the first semester of 2017-18 academic year. The researcher and her supervisor had to obtain permission from the Institutional Review Board (IRB) at the University of Charleston, South Carolina (USA) to begin the third phase data collection. For that purpose they completed the online training and obtained IRB certification. Official formalities were completed again in India and USA to begin student data collection at the school and district levels as the permissions received earlier were expired. Additionally, parent consents were required again from the US sample to begin data collection as the phase 3 sample consisted of a new group of students, though the teachers remained the same for all three academic years of data collection for this study. The pretest and posttest data was collected from both countries by the end of January, 2018 and entered as an Excel document to begin analysis.

Grouping by Previous Level of Performance on Attitude towards Physics and Achievement in physics

For analysis, the samples from India and USA were grouped based on their previous performance. By using the moderator variables, Previous Attitude toward Physics and Previous Achievement in Physics, students were categorized as "Low" and "High". Out of the 226 male students in India, 114 possessed low attitude and

112 possessed high attitude previously, whereas 149 students had low previous achievement and 77 students had high previous achievement. Among the 350 female Indian students, 165 and 185 students had previously low and high attitude respectively, whereas, 275 and 75 were having low previous achievement. Similarly, 97 and 116 students, respectively, possessed previously low and high attitude among 213 male students in USA, whereas, 40 and 173 of them respectively, had previous low and high achievement. As far as the 160 female student in USA were concerned, 108 students had previously low attitude and 52 of them had previously high attitude. Regarding previous achievement among the US females, 78 had low and 82 had high scores. The categorization of the samples from India and USA has been depicted in Figure 11.

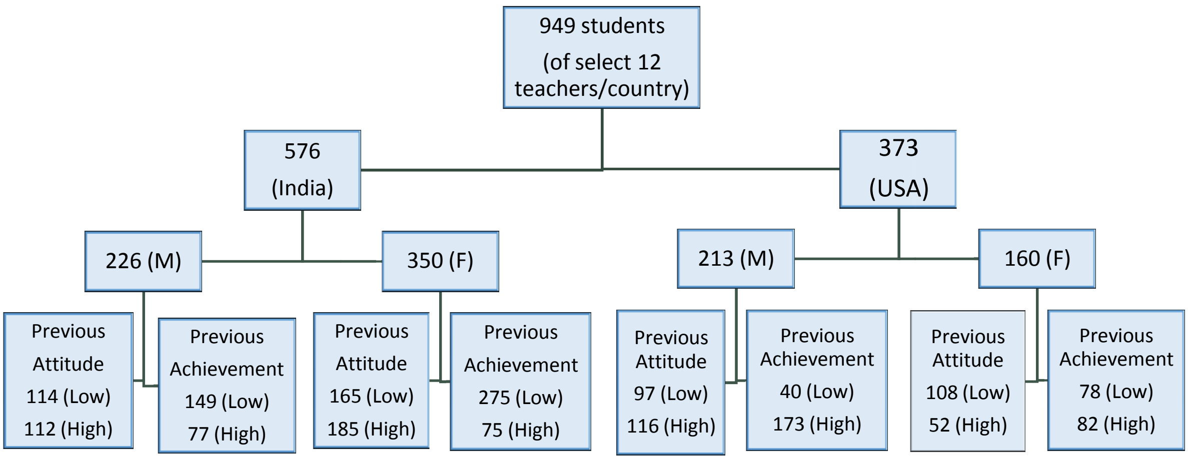

Figure 11. Categorization of student sample in the third phase based on previous performance

Statistical Tools used for the Analysis

This study has made use of both descriptive and inferential statistical tools. Several statistical tools used in different phases of this study to test the formulated hypotheses. The Statistical Package for Social Science (SPSS) Version 24 was used to perform all statistical analyses for this study. The statistical techniques used for this study are divided into seven categories as follows.

Descriptive Statistics

Basis descriptive statistics such as mean, median, standard deviation, percentage, frequency and cumulative percent frequency were used to figure out the overall behavior of the scores received from different samples at different steps during the analysis,

Chi-Square Test of Homogeneity

Chi-Square tests were performed

- to compare students' and teachers' responses on perceived and preferred classroom practices
- to compare the frequency of the type of integrated instruction (overall and specifically for each type)
- to provide additional evidence for validity of the instruments used for measuring the attitude from the random and stratified samples. One item on Self-defined Abilities was compared for both samples.

Exploratory Factor Analysis

Exploratory Factor analysis (EFA) was performed at various stages of this study. While developing and administering the Questionnaire on Attitude toward Physics and the Physics Classroom Practices Inventory, the investigator explored the dimensions as she did not have any expectations on the number or nature of the elements of these variables. Upon analyzing the data on Scale of Attitude toward Physics, EFA was used to confirm the factors loaded for the data on the Questionnaire. In addition, EFA was used as a validation tool for the instruments as well. The sampling adequacy was also calculated during the EFA by the Kaiser-Meyer-Olkin (KMO) test.

Factorial ANOVA

This study used the Four-way (4x2x2x2), Three-way, and Two-way ANOVAs during the third phase. In order to find out the interaction effect of the independent variable (Type of Integrated Instruction with four levels) along with the control variables namely, Gender, Nationality, and Previous Attitude and previous Achievement on the Attitude toward Physics and Achievement in Physics, the investigator initially used the Four-way ANOVA. Since the results revealed a significant interaction effect, two Three-way ANOVAs (4x2x2) were performed to see the interaction effect by splitting one of the control variables. A significant interaction effect was again found, and hence the data was used to perform four Two-way ANOVAs (4x2) by splitting two of the control variables.

One-way ANOVA

One-way ANOVAs were performed at various stages of this study. The main effects of Gender and Nationality on Attitude toward Physics were analyzed in Phase 1 using a One-way ANOVA. In Phase 3, a series of eight One-way ANOVAs were performed since significant interaction effect was observed during the Two-way ANOVAs. One-way ANOVAs were performed to see the effect of the Type of Integrated Instruction on Attitude toward Physics and Achievement in Physics for the male and female students having previously low and high attitude and achievement in Kerala (India) and South Carolina (USA).

Test of Significance of Difference between Means

The mean scores were compared using the independent samples t-test in all three phases to reach a conclusion, as a follow-up to analysis of variance, wherever necessary.

Effect Size using Partial Eta Squared

For all ANOVA tests conducted, this study described the significance of the effect using effect size (Draper, 2018; Bakeman, 2005). Effect size is a measure of the degree to which variability among observations is attributed to different conditions. In this study, partial η^2 has been used to demonstrate this effect. Partial η^2 is defined as the ratio of variance occurred due to an effect and the combination of the effect and its associated error variance in the ANOVA tests (Brown & Spang, 2008). Effect sizes are considered small, medium and large for in terms of partial η^2 when the values are 0.01, 0.06 and 0.14 respectively (Draper, 2018). Effect Size (η_p^2) was used in addition to the descriptive statistical parameters such as mean, standard deviation, frequency, percentage and cumulative frequency. The findings from the analyses were described in tabular and graphical representations in the following chapter.

Chapter IV

ANALYSIS

- *Perception and Preferences on Physics Instructional Strategies among Higher Secondary Students and Teachers*
- *Attitude toward physics Among Higher Secondary Students in Kerala (India) and South Carolina (USA)*
- *Extent of Student-Centeredness and Teacher-Centeredness and their Integration in Classroom Practices of Higher Secondary Physics Teachers*
  - *Incidence of the Four Types of Integrated Instruction among Higher Secondary School Physics Teachers by Nationality*
- *Effect of Integrated Instruction on Student Attitude toward Physics*
  - *Effect of Type of Integrated Instruction on Attitude toward Physics in Subsamples*
  - *Effect of Nationality and Gender on Attitude toward Physics*
- *Effect of Integrated Instruction on Student Achievement in Physics*
  - *Effects of Nationality and Gender on Achievement in Physics*
  - *Effect of Type of Integrated Instruction on Achievement in Physics*
- *Tenability of the Hypotheses*

Analysis

The study has been conducted as a mixed methods research with the exploratory sequential design. The study first investigated the perception and preferences on Physics instructional strategies among higher secondary school students and teachers in Kerala (India) and South Carolina (USA). Then it proceeded to comparison of attitude toward Physics among these higher secondary students. Analysis of teacher-centered and student-centered classroom practices of higher secondary school Physics teachers in India and USA was also performed and how frequently each of the identified four types of integration was being adopted by teachers in India and USA was studied. Then, effect of Types of Integrated Instruction on Student Attitude toward Physics and Achievement in Physics were studied through a series of analyses of variance which were followed up with test of significance of difference between means if necessary.

The analyses performed in this study are presented under 7 major sections:

Perception and Preferences on Physics Instructional Strategies among Higher Secondary Students and Teachers

The data collection, analysis and findings of the qualitative part of the study have been formulated toward development of more structured tools for quantitative part which followed it. In the qualitative phase, structured interviews were conducted in the form of questionnaire among students and teachers of Physics in higher secondary schools in India and USA. The questions included: What is the frequency of research-based instructional strategies in Physics classrooms? How do students and teachers support integration of instructional strategies in their classrooms? To what extent, can teachers control the parameters of an effective teaching and learning environment?

The questions were so structured in this exploratory study that the participants can focus on their experience, opinion, feeling and input. Responses on current practices, preferences, difficulties, personal opinions on Physics instruction were collected and analyzed from a total of 121 students and 82 teachers of Physics in higher secondary schools that are randomly selected from three different districts each in Kerala (India) and South Carolina (USA). Frequencies of strategies ranging from research-based, student-centered and inquiry-based to practices that are traditionally teacher-centered were verified. The data gathered from the interview responses was analyzed qualitatively and quantitatively.

Various measures on improving students' attitude toward Physics were formulated from students own perspective during the exploratory analysis of the findings as shown in Table 9.

Table 9

Summary of Student Perspective on Instructional Strategies that improve their Attitude toward Physics

Strategies under teacher control	Strategies beyond teacher control
Hands-on activities while lecturing	Slow pacing in explaining each concept
Problems to illustrate concepts in a concrete manner	Avoid confusing derivations and theorems
Make students think about the application of a particular concept	More visuals and animations
Reproduce activities and experiments mentioned in textbook	
Use more than one textbook	
Teach the material with more ease rather than being serious	
Materials should not be forced to memorize	
Implementing strategy to develop love towards Physics	
Lectures with student involvement	
Having a constant routine of instructional activities	

As disclosed by the findings, most of the instruction-related modifications can be controlled by teachers, and the suggestions made by students support the implementation of a unified instructional strategy to create a learning environment that improve their attitude toward Physics. Various measures provided by the teachers for improving student attitude towards Physics are listed in Table 10.

Table 10

Summary of Teacher Perspective on Instructional Strategies that Improve their Students' Attitude toward Physics

Measures	Strategies under teacher control	Strategies beyond teacher control
Measures that can be modified through instructional practices within curriculum	Reduce pacing	Reduce syllabus
	More activity-based instruction	Reduce class size
	Student-centered activities	Improved facilities
	Use Problem-based Learning	More use of technology for teaching
	Provide more demo with lecturing	More duration for class periods
	Introduce application of Physics	Flexible syllabus
	Curriculum-based lab work	Provide adequate lab facilities
	Provide real life examples	Mathematics and Physics to be taught together
	Adopt different instructional strategies	More exposure to higher level mathematics
	Projects on recent developments in Physics	Establish pre-requirements for opting science
	Deliver material in a simplified manner	Provide students guidance in selecting options
Measures that can be modified within and/or outside curriculum	Introduce self-learning strategies	Modify curriculum based on student level
	Encourage conceptual learning	Reduce breadth and focus on depth
	Awareness on current developments	
	Encourage students who are not motivated	
	Discourage memorization	
	Provide individual attention	
	Be friendly and consider student opinions	

As shown in Table 10, teachers themselves are able to make a difference in their Physics classrooms as most of the measures listed can be controlled by themselves.

Chi-Square analyses were performed to see if there were significant differences in students' and teachers' responses on perceived and preferred instructional practices. The results are summarized in Table 11.

Table 11

Summary of Chi-Square Tests for Homogeneity of Student and Teacher responses on Perception and Preference of Select Instructional Strategies

Instructional Strategies	Perception		Chi-square	Preference		Chi-square
	Students[a]	Teachers[b]		Students[a]	Teachers[b]	
Lecturing	93 (77)	42 (51)	14.42**	22 (18)	31 (38)	0.08
Interactive Lecture Demonstration	18 (15)	42 (51)	31.01**	74 (61)	40 (49)	3.04
Hands-on Learning	39 (32)	68 (83)	50.39**	25 (21)	26 (32)	3.17
Problem-Based Learning	6 (5)	58 (71)	9.37**	100 (83)	72 (87)	0.51

Note: Values in parentheses are corresponding percentages and the remaining percentage of the sample did not perceive/ prefer the instructional strategy

a, N=121; b, N=82

**$p<.01$

As shown in Table 11, there is significant difference between the perceptions of students and teachers from Kerala (India) and South Carolina (USA) on currently adopted classroom practices. While teacher-centered strategy lecturing as an instructional strategy in Physics classrooms is perceived more by students than their teachers do [χ^2 (1, N =121)= 14.42, $p<.01$], the reverse, perception being more by teachers than students is true for student-centered instructional strategies like Interactive Lecture Demonstration [χ^2 (1, N= 82) = 31.01, $p<.01$], Hands-on Learning [χ^2 (1, N =82)= 50.39, $p<.01$] and Problem-Based Learning [χ^2 (1, N = 82) = 9.37, $p<.01$]. However, students and teachers did not differ in their preferred strategies for teaching- learning Physics in higher secondary schools ($p>.05$). Both students and teachers, equally prefer for problem based learning and Interactive Lecture Demonstration over lecture which is equally less preferred by students and teachers.

Based on the findings of teachers' responses, it is speculated that examining classroom practices and measuring the extent of Student-centeredness and Teacher-centeredness with respect to Nationality would provide insight on levels of Integrated Instruction among physics teachers. Additionally, it is postulated that the difference in the extent of student-centeredness and teacher-centeredness in instruction of teachers would affect the attitude of their students toward learning Physics and thereby make an impact in their achievement in Physics.

Attitude toward Physics among Higher Secondary Students in Kerala (India) and South Carolina (USA)

As per the objectives in the initial phase of this study, the main and interaction effects of Gender and Nationality on attitude toward Physics were investigated with a 2x2 ANOVA. The results are shown in Table 12.

Table 12

Result of 2x2 ANOVA of Attitude toward Physics by Gender and Nationality of Higher Secondary Students in India and USA

Source of Variance	Sum of Squares	df	Mean Square	F	ηp^2
Intercept	215860.18	1	215860.18	14966.19	-----
Nationality	567.24	1	567.24	39.33**	0.03
Gender	384.67	1	384.67	26.67**	0.03
Nationality x Gender	259.18	1	259.18	17.97**	0.01
Error	19673.22	1364	14.42		
Total	361844.00	1368			

**$p<.01$

Table 12 reveals that the main effects and the interaction effect are significant. Main effects of Nationality [F (1, 1364) =39.33, $p<.01$] and Gender [F (1, 1364) =26.67, $p<.01$] on Attitude toward Physics of Higher Secondary Schools

Students in Kerala (India) and South Carolina (USA) were found significant. The main effects of Nationality and Gender are shown in Figure 12.

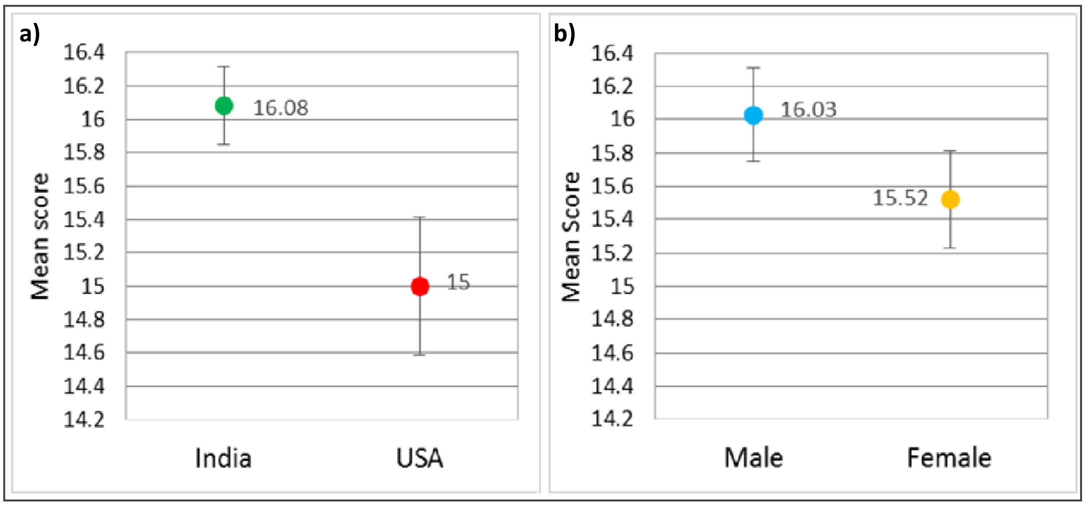

Figure 12. Mean plots (with 95% confidence interval error bars) of Attitude towards Physics by a) Nationality and b) Gender of higher secondary students.

Ogives are further plotted to show an over-all comparison, over the entire range of distribution of Attitude toward Physics by Nationality and Gender. The graphical representations of cumulative percent of the frequencies are provided in Figure 13.

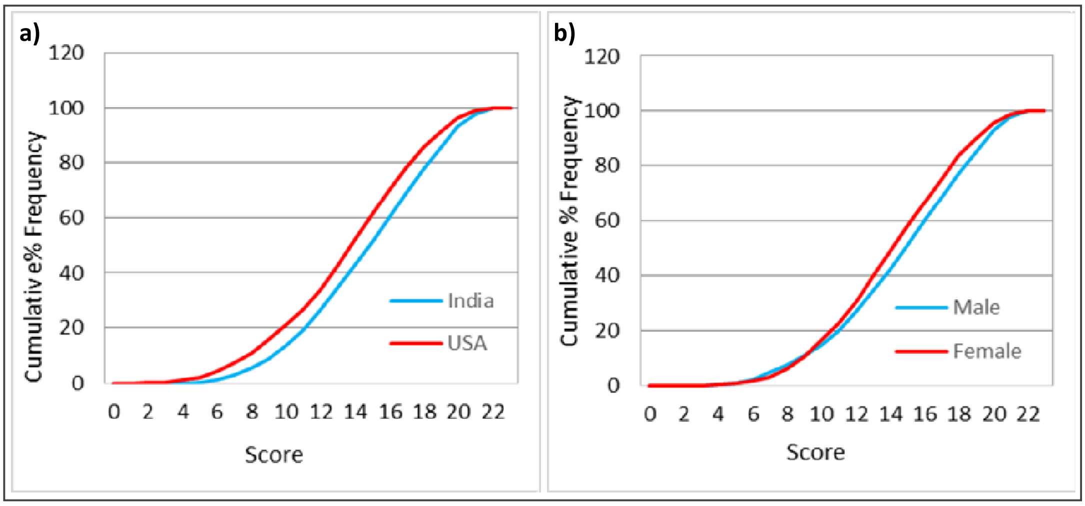

Figure 13. Ogives of distribution of scores on Attitude toward Physics a) by Nationality and b) by Gender of higher secondary students.

Figures 12 and 13 demonstrate that the difference by Gender and Nationality in Attitude towards Physics is over the entire range of the distribution and that the difference in Attitude toward Physics is more evident nation wise than Gender wise. Higher secondary students in India exhibit higher Attitude toward Physics distinctively compared to the students in USA, for students of lower as well as higher Attitudes toward Physics. However, advantage of male students over female higher secondary students in Attitude toward Physics is pronounced among students with higher attitude, than those with lower Attitude toward Physics. In other words, male and female students who show lower Attitude toward Physics, students in the lower quartile, possess similar extent of Attitudes toward Physics.

Table 12, further reveals a significant interaction effect of Gender and Nationality [F (1, 1364) =17.97, *p*<.01], on Attitude toward Physics. The descriptive statistics and the t-test statistics are shown in Table 13.

Table 13

Comparison of Means of Attitude toward Physics of Higher Secondary Students in India and USA by Gender

Gender	Nationality	N	Mean	SD	t
Male	India	500	16.20	4.07	1.66
	USA	253	15.69	3.73	
Female	India	509	15.97	3.47	6.86**
	USA	108	13.34	4.12	

***p*<.01

The comparison of means using t-test in Table 13 shows that there is no significant difference between the Attitude toward Physics of the male students in India (M=16.20, SD=4.07) and USA (M=15.69, SD=3.73, t=1.66; *p*>.05). However, the Attitude toward Physics is found significantly higher among the female students in India (M=15.97, SD=3.47) compared to their counterparts in USA (M=13.34, SD=4.12, t=6.86; $p<.01$). The interaction effect of Nationality and Gender on Attitude toward Physics is depicted in Figure 14.

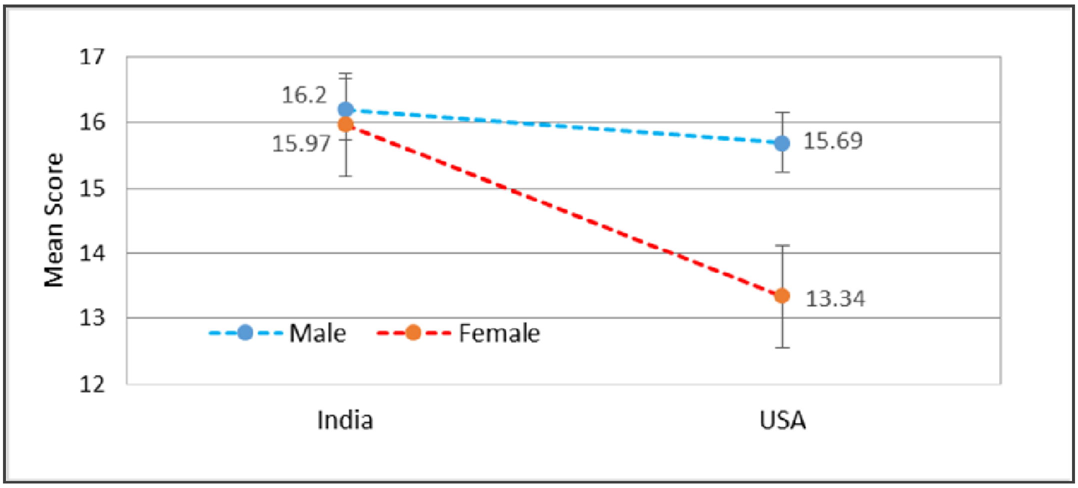

Figure 14. Mean plots (with 95% confidence interval error bars) showing the interaction effect of Gender and Nationality on attitude toward Physics among the higher secondary students

Figure 14 shows that Gender wise difference on Attitude toward Physics is significant in USA but not in India. The female students are the determining group for Nationality wise difference in Attitude toward Physics. Female students, especially those in US with comparatively low Attitude toward Physics, determine the cross-national difference in overall attitude toward Physics.

Extent of Student-centeredness and Teacher-centeredness and their Integration in Classroom Practices of Higher Secondary Physics Teachers

Classroom practices adopted by Physics teachers in Kerala (India) and South Carolina (USA) were investigated in the second phase of this study using a 32-item inventory on Physics classroom practices. The major objective in this phase was to examine the extent of Student-centeredness and Teacher-centeredness in the classroom practices of these teachers. The data was statistically analyzed by comparing means. The descriptive statistics and the t-test statistic are shown in Table 14.

Table 14

Comparison of Means of Student-centeredness and Teacher-centeredness of Higher Secondary School Physics Teachers

Variable	Sample	N	Mean	SD	t
Student-centered Instruction	India	55	53.13	7.25	3.29**
	USA	51	57.76	7.27	
Teacher-centered Instruction	India	55	55.93	7.48	0.12
	USA	51	56.14	10.33	

**$p<.01$

As seen in Table 14, there is no significant difference between extent of using Teacher-centered Instruction by teachers in Kerala (India) (M=55.93, SD=7.48) and South Carolina (USA) (M=56.14, SD=10.33, t=0.12, $p>.05$). However, the use of Student-centered Instruction in teaching Physics is significantly higher for teachers in USA (M=57.76, SD=7.27) compared to the Indian teachers (M=53.13, SD=7.25, t=3.29, $p<.01$).

The distribution of cumulative percent frequencies of extents of student-centeredness and teacher-centeredness in classroom practices by Nationality are provided in Figure 15.

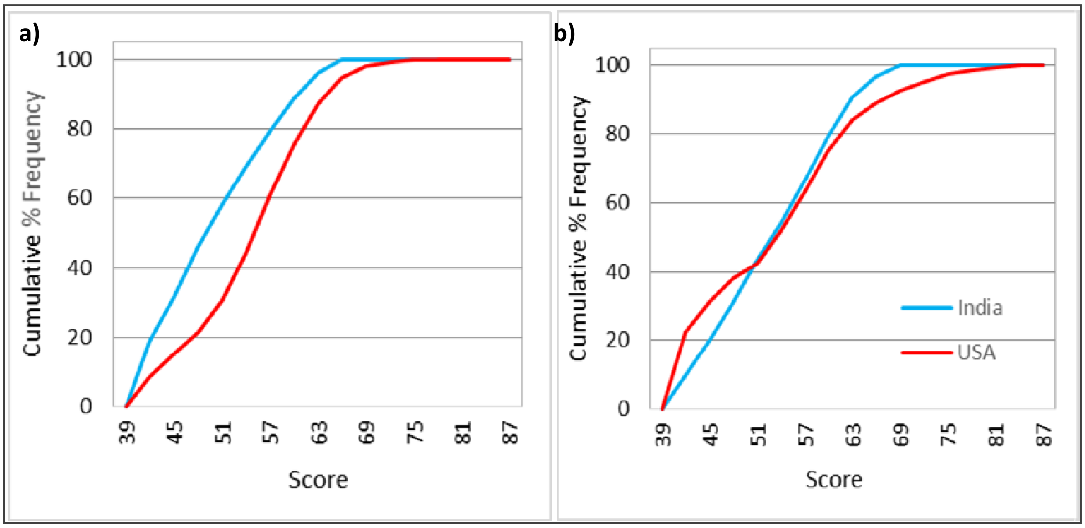

Figure 15. Ogives of distribution of scores on a) Student-Centered Instructional Strategies and b) Teacher-Centered Instructional Strategies by Nationality of higher secondary students

Though no significant difference was observed between the mean scores of teacher-centered instructional strategies of teachers of Kerala (India) and South Carolina (USA), it is worth noting in Figure 15 that the teachers in USA belong to the group having the lowest as well as the highest extent of teacher-centered instructional strategies in their classrooms. While the extent of teacher-centeredness in classroom practices does not significantly differ between higher secondary school Physics teachers in India and US, the extent of student-centered instructional strategies is significantly and consistently higher among teachers in USA than in India throughout the distribution.

Incidence of the Four Types of Integrated Instruction among Higher Secondary School Physics Teachers by Nationality

Teacher responses from the Physics Classroom Practices Inventory were further analyzed and four types of integration were identified based on a scheme developed with high and low levels, each on teacher-centered and student-centered classroom practices. How frequently each of the four types of integration was being adopted by teachers in India and USA was studied. Cross tabulation of frequency and the results of Chi-Square analysis of the four Type of Integrated Instruction by Nationality of Higher Secondary School Physics Teachers are provided in Table 15.

Table 15

Chi-square Test and Cross Tabulation of Frequency and Percentage of Type of Integrated Instruction by Nationality of Higher Secondary School Physics Teachers

Nationality	N (%) of Teachers by Type of Integrated Instruction				Row Total	Chi-square
	IT	SI	TI	FI		
India	18 (62)	8 (38)	18 (72)	11 (35)	55 (52)	10.20*
USA	11 (38)	13 (62)	7 (28)	20 (65)	51 (48)	
Total	29 (27)	21 (20)	25 (24)	31 (29)	106 (100)	

Note: Value in each cell are sample sizes and Percentages, Percentages are in Parentheses
a, N=55; b, N=51
**p*<.05

The Chi-square analysis confirmed that Type of Integrated Instruction differ by Nationality, [χ^2 (3, N = 106) = 10.20, p<.01]. Type of Integrated Instruction differ among teachers in Kerala (India) and South Carolina (USA). The frequency of classroom practices with respect to Type of Integrated Instruction is studied further to specifically figure out the frequency of incidence. Results of Chi-square analysis is given in Table 16.

Table 16

Chi-square Test and Cross Tabulation of Frequency of Incidence of the Four Types of Integrated Instruction by Nationality of Higher Secondary School Physics Teachers

Integrated Instruction		Teachers in Kerala (India)		Teachers in South Carolina (US)		Chi square
Type	Level	Frequency	%	Frequency	%	
Incompetent Teaching (IT)	Yes	18	17	11	10	1.66
	No	37	35	40	38	
Student-dominant Integration (SI)	Yes	8	8	13	12	2.00
	No	47	44	38	36	
Teacher-dominant integration (TI)	Yes	18	17	7	7	5.30*
	No	37	35	44	42	
Fair Integration (FI)	Yes	11	10	20	19	4.72*
	No	44	42	31	29	

a, N=55; b, N=51
*p<.05

As shown in Table 16, The Chi-square analysis confirmed that Indian teachers use more Teacher-dominant Integration (TI) [(χ^2 (1, N=106)= 5.30, p<.05], whereas those in USA use more Fair Integration (FI) [(χ^2 (1, N=106)= 4.72, p<.05]. There is no significant difference in using Incompetent Teaching (IT) and Student-dominant Integration (SI). Eventually, the effect of these types of integrated Instruction of the select teachers on Attitude toward Physics and Achievement in Physics of their students was investigated.

Effect of Integrated Instruction on Student Attitude toward Physics

The influence of Integrated Instruction on post-test scores of Attitude toward Physics after controlling for their levels of Previous Attitude toward Physics was studied in male and female students separately among higher secondary students in Kerala (India) and South Carolina (USA) through a planned sequence of factorial ANOVAs, approximately followed up by One Way ANOVAs.

As a preliminary step, the means and standard deviations of Attitude toward Physics of Male and Female students with high and low levels of Previous Attitude toward Physics by Nationality are provided in table 17.

Table 17

Mean and Standard Deviation of Attitude toward Physics of Male and Female students with high and low levels of Previous Attitude toward Physics by Nationality

Type of Integrated Instruction	Kerala (India)				South Carolina (USA)				Total
	Level of Previous Attitude				Level of Previous Attitude				
	Low		High		Low		High		
	Male	Female	Male	Female	Male	Female	Male	Female	
Incompetent Teaching (IT)	56.76 (12.43)	55.29 (14.88)	64.11 (13.71)	64.05 (15.49)	56.23 (10.43)	51.50 (12.26)	67.95 (15.31)	69.00 (6.50)	58.15 (14.28)
Student-Dominant Integration (SI)	56.10 (9.48)	61.40 (8.89)	66.97 (12.73)	70.44 (9.52)	51.84 (12.50)	52.77 (15.32)	71.57 (8.50)	67.50 (10.31)	62.15 (13.27)
Teacher- Dominant Integration (TI)	60.56 (15.15)	64.08 (10.54)	68.06 (12.27)	72.59 (8.92)	65.16 (12.10)	65.67 (9.37)	69.23 (11.97)	68.42 (10.22)	67.55 (11.75)
Fair Integration (FI)	65.30 (9.79)	63.28 (11.61)	68.45 (14.09)	70.00 (11.64)	58.74 (16.68)	57.88 (16.79)	70.06 (12.84)	66.58 (15.91)	65.97 (14.01)
Total	58.99 (12.38)	60.01 (12.76)	67.20 (13.03)	70.30 (11.03)	57.55 (13.82)	54.92 (14.61)	69.71 (12.27)	68.00 (10.97)	63.53 (13.83)

Note: Values in each cell are means and standard deviations; Standard deviations are in parentheses.

To test the effect of Type of Integrated Instruction on Attitude toward Physics, a one way ANOVA was performed in the total sample. Then, this effect was studied in various subsamples by previous levels of attitude, Gender and Nationality by exploring their 4-way interaction effect on Attitude toward Physics. This was followed by two separate 3-way Interaction effects of Type of Integrated Instruction, Previous Attitude toward Physics and Gender among the Indian and US students separately. Then four 2-way Interaction Effects of Type of Integrated Instruction and Gender on Attitude toward Physics was performed on subsamples by Nationality and Previous Attitude. This led to eight distinct one-way ANOVAs to figure out the effect of Type of Integrated Instruction on attitude toward Physics among male and female higher secondary students in India and USA who had low and high attitude previously.

The effect of Type of Integrated Instruction (IT, SI, TI, and FI) on Attitude toward Physics among total sample of students in Kerala (India) and South Carolina (USA) was verified using One-way ANOVA as shown in Table 18.

Table 18

ANOVA of Attitude toward Physics of Higher Secondary Students by Type of Integrated Instruction

Source	Sum of Squares	df	Mean Square	F	ηp^2
Intercept	3814824.22	1	3814824.22	21392.49	
Type of Integrated Instruction	12714.65	3	4238.21	23.76**	0.070
Error	168517.48	945	178.32		
Total	4011966.00	949			

$^{**}p<.01$

As shown in Table 18, significant effect of Type of Integrated Instruction [F (3, 945) =23.77, $p<.01$], with a medium size ($\eta p^2=0.07$), has been observed on Attitude toward Physics.

In order to verify the effect of the Type of Integrated Instruction on Attitude toward Physics, test of comparisons of difference between large independent samples was performed as a follow up. Means and standard deviations of Attitude toward Physics by Type of Integrated Instruction for the total sample along with a comparison of means using t-test are shown in Table 19.

Table 19

Comparison of Means of Attitude toward Physics by Type of Integrated Instruction in Higher Secondary Students

Type of Integrated Instruction	Descriptive Statistics			t values obtained for Comparison of Means against the group		
	Mean	S.D	N	SI	TI	FI
Incompetent Teaching (IT)	58.15	14.28	237	-3.10**	-7.92**	-6.05**
Student-Dominant Integration (SI)	62.15	13.27	222	-	-4.68**	-3.01**
Teacher- Dominant Integration (TI)	67.55	11.75	247	-	-	1.36
Fair Integration (FI)	65.97	14.01	243	-	-	-

**p<.01

Effect of IT (M=58.15, SD=14.28) is significantly lower compared to SI (M= 62.15, SD= 13.27, t=3.10, p<.01), TI (M= 67.55, SD= 11.75, t=7.92, p<.01), and FI (M= 65.97, SD=14.01, t=6.05, p<.01) on Attitude toward Physics of higher secondary students. Effect of SI also is significantly less than those of TI (t=4.68, p<.01) and FI (t=3.01, p<.01) on Attitude toward Physics. Table 19 further shows that there is no significant difference between the Attitude toward Physics of students receiving TI and FI (t= 1.36, p>.05); though they are significantly higher compared to the effects of SI and IT. Attitude toward Physics is higher for students receiving TI and FI compared to those receiving IT and SI. Figure 16 shows the graphical representation of this effect.

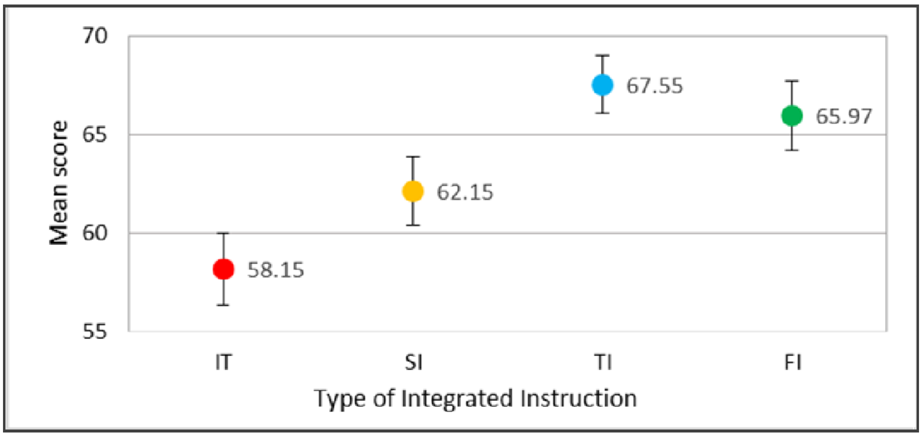

Figure 16. Mean plots with 95% confidence interval error bars of attitude towards Physics of higher secondary students by Type of Integrated Instruction

Four-Way Interaction Effect of Type of Integrated Instruction, Gender, Nationality, and Previous Attitude toward Physics on Student Attitude toward Physics

The interaction of Previous Attitude toward Physics (low and high), Gender (male and female), and Nationality (India and USA) with the effect of the Type of Integrated Instruction (IT, SI, TI, and FI) on Attitude toward Physics is verified using a 4x2x2x2 factorial ANOVA. The results are shown in Table 20.

Table 20

Summary of Four-way ANOVA of Attitude toward Physics by Type of Integrated Instruction, Previous Attitude toward Physics, Gender and Nationality of Higher Secondary Students

Source of Variance	Sum of Squares	df	Mean Square	F	ηp^2
Intercept	2971447.63	1	2971447.63	19396.89	------
Type of Integrated Instruction x Gender x Nationality x Previous Attitude	40755.14	31	1314.68	8.58**	0.23
Error	140477.00	917	153.19		
Total	4011966.00	949			

**$p<.01$

A significant interaction effect of Type of Integrated Instruction, Gender, Nationality, and Previous Attitude toward Physics on Student Attitude toward Physics, [F (31, 917) =8.58, $p<.01$] of large size ($\eta p^2= 0.23$) is observed. Figure 17 shows the graphical representation of the effect.

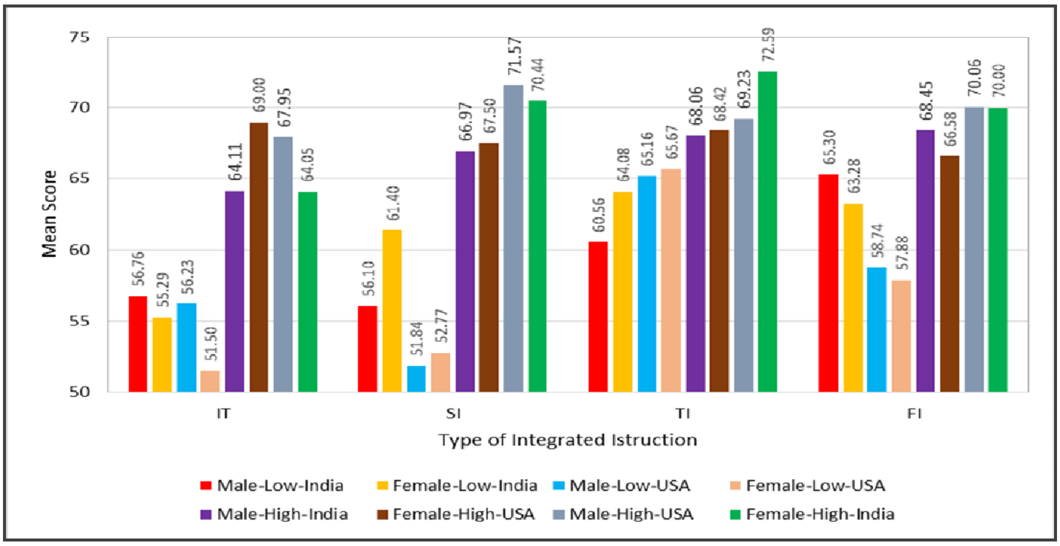

Figure 17. Bar graph showing mean score of attitude towards Physics in 32 groups among the higher secondary students based on Type of Integrated Instruction, Gender, Previous Attitude toward Physics and Nationality

Comparison of mean scores reveal that students with high Previous Attitude toward Physics disclose or maintain higher Attitude toward Physics. In other words, Type of integrated Instruction, Gender or Nationality did not affect their Attitude toward Physics to a large extent. More specifically, female students in India with high Previous Attitude toward Physics displayed the highest Attitude toward Physics with Teacher-dominant Integration (TI) and scored the least with Incompetent Teaching (IT).

Among students with high Previous Attitude toward Physics, both in India and USA, the Attitude toward Physics is high regardless of the Type of Integrated Instruction. The interaction effect of Gender and Nationality on the Type of Integrated Instruction is more evident among students with previously low attitude in India and USA. More specifically, students receiving Teacher-dominant Integration and Fair Integration improved their Attitude toward Physics significantly.

It is worth mentioning that the Attitude toward Physics of students with low Previous Attitude toward Physics improved with Teacher-dominant Integration (TI) and Fair Integration (FI) regardless of Gender and Nationality.

Main and interaction effects of Type of Integrated Instruction with moderator variables, namely, Gender, Nationality, and Previous Attitude toward Physics on students' Attitude toward Physics have been investigated. Different combinations of the variables interact one another to create the effect. In order to confirm the progression of the interaction effect, the analysis has been further conducted by investigating the effect of the independent variable by successively withdrawing the moderator variables as a factor from the model. Then the interaction effects of the remaining variables were investigated in appropriate subsamples till the main effect of Type of Integrated Instruction on Attitude toward Physics is reached.

Three-way Interaction Effects of Type of Integrated Instruction, Previous Attitude toward Physics and Gender on Attitude toward Physics among the Indian and US students

Two separate factorial (Three-way) ANOVAs were performed for confirming the effect of Type of integrated Instruction, Previous Attitude toward Physics and Gender with a 4x2x2 design, on Indian and US samples. The results are shown in Table 21.

Table 21

Summary of Three-way ANOVA of Attitude toward Physics by Type of Integrated Instruction, Previous Attitude toward Physics and Gender among Higher Secondary Students in India and USA

	Source of Variance	Sum of Squares	df	Mean Square	F	ηp^2
India	Intercept	2063923.99	1	2063923.99	14402.16	-----
	Type of Integrated Instruction x Gender x Previous Attitude	18836.25	15	1255.75	8.76**	0.19
	Error	80251.67	560	143.31		
	Total	2496295.00	576			
USA	Intercept	1151997.85	1	1151997.85	6828.74	-----
	Type of Integrated Instruction x Gender x Previous Attitude	20517.45	15	1367.83	8.11**	0.25
	Error	60225.33	357	168.70		
	Total	1515671.00	373			

$^{**}p<.01$

Significant interaction effects of Type of Integrated Instruction, Previous Attitude toward Physics and Gender on Attitude toward Physics of higher secondary students is observed both in India [$F\ (15, 560) = 8.76, p<.01$] and in USA [$F\ (15, 357) = 8.11, p<.01$]. The size of combined effect of the three moderator variables on Attitude toward Physics is large in India ($\eta p^2 = 0.19$) as well as USA ($\eta p^2 = 0.25$). Figure 18 shows the graphical representation of this effect.

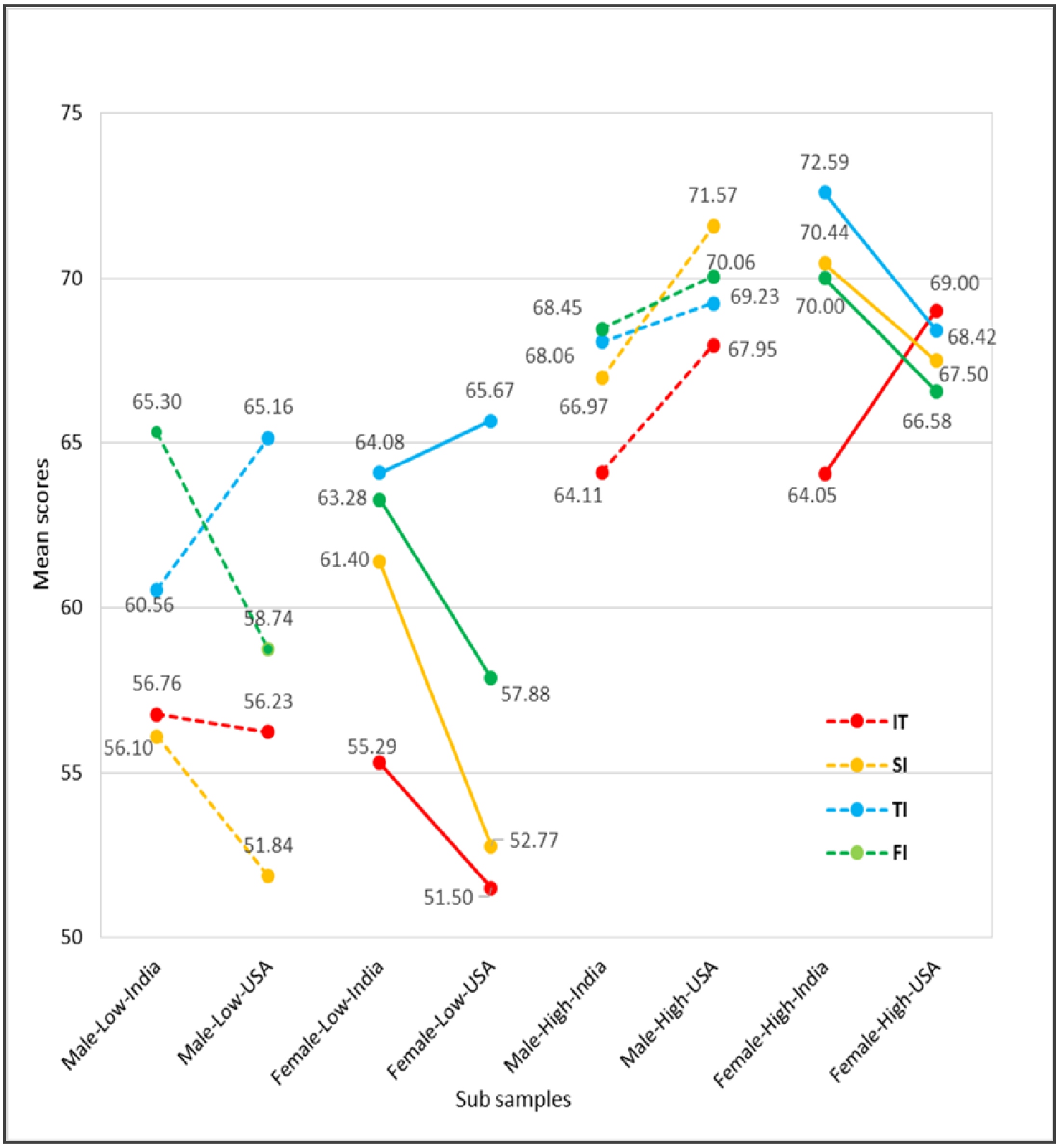

Figure 18. The interaction effect of Type of Integrated Instruction, Previous Attitude and Gender on attitude toward Physics among the higher secondary students in India and USA

Figure 18 shows that among male students with low Previous Attitude toward Physics, unlike other groups, Attitude toward Physics is the lowest after student dominant instruction. Among male students with low Previous Attitude toward Physics, Indian students have the highest Attitude toward Physics after Fair Integration while US students have the highest Attitude toward Physics after Teacher-dominant Integration.

Figure 18 further shows that among female students with low Previous Attitude toward Physics, Attitude toward Physics is the highest after Student-dominant Integration. Among female students with low Previous Attitude toward Physics, US students have the least and nearly equal Attitude toward Physics after Incompetent Teaching and Student-dominant Integration. Among female students with low Previous Attitude toward Physics, Indian students have nearly comparable levels of Attitude toward Physics after Student-dominant Integration, Teacher-dominant Integration and Fair integration.

Figure 18 additionally shows that among male students with high Previous Attitude toward Physics, there is no effect of Teacher-dominant Integration or Fair integration above and over Student-dominant Integration though these are better than incompetent teaching. Likewise among female high achievers in India, these three Types of Integrated Instruction though are not different one another in impacting Attitude toward Physics. They are better than Incompetent Teaching. Only group where the four types of integration makes no difference in Attitude toward Physics seems to be female students in USA with high Previous Attitude toward Physics.

As the next step, the effect of the Type of Integrated Instruction and Gender were analyzed using Two-way ANOVAs among students in Kerala (India) and South Carolina (USA) with low and high Previous Attitude toward Physics separately.

Two-way Interaction Effects of Type of Integrated Instruction and Gender on Attitude toward Physics of Students in India and USA with Low and High Previous Attitude

Four separate Two-way ANOVAs were performed for confirming the effect of Type of Integrated Instruction and Gender on Attitude toward Physics among Indian and US higher secondary students with low and high Previous Attitude towards Physics. The results are shown in Table 22.

Table 22

Summary of Two-way ANOVAs of Attitude toward Physics by Type of Integrated Instruction and Gender among Higher Secondary Students by Nationality and Previous Attitude toward Physics

Subsample by Nationality and Previous Attitude		Source of Variance	Sum of Squares	df	Mean Square	F	ηp^2
India	Low	Intercept	920899.01	1	920899.01	6189.54	-----
		Type of Integrated Instruction x Gender	3775.00	7	539.29	3.62**	0.09
		Error	40320.24	271	148.78		
		Total	1034981.00	279			
	High	Intercept	1148163.401	1	1148163.40	8309.725	------
		Type of Integrated Instruction x Gender	1978.45	7	282.64	2.05*	0.047
		Error	39931.43	289	138.17		
		Total	1461314.00	297			
USA	Low	Intercept	606234.649	1	606234.65	3230.02	------
		Type of Integrated Instruction x Gender	4567.275	7	652.47	3.48**	0.11
		Error	36974.413	197	187.69		
		Total	688123.000	205			
	High	Intercept	563991.28	1	563991.28	3881.077	------
		Type of Integrated Instruction x Gender	303.73	7	43.39	0.30	------
		Error	23250.92	160	145.32		
		Total	827548.00	168			

*$p<.05$;**$p<.01$

For students with low Previous Attitude toward Physics, interaction effects of the Type of Integrated Instruction and Gender are significant in India [F (7, 271) = 3.62, $p<.01$] and USA [F (7,197) = 3.48, $p<.01$]. Likewise, for students with previously high Previous Attitude toward Physics, interaction effects of the Type of Integrated Instruction and Gender are significant in India [F (7, 289) = 2.05, $p<.05$], but not found significant in USA [F (7, 160) = 0.30, $p>.05$]. The interaction effects of Type of Integrated Instruction and Gender on Attitude toward Physics was found significant irrespective of the level of Previous Attitude toward Physics among higher secondary students in India. Among the US students, the interaction is significant only for the students who had low Previous Attitude toward Physics. The size of interaction effect is medium in students with low Previous Attitude toward Physics both in India (ηp^2=0.086) and USA (ηp^2=0.110), and the effect size for those with high Previous Attitude toward Physics in India is medium (ηp^2=0.047). Figure 19 shows the graphical representation of these effects.

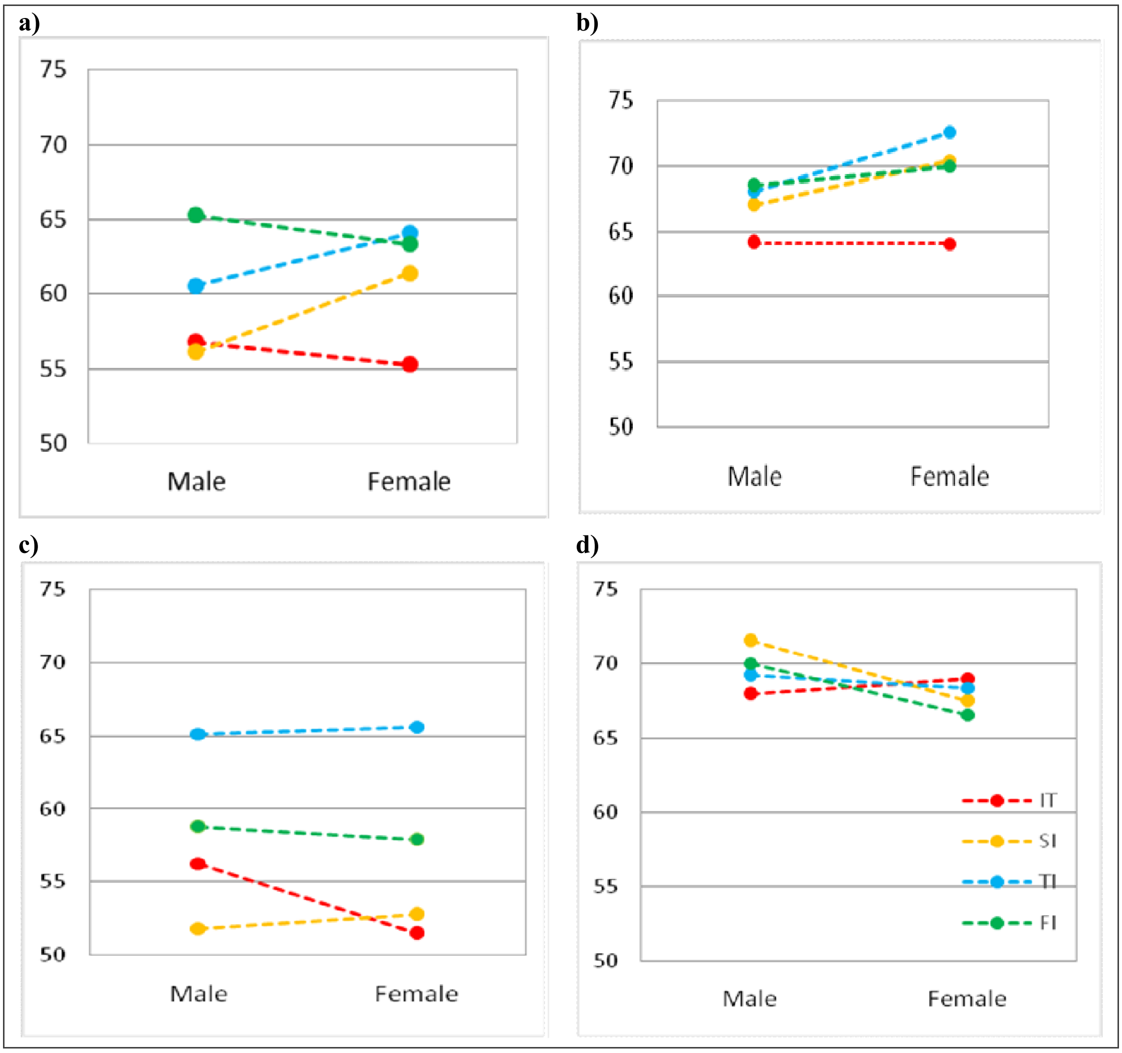

Figure 19. The interaction effect of the Type of Integrated Instruction and Gender on attitude toward Physics among the (a) Indian students with previously low attitude; (b) Indian students with previously high attitude; (c) US students with previously low attitude; (d) US students with previously high attitude

The factorial (Two-way) ANOVA findings reinforced the significance of the interaction effect of the Type of Integrated Instruction and Gender on the Attitude toward Physics of the higher secondary school students in Kerala (India) and South Carolina (USA). As revealed by Figure 19, there is significant difference in the Attitude toward Physics of students in Kerala (India) and South Carolina (USA) with low Previous Attitude toward Physics. Also, it is evident that the students with teacher-dominant instructional strategies (TI and FI) reveal higher attitude than those with less teacher involvement (IT and SI).

In order to confirm the main effect of the Type of Integrated Instruction on Attitude toward Physics among male and female students with low and high Previous Attitude toward Physics in Kerala (India) and South Carolina (USA), One-way ANOVAs were performed separately.

Effect of Integrated Instruction on Attitude toward Physics in Subsamples

Eight distinct one-way ANOVAs were performed to figure out the effect of Type of Integrated Instruction on attitude toward Physics among male and female higher secondary students in India and USA who had low and high attitude previously. The results are shown in Table 23.

Table 23

Summary of One-way ANOVAs of Attitude toward Physics by Type of Integrated Instruction in sub-samples by Nationality Gender and Levels of Previous Attitude toward Physics

Sub sample by Nationality, Gender and Previous Attitude toward Physics			Source of Variance	Sum of Squares	df	Mean Square	F	ηp^2
India	Male	Low	Intercept	385484.12	1	385484.120	2647.16	------
			Type of Integrated Instruction	1292.57	3	430.855	2.96*	0.07
			Error	16018.43	110	145.622		
			Total	414027.00	114			
		High	Intercept	477771.30	1	477771.297	2773.59	------
			Type of Integrated Instruction	253.87	3	84.623	0.49	------
			Error	18603.81	108	172.258		
			Total	524578.00	112			
	Female	Low	Intercept	565888.29	1	565888.291	3749.02	------
			Type of Integrated Instruction	2412.16	3	804.054	5.33**	0.09
			Error	24301.81	161	150.943		
			Total	620954.00	165			
		High	Intercept	707504.53	1	707504.534	6004.34	------
			Type of Integrated Instruction	1051.43	3	350.476	2.97*	0.05
			Error	21327.62	181	117.832		
			Total	936736.00	185			
USA	Male	Low	Intercept	320048.51	1	320048.506	1821.16	------
			Type of Integrated Instruction	1998.35	3	666.118	3.79*	0.11
			Error	16343.69	93	175.739		
			Total	339566.00	97			
		High	Intercept	535039.46	1	535039.456	3493.18	------
			Type of Integrated Instruction	159.37	3	53.122	0.35	-----
			Error	17154.67	112	153.167		
			Total	580964.00	116			
	Female	Low	Intercept	287402.09	1	287402.085	1448.80	------
			Type of Integrated Instruction	2215.52	3	738.508	3.72*	0.10
			Error	20630.72	104	198.372		
			Total	348557.00	108			
		High	Intercept	188201.49	1	188201.489	1481.84	------
			Type of Integrated Instruction	39.75	3	13.250	0.10	------
			Error	6096.25	48	127.005		
			Total	246584.00	52			

*p<.05;**p<.01

Findings in Table 23 are interpreted under eight sections for the Indian and US male and female subsamples with low and high Previous Attitude toward Physics. The t-test of comparison of means for independent samples is carried out as the follow up.

Effect of Type of Integrated Instruction on Attitude toward Physics of Male and Female Students in India with Low Previous Attitude toward Physics

Among students in India with low Previous Attitude, the effect of the Type of Integrated Instruction on Attitude toward Physics is significant both in males [F (3, 110) = 2.96, p<.05, (ηp^2=0.07)] and females [F (3, 161) = 5.33, p<.01, (ηp^2=0.09)] with medium size. The comparison of the means of Attitude towards Physics of four groups based on Type of Integrated Instruction, among male and female students in India with previously low attitude, are provided in Table 24.

Table 24

Comparison of Means of Attitude toward Physics by Type of Integrated Instruction for Male and Female Students in India with Previously Low Attitude toward Physics

Gender	Types of Integration	Descriptive Statistics			t values obtained for Comparison of Means against the group		
		Mean	SD	N	SI	TI	FI
Male	Incompetent Teaching (IT)	56.76	12.43	38	0.24	-1.11	-2.66**
	Student-Dominant Integration (SI)	56.10	9.48	29	-	-1.33	-3.29**
	Teacher- Dominant Integration (TI)	60.56	15.15	27	-	-	-1.22
	Fair Integration (FI)	65.30	9.79	20	-	-	-
Female	Incompetent Teaching (IT)	55.29	14.88	63	-2.22*	-3.19**	-2.55*
	Student-Dominant Integration (SI)	61.40	8.89	35	-	-1.17	-0.73
	Teacher- Dominant Integration (TI)	64.08	10.54	38	-	-	0.30
	Fair Integration (FI)	63.28	11.61	29	-	-	-

*p<.05;**p<.01

As shown in Table 24, among male students in India with low Previous Attitude toward Physics, those with FI (M=65.30, SD=9.79) achieved significantly higher than those with IT (M=56.76, SD=12.43, t= 2.66, p<.01) and SI (M=56.10, SD=9.48, t=3.29, p<.01). Effects of TI (M=60.56, SD=15.15) and FI on students' Attitude toward Physics did not show any significant difference for this group (t=1.22, p>.05). In other words, male students in India who possessed low Previous Attitude toward Physics showed improved Attitude toward Physics after instruction with more teacher involvement namely, TI and FI than after instruction with minimum teacher-centered strategies, IT and SI. Mean plots and the cumulative frequency distribution shown in Figure 20 clearly shows that higher attitude towards Physics after FI, compared to IT and SI, is throughout the distribution, and not limited to the mean scores of the groups.

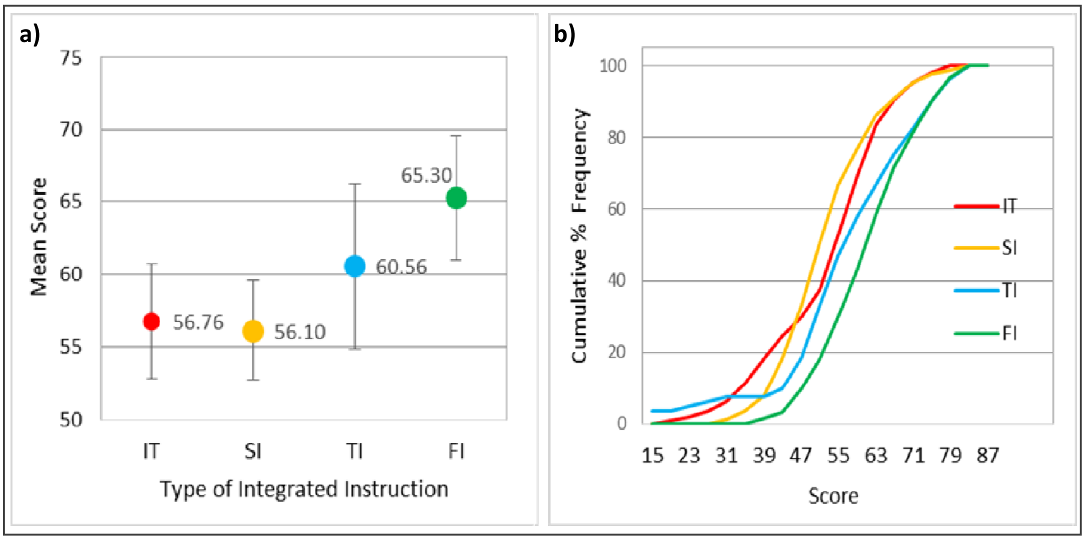

Figure 20. Attitudes towards Physics of Male Students in India with Previously Low Attitude toward Physics presented as (a) Mean plots with 95% confidence interval error bars by Type of Integrated Instruction (b) cumulative frequency distribution by Type of Integrated Instruction

Table 24 further shows that among the female students in India with low Previous Attitude toward Physics, those with IT (M=55.29, SD=14.88) achieved significantly lower than SI (M=61.40, SD= 8.89, t= 2.22, p<.05), TI (M=64.08, SD=10.54, t=3.19, $p<.01$), and FI (M=63.28, SD=11.61, t=2.55, $p<.05$). None of the comparisons among SI, TI and FI revealed significant difference in the Attitude toward Physics. Unlike male students in India with low attitude previously, integration of any type makes a positive impact on female students with low attitude previously. Mean plots and the cumulative frequency distribution in Figure 21 clearly shows that higher Attitude toward Physics after FI, IT and SI, in comparison to that after TI is throughout the distribution, and not limited to the mean scores of the groups. This difference is even more pronounced for students at the lowest quartile of the distribution.

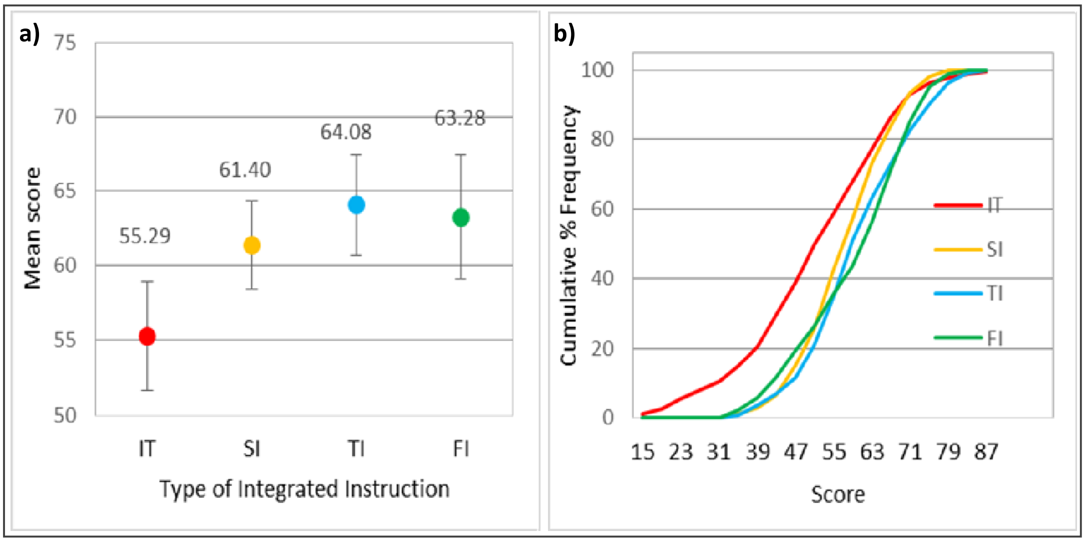

Figure 21. Attitudes towards Physics of female students in India with previously low attitude toward Physics presented as (a) mean plots with 95% confidence interval error bars by Type of Integrated Instruction (b) cumulative frequency distribution by Type of integrated Instruction

Effect of Type of Integrated Instruction on attitude toward Physics of Male and Female Students in USA with Low Previous Attitude toward Physics

As shown in Table 23, among higher secondary students in USA with low Previous Attitude toward Physics, the effect of Type of Integrated Instruction on Attitude toward Physics is significant both in males [$F(3, 93) = 3.79$, $p<.05$; $\eta p^2=0.11$] and females [$F(3, 104) = 3.72$, $p<.05$; $\eta p^2=0.10$] with medium size.

Comparisons of means of Attitude toward Physics by Type of Integrated Instruction for Male and Female Students in USA with low Previous Attitude toward Physics using t-test are shown in Table 25.

Table 25

Comparison of Means of Attitude toward Physics by Type of Integrated Instruction for Male and Female Students in USA with Previously Low Attitude toward Physics

Gender	Types of Integration	Descriptive Statistics			t values obtained for Comparison of Means against the group		
		Mean	SD	N	SI	TI	FI
Male	Incompetent Teaching (IT)	56.23	10.43	26	1.36	-2.65**	-0.65
	Student-Dominant Integration (SI)	51.84	12.50	25	-	-3.55**	-1.68
	Teacher- Dominant Integration (TI)	65.16	12.10	19	-	-	1.43
	Fair Integration (FI)	58.74	16.68	27	-	-	-
Female	Incompetent Teaching (IT)	51.50	12.26	40	-0.39	-3.69**	-1.77
	Student-Dominant Integration (SI)	52.77	15.32	31	-	-2.71**	-1.19
	Teacher- Dominant Integration (TI)	65.67	9.37	12	-	-	1.49
	Fair Integration (FI)	57.88	16.79	25			

**p<.01

Comparison of means using t-test shows that male as well as female students in USA with low Previous Attitude toward Physics revealed significantly higher Attitude toward Physics with TI. Attitude toward Physics with TI (M=65.16, SD=12.10) is significantly higher than that with IT (M=56.23, SD=10.43, t=2.65, p<.01) and SI (M=51.84, SD=12.50, t=3.55, p<.01) for US male students with low Previous Attitude toward Physics. US males with low Previous Attitude toward Physics after FI Type of Integrated Instruction (M=58.74, SD=16.68), in comparison with TI, had no significant difference in Attitude toward Physics (t=1.43, p>.05). Mean plots and the cumulative frequency distribution shown in Figure 22 demonstrate that higher Attitude toward Physics in students who received TI, in comparison with those who received IT or SI is in all the quartiles of the distribution, and not limited to the mean scores of the groups. As shown in Figure 22b, Attitude toward Physics is the least for those who received SI among US higher secondary male students with low Previous Attitude toward Physics.

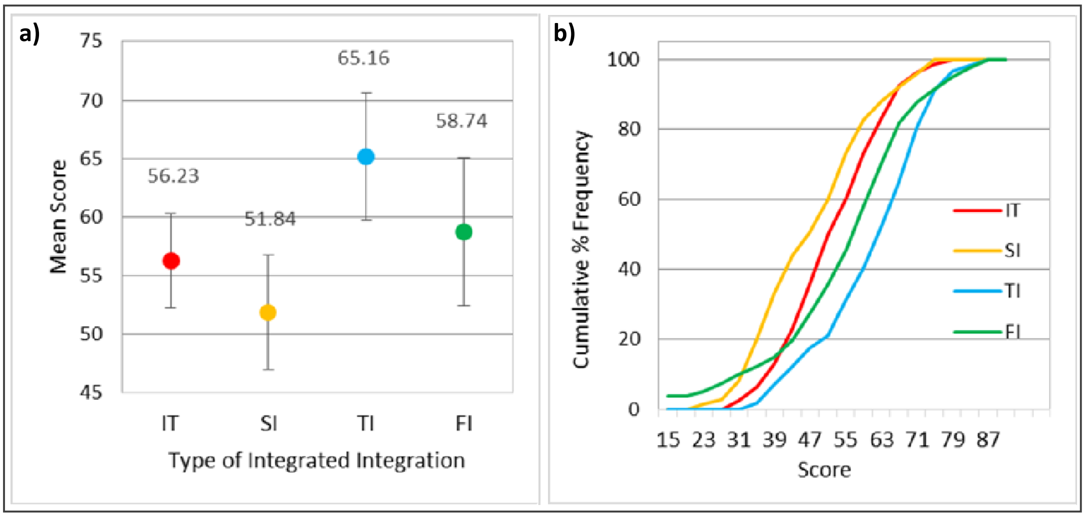

Figure 22. (a) Mean plots with 95% confidence interval error bars of attitude towards Physics in four groups by Type of Integrated Instruction (b) The cumulative frequency distribution of attitude toward Physics in four groups by Type of Integrated Instruction among the male students in USA with previously low attitude

Table 25 further shows that, among females in USA with low Previous Attitude toward Physics, Attitude toward Physics after TI (M=65.67, SD=9.37) was significantly higher than that after IT (M=51.50, SD=12.26, t= 3.69, $p<.01$) and SI (M=52.77, SD=15.32, t= 2.71, $p<.01$). US females received FI (M=57.88, SD=16.79), in comparison to TI, had no significant difference in Attitude toward Physics (t=1.49, $p>.05$).

Students who had previously low attitude in USA regardless of their Gender, showed improved attitude with instructional strategies with more teacher-centeredness. This finding is similar to that of the male students in India who had low Previous Attitude toward Physics. Mean plots and the cumulative frequency distribution shown in Figure 23 demonstrate that higher Attitude toward Physics in female students in USA with low Previous Attitude toward Physics who received TI, in comparison to those who received IT or SI is in all the quartiles of the distribution, and not limited to the mean scores of the groups. Figure 23b, for US higher secondary female students with low Previous Attitude toward Physics, effect of FI is almost same as that of TI, especially in the upper half of the distribution.

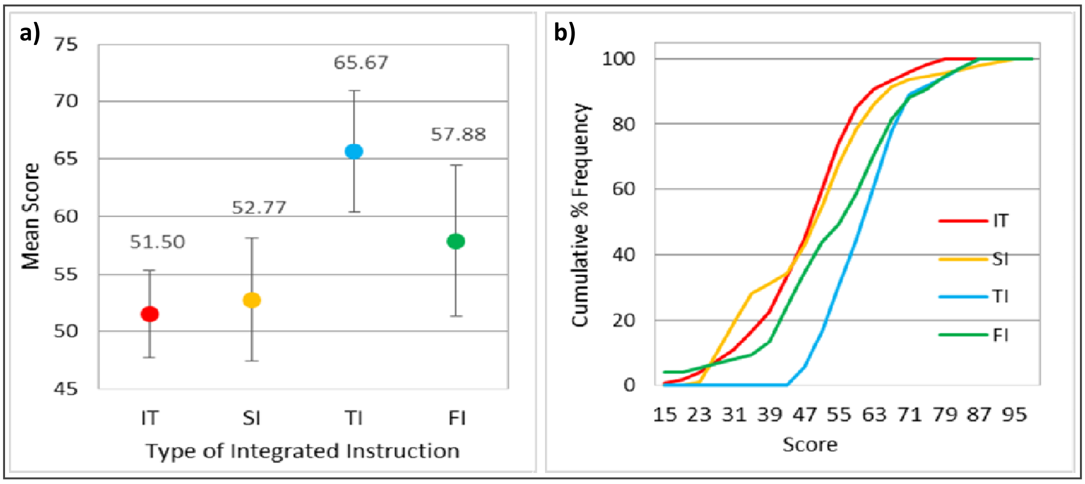

Figure 23. (a) Mean plots with 95% confidence interval error bars of attitude towards Physics in four groups by Type of Integrated Instruction (b) The cumulative frequency distribution of attitude toward Physics in four groups by Type of Integrated Instruction among the female students in USA with previously low attitude

Effect of Type of Integrated Instruction on attitude towards Physics of Male and Female Students in India with Previously High Attitude toward Physics

As shown in Table 23, among students in India with previously high attitude towards Physics, the effect of the Type of Integrated Instruction on attitude toward Physics is significant in females [F (3, 181) = 2.97, $p<.05$] (medium effect size; $\eta p^2=.05$), whereas it is not significant in males [F (3, 108) = .49, p>.05]. Comparisons of means of Attitude toward Physics by Type of Integrated Instruction for the female students in India with Previously High Attitude toward Physics using t-test are shown in Table 26.

Table 26

Comparison of Means of Attitude toward Physics by Type of Integrated Instruction for the Female Students in India with Previously High Attitude toward Physics

Types of Integration	Descriptive Statistics			t values obtained for Comparison of Means against the group		
	Mean	SD	N	SI	TI	FI
Incompetent Teaching (IT)	64.05	15.49	19	-1.99*	-2.97**	-1.81
Student-Dominant Integration (SI)	70.44	9.52	43	-	-1.16	0.21
Teacher- Dominant Integration (TI)	72.59	8.92	58	-	-	1.37
Fair Integration (FI)	70.00	11.64	65	-	-	-

*$p<.05$;**$p<.01$

Table 26 shows that Indian female students with high Previous Attitude toward Physics revealed significantly low Attitude toward Physics after IT (M=64.05, SD=15.49) in comparison with that of SI (M=70.44, SD=9.52, t= 1.99, $p<.05$) and TI (M=72.59, SD=8.92, t=2.97, $p<.01$). There is no significant difference in Attitude toward Physics for FI (M=70.00, SD=11.64) in comparison with TI (t=1.37, $p>.05$) and SI (t=0.21, $p>.05$), which is confirmed by the frequency distribution in Figure 24 as well. Therefore, it is obvious that the Indian female students with high Previous Attitude toward Physics, show high Attitude toward Physics irrespective of the Type of Integrated Instruction. Mean plots and the cumulative frequency distribution are shown in Figure 24. Figure 24b clearly shows that higher Attitude toward Physics among Indian female students with high Previous Attitude toward Physics in TI, SI and FI groups, in comparison with that in IT group, is noticeable especially in second and third quartiles of the distribution.

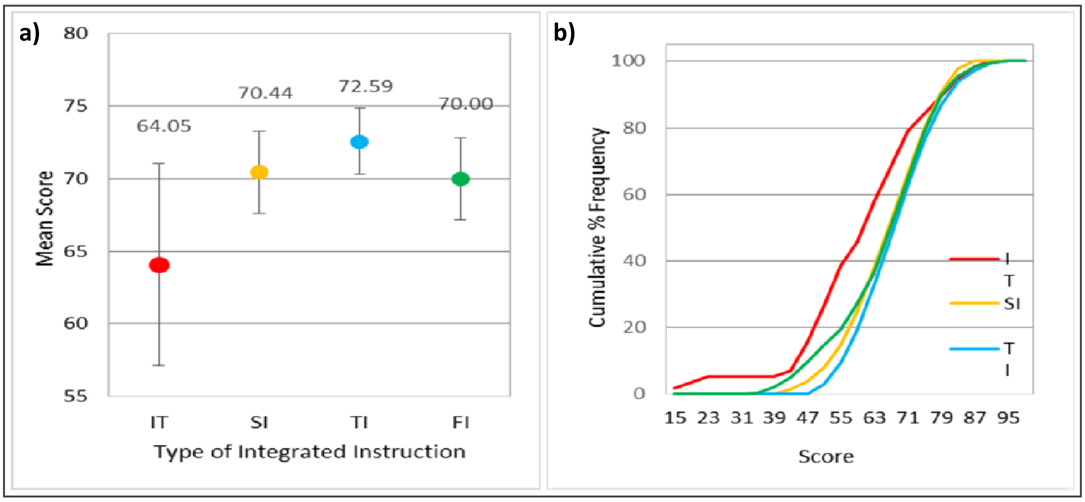

Figure 24. (a) Mean plots with 95% confidence interval error bars of attitude towards Physics in four groups by Type of Integrated Instruction (b) The cumulative frequency distribution of attitude toward Physics in four groups by Type of Integrated Instruction among the female students in India with previously high attitude

Figure 25 shows that though the ANOVA results do not show a significant interaction effect of Type of Integrated Instruction on Attitude toward Physics among the Indian male students with high Previous Attitude toward Physics, the mean plots and the cumulative frequency distribution show that there is a positive impact of integration over Incompetent Teaching on the Attitude toward Physics. This finding reveals that integration impacts positively on the Attitude toward Physics of the Indian male students with high Previous Attitude toward Physics. Mean plots and the cumulative frequency distribution are shown in Figure 25.

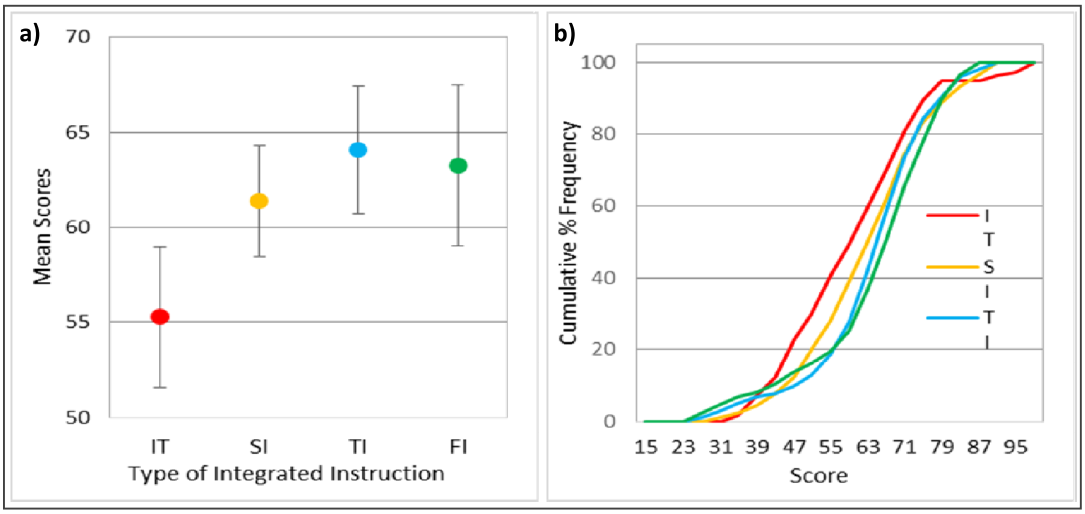

Figure 25. (a) Mean plots with 95% confidence interval error bars of attitude towards Physics in four groups by Type of Integrated Instruction (b) The cumulative frequency distribution of attitude toward Physics in four groups by Type of Integrated Instruction among the male students in India with previously high attitude

Effect of Type of Integrated Instruction on Attitude toward Physics for male and female students in USA with previously high attitude

As shown in Table 23, among students in USA with high Previous Attitude toward Physics, the effect of Type of Integrated Instruction on Attitude toward Physics is neither significant in males [F (3, 112) = .35, p>.05], nor in females [F (3, 48)=.10, p>.05]. There is no significant difference in the Attitude toward Physics by type of integrated Instruction among the male students in USA having high Previous Attitude toward Physics. Mean scores show no statistical difference with IT (M=67.95, SD=15.31), SI (M=71.57, SD=8.50), TI (M=69.23, SD=11.97), and FI (M=70.06, SD=12.84).

However figure 26 shows that there is a positive impact of Student-dominant Integration on the Attitude toward Physics among the students in the lower spectrum of the distribution but no obvious difference in the upper part. This finding reinstates that the Type of Integrated Instruction does not significantly affect the Attitude toward Physics of the US male students with high Previous Attitude toward Physics. Mean plots and the cumulative frequency distribution are shown in Figure 26.

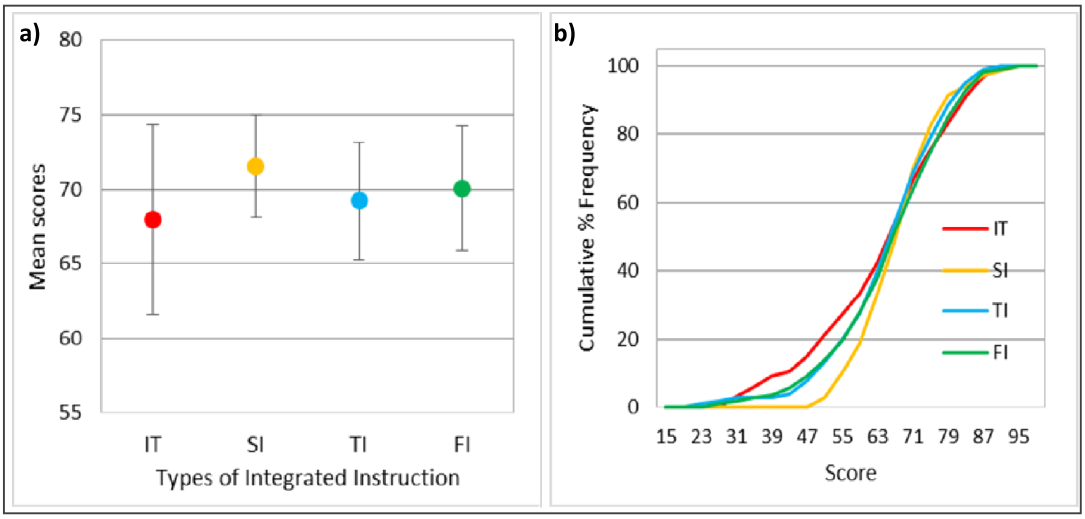

Figure 26. (a) Mean plots with 95% confidence interval error bars of attitude towards Physics in four groups by Type of Integrated Instruction (b) The cumulative frequency distribution of attitude toward Physics in four groups by Type of Integrated Instruction among the male students in USA with previously high attitude

As in the case of their male counterparts, there is no significant difference on the effect of different types of integration on Attitude toward Physics among the female students in USA having high Previous Attitude toward Physics. Mean scores do not show significant difference for IT (M=69.00, SD=6.50), SI (M=67.50, SD=10.31), TI (M=68.42, SD=10.22), and FI (M=66.58, SD=15.91).

These findings are very similar for male students with high Previous Attitude toward Physics in India and USA. It is worth mentioning that these three groups had high Attitude toward Physics prior to having instruction with different types of integration, and there is no drop in their attitudes due to any Type of Integrated Instruction. In other words, the way of instruction does not particularly affect students' Attitudes toward Physics if they have high Previous Attitude toward Physics already.

Figure 27 shows that there is a positive impact of Incompetent Teaching on the Attitude toward Physics among the students in the lower spectrum of the distribution but it disappears in the upper part. This finding reinstates that the Type of Integrated Instruction does not significantly affect the Attitude toward Physics of the US female students with high Previous Attitude toward Physics. Mean plots and the cumulative frequency distribution are shown in Figure 27.

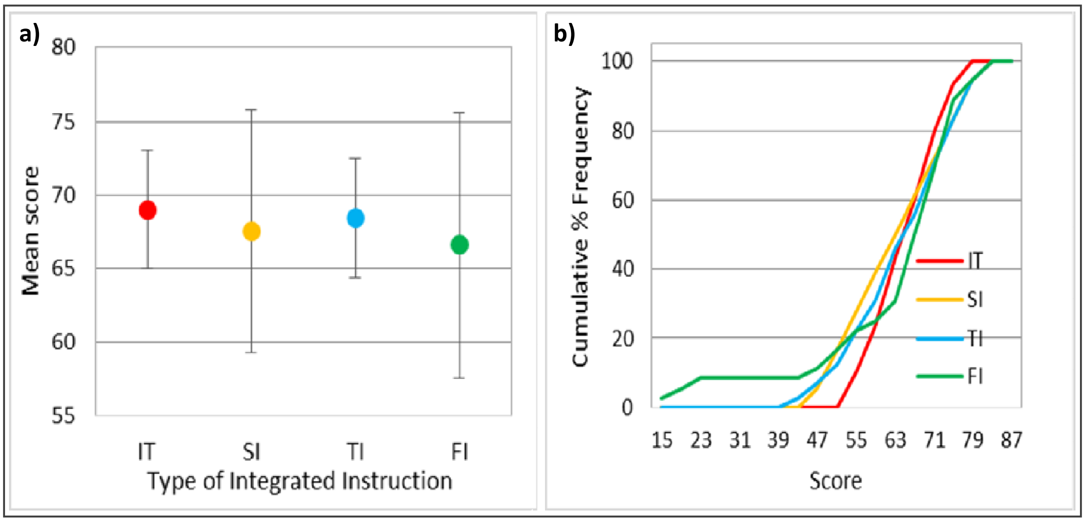

Figure 27. (a) Mean plots with 95% confidence interval error bars of attitude towards Physics in four groups by Type of Integrated Instruction (b) The cumulative frequency distribution of attitude toward Physics in four groups by Type of Integrated Instruction among the female students in USA with previously high attitude

Summary of effect of Type of Integrated Instruction on Attitude toward Physics by subsamples of Gender, Nationality, and Previous Attitude toward Physics

The individual impacts of Type of Integrated Instruction, Gender, Nationality and Previous Attitude toward Physics for the male and female students in Kerala (India) and South Carolina (USA) have been depicted in Figure 28.

Type of Integrated Instruction	India				USA			
	Previous Attitude				Previous Attitude			
	Low		High		Low		High	
	Male	Female	Male	Female	Male	Female	Male	Female
Incompetent Teaching (IT)	↓ 56.76	↓ 55.29	↓ 64.11	↓ 64.05	↓ 56.23	↓ 51.50	↓ 67.95	↑ 69.00
Student-Dominant Integration (SI)	↓ 56.10	↑ 61.40	→ 66.97	↑ 70.44	↓ 51.84	↓ 52.77	↑ 71.57	→ 67.50
Teacher- Dominant Integration (TI)	→ 60.56	↑ 64.08	↑ 68.06	↑ 72.59	↑ 65.16	↑ 65.67	→ 69.23	↑ 68.42
Fair Integration (FI)	↑ 65.30	↑ 63.28	↑ 68.45	↑ 70.00	→ 58.74	→ 57.88	→ 70.06	↓ 66.58
Overall M (SD)	58.99 (12.38)	60.01 (12.76)	67.20 (13.03)	70.30 (11.03)	57.55 (13.82)	54.92 (14.61)	69.71 (12.27)	68.00 (10.97)

Figure 28. The individual impact of each Type of Integrated Instruction on the effect on attitude toward Physics among the students in Kerala (India) and South Carolina (USA)

Effect of Type of Integrated Instruction on Factors of Attitude towards Physics

Student attitude toward Physics has been further analyzed on its sub-scales namely Affect toward Physics, Self-defined Abilities in learning physics, Perception of Content/ Personal Difficulties in learning physics, and Future Expectations on Physics. One-way ANOVAs were conducted to see if there is an effect by Type of Integrated Instruction on each of these sub-scales of the student Attitude toward Physics.

Effect of Type of Integrated Instruction on Affect toward Physics among higher secondary students

Four One-way ANOVAs were performed to figure out the effect of Type of Integrated Instruction on Affect toward Physics among male and female higher secondary students in Kerala (India) and South Carolina (USA). The results are shown in Table 27.

Table 27

Summary of One-way ANOVAs of Affect toward Physics by Type of Integrated Instruction (in sub-samples by Nationality and Gender)

Subsample by Nationality and Gender		Source of variance	Sum of Squares	df	Mean Square	F	ηp²
India	Male	Intercept	69392.99	1	69392.99	2981.73	-----
		Type of Integrated Instruction	239.42	3	79.81	3.43**	0.044
		Error	5166.54	222	23.27		
		Total	75004.00	226			
	Female	Intercept	110156.72	1	110156.72	5361.47	-----
		Type of Integrated Instruction	633.03	3	211.01	10.27**	0.082
		Error	7108.92	346	20.55		
		Total	119492.00	350			
USA	Male	Intercept	60300.46	1	60300.46	1942.99	------
		Type of Integrated Instruction	343.62	3	114.54	3.69**	0.050
		Error	6486.31	209	31.04		
		Total	68523.00	213			
	Female	Intercept	33340.63	1	33340.63	1086.98	-----
		Type of Integrated Instruction	752.55	3	250.85	8.18**	0.14
		Error	4784.95	156	30.67		
		Total	38600.00	160			

**$p<.01$

Findings in table 27 are interpreted under four separate sections for the Indian and US male and female samples. The t-test of comparison of means for independent samples has been carried out as the follow up.

The effect of Type of Integrated Instruction on Affect toward Physics is significant in males [F (3, 222) =3.43, $p<.05$] and females [F(3, 346) =10.27, $p<.01$] in India with medium size ($\eta p^2=0.04$ and $\eta p^2=0.08$, respectively). The effect of Type of Integrated Instruction on Affect toward Physics is significant among the male [F(3, 209) = 3.69, $p<.05$] and female [F (3, 156) = 8.18, $p<.01$] students in USA with medium size ($\eta p^2=0.05$ and $\eta p^2=0.14$, respectively). Figure 29 shows the graphical representation of the effect of Type of Integrated Instruction on the Affect toward Physics.

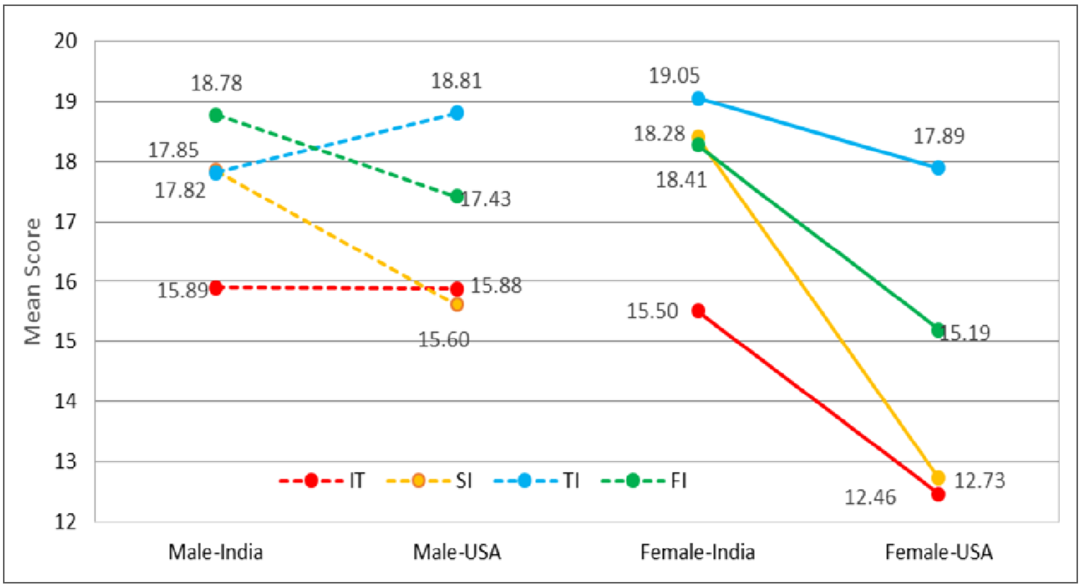

Figure 29. The effect of Type of Integrated Instruction on the affect toward Physics of the male and female students in Kerala (India) and South Carolina (USA)

As shown in Figure 29, lower Affect toward Physics is revealed by female students in USA compared to their Indian counterparts.

The mean scores were compared to investigate the findings statistically. The descriptive statistical data and comparison of means using t-test are provided in Table 28 for Indian students.

Table 28

Comparison of Means of Affect toward Physics by Type of Integrated Instruction for Male and Female Students in India

Gender	Types of Integration	Descriptive Statistics			t values obtained for Comparison of Means against the group		
		Mean	SD	N	SI	TI	FI
Male	Incompetent Teaching (IT)	15.89	5.38	57	-2.18*	-2.00*	-2.96**
	Student-Dominant Integration (SI)	17.85	4.23	59	-	0.033	-1.10
	Teacher- Dominant Integration (TI)	17.82	5.05	61	-	-	-1.03
	Fair Integration (FI)	18.78	4.51	49	-	-	-
Female	Incompetent Teaching (IT)	15.50	5.41	82	-3.86**	-5.26**	-3.54**
	Student-Dominant Integration (SI)	18.41	3.99	78	-	-1.12	0.19
	Teacher- Dominant Integration (TI)	19.05	3.53	96	-	-	1.24
	Fair Integration (FI)	18.28	5.00	94	-	-	-

p*<.05;*p*<.01

The follow-up test confirms the significance on the effect of Type of Integrated Instruction on Affect toward Physics of male and female students in India. As shown in Table 28, among the male students in India, those received IT (M=15.89, SD=5.38) have significantly lower Affect toward Physics than those receiving FI (M=18.78, SD=4.51, t= 2.96, $p<.01$), TI (M=17.82, SD= 5.05, t=2.0, $p<.05$), and SI (M=17.85, SD=4.23, t= 2.18, $p<.05$). Effects of FI with TI (t=1.03, $p>.05$) and SI (t=1.10, $p>.05$) did not show any significant difference for this group. In other words, male students in India possessed high Affect toward Physics with integrated instructional strategies, student-dominant, teacher-dominant or both.

Effect of Integrated Instruction on Affect toward Physics among female students in India revealed similar pattern as that of the male students. Among the female students in India, those received IT (M=15.50, SD=5.41) have significantly lower Affect toward Physics than those who received FI (M=18.28, SD=5.00, t=3.54, $p<.01$), TI (M=19.05, SD= 3.53, t=5.26, $p<.01$), and SI (M=18.41, SD=3.99, t=3.86, $p<.01$). None of the comparisons among SI, TI and FI revealed significant difference on Affect toward Physics ($p>.05$).

Among male as well as female students, any Type of Integrated Instruction, whether student-dominant, teacher-dominant or fair makes a significant positive effect, compared to incompetent teaching, on students' Affect toward Physics. Effect of Type of Integrated Instruction on Affect toward Physics contributes to the overall Attitude toward Physics for Indian students regardless of Gender.

As seen earlier in Table 27, the effect of Type of Integrated Instruction on Affect toward Physics is significant among the male and female students in USA. Hence the mean scores for the US sample were also compared to investigate the findings statistically. The descriptive statistical data and comparison of means using t-test are provided in Table 29 for US students.

Table 29

Comparison of Means of Affect toward Physics by Type of Integrated Instruction for Male and Female Students in USA

Gender	Types of Integration	Descriptive Statistics			t values obtained for Comparison of Means against the group		
		Mean	SD	N	SI	TI	FI
Male	Incompetent Teaching (IT)	15.88	4.84	48	0.24	-3.05**	-1.45
	Student-Dominant Integration (SI)	15.60	6.23	48	-	-2.91**	-1.55
	Teacher- Dominant Integration (TI)	18.81	4.88	54	-	-	1.34
	Fair Integration (FI)	17.43	6.09	63	-	-	-
Female	Incompetent Teaching (IT)	12.46	5.25	50	0.2214	-5.11**	-2.19*
	Student-Dominant Integration (SI)	12.73	6.09	37	-	-4.18**	-1.70
	Teacher- Dominant Integration (TI)	17.89	4.27	36	-	-	2.12*
	Fair Integration (FI)	15.19	6.37	37			

*$p<.05$;**$p<.01$

The follow-up test confirms the significance on the effect of Type of Integrated Instruction on Affect toward Physics of male and female students in USA. As shown in Table 29, among the male students in USA, those with TI (M=18.81, SD=4.88) were found to have significantly higher Affect toward Physics than those with IT (M=15.88, SD=4.84, t= 3.05, $p<.01$) and SI (M=15.60, SD=6.23, t=2.91, $p<.01$). Effects of SI with FI did not show any significant difference for this group (t=-1.55, $p>.05$). In other words, male students in USA possessed high Affect toward Physics with instruction consisted of more teacher-dominant strategies.

Table 29 further shows that female students in USA revealed the same effect as that of the male students along with a high score for FI. Among the female students in USA, those with TI (M=17.89, SD=4.27) had significantly higher Affect toward Physics than those with IT (M=12.46, SD=5.25, t=5.11, $p<.01$), SI

(M=12.73, SD=6.09, t = 4.18, $p<.01$) and FI (M=15.19, SD= 6.37, t= 2.12, $p<.05$). Female students in USA show a concrete improvement after integration with teacher dominance. In other words, male and female students show similar tendency and score high on Affect toward Physics after instructional strategies with noticeable teacher dominance.

Effect of Type of Integrated Instruction on Affect toward Physics contributes to the overall attitude toward Physics for students in USA regardless of Gender. Findings reveal that integration with prominent teacher dominance improves the Affect toward Physics significantly among students in USA. Similar to Indian students, the effect of Type of Integrated Instruction on affect toward Physics is an indicator of the effect of Type of Integrated Instruction on the overall Attitude toward Physics of the male as well as female students in USA. The Type of Integrated Instruction significantly affects the Affect toward Physics of the students.

Effect of Type of Integrated Instruction on Self-defined Abilities in Learning Physics among higher secondary students.

Four One-way ANOVAs were performed to figure out the effect of Type of Integrated Instruction on Self-defined Abilities in Learning Physics among male and female higher secondary students in Kerala (India) and South Carolina (USA). The results are shown in Table 30.

Table 30

Summary of One-way ANOVAs of Self-defined Abilities in learning Physics by Type of Integrated Instruction (in subsamples by Nationality and Gender)

Subsample by Nationality and Gender		Source of variance	Sum of Squares	df	Mean Square	F	ηp²
India	Male	Intercept	69089.63	1	69089.63	5357.01	------
		Type of Integrated Instruction	145.28	3	48.43	3.76*	0.048
		Error	2863.14	222	12.90		
		Total	72361.00	226			
	Female	Intercept	116530.66	1	116530.66	12782.899	------
		Type of Integrated Instruction	384.28	3	128.09	14.05**	0.11
		Error	3154.18	346	9.12		
		Total	121777.00	350			
USA	Male	Intercept	62304.94	1	62304.94	5104.65	------
		Type of Integrated Instruction	65.84	3	21.95	1.80	------
		Error	2550.96	209	12.21		
		Total	66058.00	213			
	Female	Intercept	41276.29	1	41276.29	2823.90	------
		Type of Integrated Instruction	112.88	3	37.63	2.57	-----
		Error	2280.21	156	14.62		
		Total	44157.00	160			

$^{*}p<.05$; $^{**}p<.01$

As shown in Table 30, the effect of Type of Integrated Instruction is evident only among the Indian students. The effect of Type of Integrated Instruction on Self-defined Abilities in Learning Physics is significant in males [F (3, 222) = 3.76, *p*<.05] and females [F (3, 346) = 14.05, *p*<.01] in India with medium size (ηp^2=0.048 and ηp^2=0.11, respectively).

There is no significant effect of the Type of Integrated Instruction on Self-defined Abilities in Learning Physics among the male [F (3, 209) = 1.80, *p*>.05] and female [F (3, 156) = 2.57, *p*>.05] students in USA. Figure 30 shows the graphical representation of the effect of Type of Integrated Instruction on the Self-defined

Abilities in Learning Physics of higher secondary male and female students in Kerala (India) and South Carolina (USA).

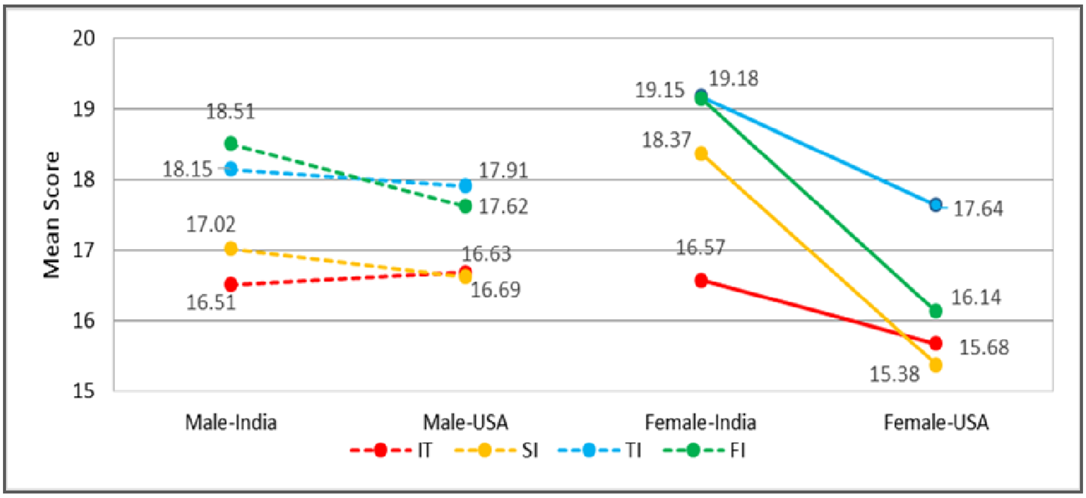

Figure 30. The effect of Type of Integrated Instruction on self-defined abilities in learning Physics of the male and female students in Kerala (India) and South Carolina (USA)

The t-test of comparison of means for independent samples has been carried out as the follow up. The descriptive statistical data and comparison of means using t-test are provided in Table 31.

Table 31

Comparison of Means of Self-defined Abilities in Learning Physics by Type of Integrated Instruction for Male and Female Students in India

Gender	Types of Integration	Descriptive Statistics			t values obtained for Comparison of Means against the group		
		Mean	SD	N	SI	TI	FI
Male	Incompetent Teaching (IT)	16.51	4.05	57	0.73	-2.39*	-2.72**
	Student-Dominant Integration (SI)	17.02	3.42	59	-	-1.81	-2.25*
	Teacher- Dominant Integration (TI)	18.15	3.41	61	-	-	-0.55
	Fair Integration (FI)	18.51	3.45	49	-	-	-
Female	Incompetent Teaching (IT)	16.57	3.49	82	-3.58**	-5.46**	-5.39**
	Student-Dominant Integration (SI)	18.37	2.86	78	-	-1.84	-1.78
	Teacher- Dominant Integration (TI)	19.18	2.88	96	-	-	0.068
	Fair Integration (FI)	19.15	2.85	94	-	-	-

*p<.05;**p<.01

As shown in Table 31, among the male students in India, those with IT (M=16.51, SD=4.05) has significantly lower Self-defined Abilities in Learning Physics than those with FI (M=18.51, SD=3.45, t= 2.72, $p<.01$) and TI (M=18.15, SD= 3.41, t=2.39, $p<.05$)). The effect of FI is found significantly higher compared to SI (M=17.02, SD=3.42, t=2.25, $p<.05$). Effects of TI and FI did not show any significant difference for the Indian males (t=0.55, $p>.05$). In other words, male students in India possessed high Self-defined Abilities in Learning Physics with integrated instruction consisted of more teacher-centered strategies.

Female students in India revealed the same effect as that of the male students. Among the female students in India, those with FI (M=19.15, SD=2.85) achieved significantly higher than those with IT (M=16.57, SD=3.49, t=5.39, $p<.01$), SI (M=18.37, SD=2.86, t=3.58, $p<.01$) and TI (M=19.18, SD= 2.88, t=5.46, $p<.01$). None of the comparisons among SI, TI and FI revealed significant difference in self-defined abilities in learning Physics (p>.05).

Findings reveal that any Type of Integrated Instruction whether student-dominant, teacher-dominant or fair makes a significant positive effect on students' self-defined abilities in Learning Physics which contributes to attitude toward Physics regardless of Gender.

Table 30 also revealed that the self-defined abilities in Learning Physics of the students in USA are not significantly improved by the Type of Integrated Instruction.

Effect of Type of Integrated Instruction on Perception of Content/Personal Difficulties in Learning Physics among higher secondary school students

Four One-way ANOVAs were performed to figure out the effect of Type of Integrated Instruction on Perception of content/personal difficulties in learning

Physics among male and female higher secondary students in Kerala (India) and South Carolina (USA). The results are shown in Table 32.

Table 32

Summary of One-way ANOVAs of Perception of Content/Personal Difficulties in Learning Physics by Type of Integrated Instruction (in subsamples by Nationality and Gender)

Subsample by Nationality and Gender		Source of variance	Sum of Squares	df	Mean Square	F	ηp²
India	Male	Intercept	19527.48	1	19527.48	961.00	-----
		Type of Integrated Instruction	193.68	3	64.56	3.18*	0.041
		Error	4511.05	222	20.32		
		Total	24218.00	226			
	Female	Intercept	33335.01	1	33335.01	1538.23	-----
		Type of Integrated Instruction	649.95	3	216.65	10.00**	0.080
		Error	7498.19	346	21.67		
		Total	42175.00	350			
USA	Male	Intercept	31033.34	1	31033.34	1803.63	------
		Type of Integrated Instruction	29.00	3	9.67	0.56	------
		Error	3596.06	209	17.21		
		Total	34997.00	213			
	Female	Intercept	20444.49	1	20444.49	1428.79	-------
		Type of Integrated Instruction	87.25	3	29.08	2.03	-------
		Error	2232.20	156	14.31		
		Total	22863.00	160			

*p<.05;**p<.01

As shown in Table 32, significant effect of Type of Integrated Instruction on perception of Content/Personal Difficulties in Learning Physics is revealed only by the Indian students. The effect of Type of Integrated Instruction on perception of Content/Personal Difficulties in Learning Physics is significant in males [F (3, 222) = 3.18, *p*<.05] and females [F (3, 346) = 10.00, *p*<.01] in India with medium size (ηp^2=0.041 and ηp^2=0.08, respectively).

There is no significant difference in the effect of Type of Integrated Instruction on perception of Content/Personal Difficulties in Learning Physics among the male [F (3, 209) = 0.562, *p*>.05] and female [F (3, 156) = 2.03, *p*>.05] students in USA. Figure 31 shows the graphical representation of the effect of Type of Integrated Instruction on the perception of Content/Personal Difficulties in Learning Physics.

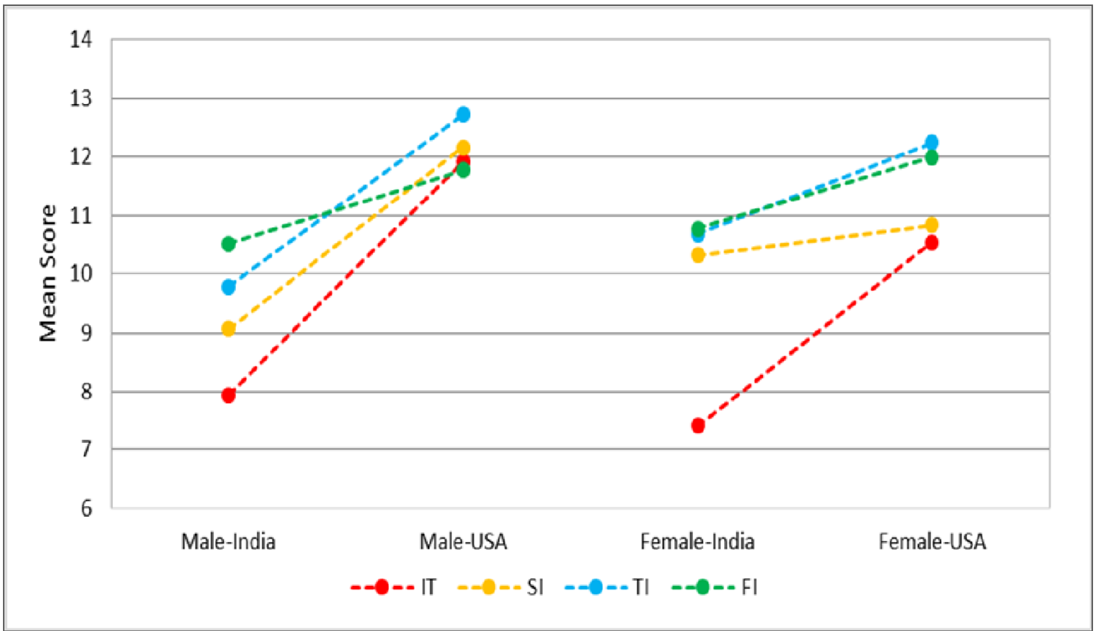

Figure 31. The effect of Type of Integrated Instruction on Perception of content/personal difficulties in Learning Physics of the male and female students in Kerala (India) and South Carolina (USA)

As shown in Figure 31, there is no significant difference in Perception of content/personal difficulties in Learning Physics with respect to the Type of Integrated Instruction received by the students in USA. The t-test of comparison of means for independent samples has been carried out as the follow up. The descriptive statistical data and comparison of means using t-test are provided in Table 33.

Table 33

Comparison of Means of Perception of Content/Personal Difficulties in Learning Physics by Type of Integrated Instruction for Male and Female Students in India

Gender	Types of Integration	Descriptive Statistics			t values obtained for Comparison of Means against the group		
		Mean	SD	N	SI	TI	FI
Male	Incompetent Teaching (IT)	7.95	5.00	57	-1.33	-2.09*	-2.80**
	Student-Dominant Integration (SI)	9.07	4.04	59	-	-0.91	-1.79
	Teacher- Dominant Integration (TI)	9.79	4.59	61	-	-	-0.84
	Fair Integration (FI)	10.51	4.35	49	-	-	-
Female	Incompetent Teaching (IT)	7.41	5.37	82	-3.75**	-4.36**	-4.63**
	Student-Dominant Integration (SI)	10.32	4.37	78	-	-0.52	0.69
	Teacher- Dominant Integration (TI)	10.68	4.61	96	-	-	-0.16
	Fair Integration (FI)	10.78	4.25	94			

*$p<.05$;**$p<.01$

The follow up test confirms the significance of the effect of Type of Integrated Instruction on Perception of Content/Personal Difficulties in Learning Physics of male and female students in India. Findings reveal that Integrated Instruction whether student-dominant, teacher-dominant or fair makes a significant positive effect on students' Perception of Content/Personal Difficulties in Learning Physics which contributes to Attitude toward Physics.

As shown in Table 33, the male students in India receiving IT (M=7.95, SD=5.00) had significantly lower Perception of Content/Personal Difficulties in Learning Physics than those with FI (M=10.51, SD=4.35, t= 2.80, $p<.01$) and TI (M=9.79, SD= 4.59, t= 2.09, $p<.01$). Mean scores of Perception of Content/ Personal Difficulties in Learning Physics of Indian male students with SI and TI did not show any significant difference compared to those with FI ($p>.05$). In other words, Perception of Content/Personal Difficulties in Learning Physics of male students in India contribute to high Attitude toward Physics with more teacher-dominant instructional strategies.

Female students in India revealed the same effect as that of the male students. Among the female students in India, compared to those with IT (M=7.41, SD=5.37) students who receive FI (M=10.78, SD=4.25, t=4.63, $p<.01$), SI (M=10.32, SD=4.37, t= 3.75, $p<.01$) and TI (M=10.68, SD= 4.61, t=4.36, $p<.01$) have significantly higher Perception of Content/Personal Difficulties in Learning Physics. None of the comparisons among SI, TI and FI revealed statistically significant difference.

The effect of Type of Integrated Instruction on Perception of Content/ Personal Difficulties in Learning Physics is comparable with effect of former on overall Attitude toward Physics of the Indian female students, whereas the pattern of effect is partially supportive for the male students.

Table 32 further reveals that, the Perception of Personal/Content Difficulties in Learning Physics of the students in USA are not significantly improved by integrated instruction of any level.

Effect of Type of Integrated Instruction on Future Expectations on Physics among Higher Secondary Students

Four One-way ANOVAs were performed to figure out the effect of Type of Integrated Instruction on Future Expectations on Physics among male and female higher secondary students in Kerala (India) and South Carolina (USA). The results are shown in Table 34.

Table 34

Summary of One-way ANOVAs of Future Expectations on Physics by Type of Integrated Instruction (in subsamples by Nationality and Gender)

Subsample by Nationality and Gender		Source of variance	Sum of Squares	df	Mean Square	F	ηp^2
India	Male	Intercept	78699.30	1	78699.30	5088.08	----
		Type of Integrated Instruction	87.78	3	29.26	1.89	----
		Error	3433.76	222	15.47		
		Total	82544.00	226			
	Female	Intercept	129186.38	1	129186.38	12143.56	-----
		Type of Integrated Instruction	292.02	3	97.34	9.15**	0.074
		Error	3680.83	346	10.64		
		Total	134924.00	350			
USA	Male	Intercept	65819.03	1	65819.03	4119.97	----
		Type of Integrated Instruction	98.40	3	32.80	2.05	----
		Error	3338.90	209	15.98		
		Total	70590.00	213			
	Female	Intercept	47620.53	1	47620.53	2297.75	-----
		Type of Integrated Instruction	302.92	3	100.97	4.87**	0.086
		Error	3233.08	156	20.73		
		Total	51457.00	160			

**$p<.01$

As shown in Table 34, significant effect of Type of Integrated Instruction on Future Expectations on Physics is revealed only among female students in India [F (3, 346) = 9.15, $p<.01$] with medium size ($\eta p^2=.074$) and USA [F (3, 156) = 4.87, $p<.01$] with medium size ($\eta p^2=.086$).

There is no significant difference in the effect of Type of Integrated Instruction on Future Expectations on Physics among the male students in India [F (3, 222) = 1.89, $p>.05$] and USA [F (3, 209) = 2.05, $p>.05$]. Figure 32 shows the graphical representation of the effect of Type of Integrated Instruction on Future Expectations on Physics among higher secondary students.

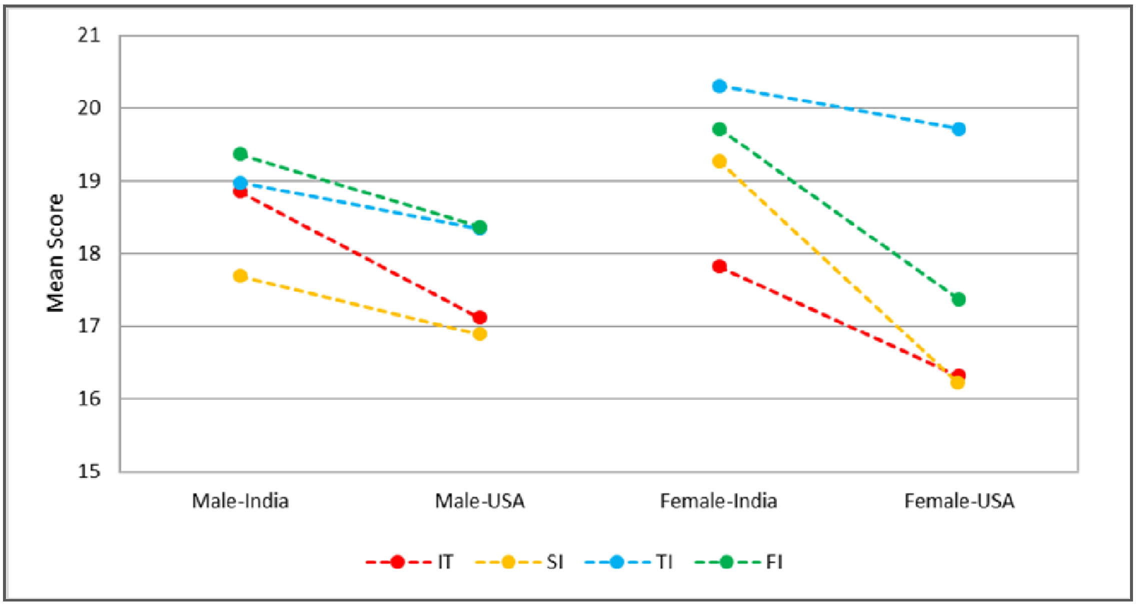

Figure 32. Effect of Type of Integrated Instruction on Future Expectations in Physics of the male and female students in Kerala (India) and South Carolina (USA)

The follow-up test confirms the significance on the effect of Type of Integrated Instruction on Future Expectations on Physics of female students in Kerala (India) and South Carolina (USA). The descriptive statistical data and comparison of means using t-test are provided in Table 35.

Table 35

Comparison of Means of Future Expectations on Physics by Type of Integrated Instruction for Female Students in India and USA

Nationality	Types of Integration	Descriptive Statistics			t values obtained for Comparison of Means against the group		
		Mean	SD	N	SI	TI	FI
India	Incompetent Teaching (IT)	17.83	3.85	82	-2.72**	-4.77**	-3.56**
	Student-Dominant Integration (SI)	19.28	2.82	78	-	-2.27*	-0.95
	Teacher- Dominant Integration (TI)	20.31	3.09	96	-	-	1.29
	Fair Integration (FI)	19.72	3.21	94	-	-	-
USA	Incompetent Teaching (IT)	16.32	4.40	50	0.097	-3.79**	-1.11
	Student-Dominant Integration (SI)	16.22	5.55	37	-	-3.17**	-1.00
	Teacher- Dominant Integration (TI)	19.72	3.67	36	-	-	2.46*
	Fair Integration (FI)	17.38	4.42	37			

*$p<.05$;**$p<.01$

As shown in Table 35, among the female students in India, compared to those with IT (M=17.83, SD=3.85) students with FI (M=19.72, SD=3.21, t= 3.56, $p<.01$), TI (M=20.31, SD= 3.09, t=4.77, $p<.01$) and SI (M=19.28, SD= 2.82, t=2.72, $p<.01$) possessed significantly higher Future Expectations on Physics. It is worth noting that students with teacher-dominant instruction revealed higher Future Expectations on Physics than those who had student-dominant instruction. Effects of SI and FI did not show any significant difference for this group. In other words, for female students in India, Integrated Instruction with teacher-dominant strategies contributes to high Attitude toward Physics through improved Future Expectations on Physics.

Female students in USA revealed the same pattern as that of the Indian females. A significantly higher Future Expectation on Physics with teacher-dominant instruction compared to any other types of integration was disclosed. Among the US females, those with TI (M=19.72, SD=3.67) were found to have significantly higher Future Expectation on Physics than those with IT (M=16.32, SD=4.40, t= 3.79, $p<.01$), SI (M=16.22, SD=5.55, t=3.17, $p<.01$) and FI (M=17.38, SD=4.42, t=2.46, $p<.01$). The effects of SI and FI did not show any significant difference (t=1.00, $p>.05$). Findings reveal the impact of teacher-dominant integration on Future Expectations on Physics contributes to Attitude toward Physics in females students in USA.

Similar to the female students in India, integration with teacher dominance causes a positive effect on female students in USA. Teacher-dominant integration improves Future Expectations on Physics among the female students regardless of Nationality, and this effect contributes to their overall attitude toward Physics.

Table 34 shows that, among male students in India and USA, the effect of Type of Integrated Instruction on Future Expectations on Physics is not significant.

Effect of Nationality and Gender on Attitude toward Physics

Since the effect of Nationality and Gender on Attitude toward Physics was studied in the initial phase of this study, on a different sample using a different type of instrument-questionnaire, that finding was cross checked again using samples from both India and USA with data obtained through scale of Attitude toward Physics. Since the sample in ex post facto phase is almost equally represented by all the four types of integration, it can be presumed that difference in instructional practices between the two countries is controlled. Interaction of Gender and Nationality on Attitude toward Physics of higher secondary school students is studied using a 2 x 2 ANOVA. The results are in Table 36.

Table 36

Result of 2x2 ANOVA of Attitude toward Physics by Gender and Nationality (of Phase 3 Sample) of Higher Secondary Students in India and USA

Source of Variance	Sum of Squares	df	Mean Square	F	ηp^2
Intercept	215860.183	1	3479871.197	18604.27	-----
Nationality	567.241	1	1467.138	7.84**	0.008
Gender	384.673	1	372.699	1.99	------
Nationality x Gender	259.183	1	2999.643	16.04**	0.017
Error	19673.223	945	187.047		
Total	361844	949			

***p*<.01

Main effects of Nationality on Attitude toward Physics is significant [F (1, 947) = 7.84, *p*<.01] whereas as the effect of Gender [F (1, 947) = 1.99, *p*>.05] is not significant in the phase 3 sample. The main effects of Nationality and Gender are shown in Figure 33.

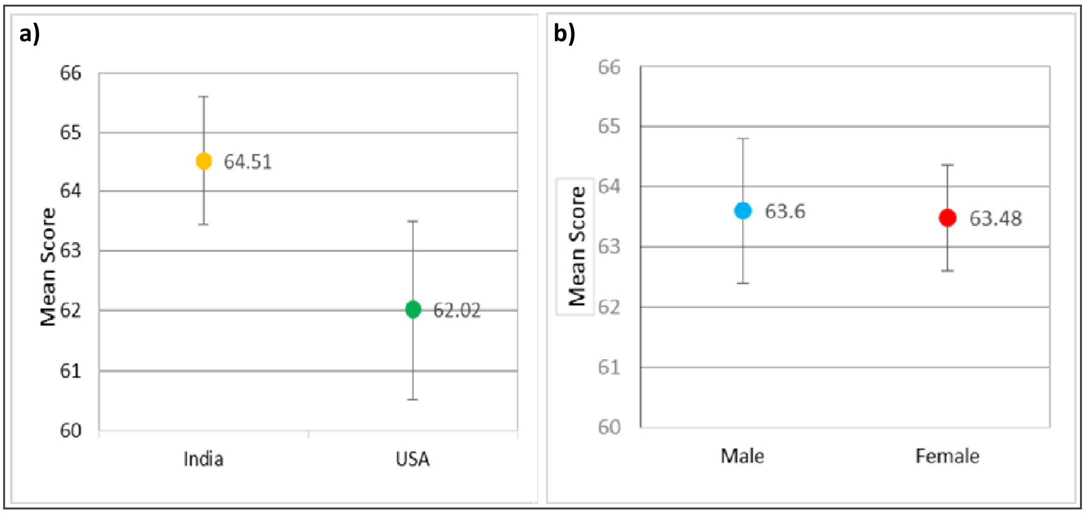

Figure 33. Mean plots (with 95% confidence interval error bars) of attitude toward Physics by a) Nationality and b) Gender of higher secondary students in Kerala (India) and South Carolina (USA) for phase 3

Ogives are further plotted to show an over-all comparison, over the entire range of distribution of Attitude toward Physics by Nationality and Gender in phase 3 sample. The graphical representations of cumulative percent of the frequencies are provided in Figures 34.

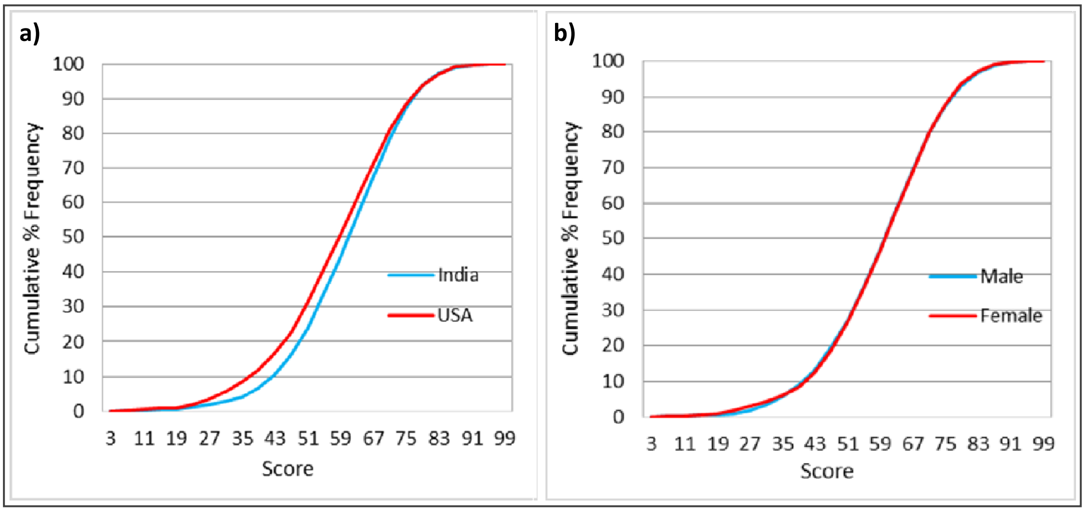

Figure 34. Ogives of distribution of scores on attitude toward Physics by a) Nationality and b) Gender of higher secondary students in Kerala (India) and South Carolina (USA) for phase 3

As shown in Figures 33 and 34, students in India exhibit significantly higher attitude compared to the students in USA, however, the effect is not so evident in the lower and higher parts of the total distribution. The effect of Gender is not significant in the phase 3 sample of students, which is identical on the mean plot and the cumulative frequency distribution.

As shown in Table 36, a significant interaction effect of Gender and Nationality [F (1, 947) = 16.04, p<.01], has also been observed on Attitude toward Physics. This interaction effect is shown in Figure 35.

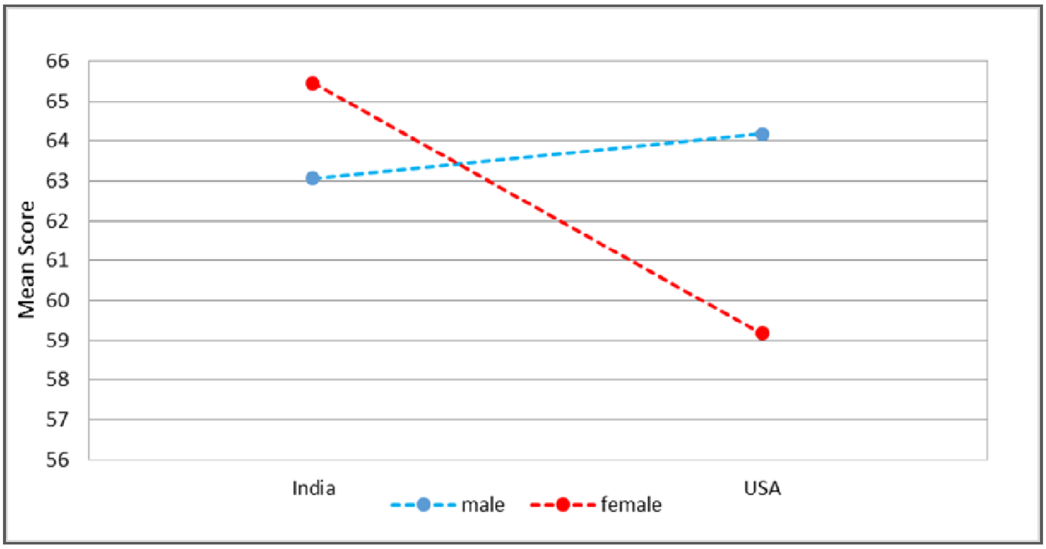

Figure 35. Mean plots (with 95% confidence interval error bars) of the interaction effect of Gender and Nationality on attitude toward Physics among the higher secondary students in Kerala (India) and South Carolina (USA) for the phase 3 sample.

The mean scores were compared to find out if there is significant effect of Nationality within the Gender using t-test. The results is given in Table 37.

Table 37

Comparison of Mean Scores of Attitude towards Physics of higher Secondary Students in India and USA by Gender

Gender	Nationality	N	Mean	SD	t
Male	India	226	63.06	13.32	0.842
	USA	213	64.17	14.32	
Female	India	350	65.45	12.93	4.86**
	USA	160	59.17	14.84	

***p*<.01

As in Table 37, the comparison of means using t-test shows that there is no significant difference between the Attitudes toward Physics of the male students in

India (M=63.06, SD=13.32) and USA (M=64.17, SD=14.32, t= 0.842, $p>.05$). However, the attitude is found significantly higher among the female students in India (M=65.45, SD=12.93) compared to their counterparts in USA (M=59.17, SD=14.84, t=4.86, $p<.01$). As depicted in the random sample of students in phase 2, the significant effect of Nationality on the Attitude toward Physics is due to the significant difference between the attitudes of the female students in India and USA.

Summary of the Effect of Type of Integrated Instruction on Attitude toward Physics

The overall effect of Type of Integrated Instruction is found significant among students regardless of Gender and Nationality. Attitude toward Physics is higher for students receiving TI and FI compared to those receiving IT and SI. Unlike male students in India with low attitude previously, integration of any type makes a positive impact on female students with low attitude previously. Students who had previously low attitude in USA regardless of their Gender, showed improved attitude with instructional strategies with more teacher-centeredness. This finding is similar to that of the male students in India who had previously low attitude toward Physics. Type of Integrated Instruction does not significantly affect the attitude toward Physics of the US female students with previously high attitude. However, Attitude toward Physics of the Indian males and US males and females, with low Previous Attitude toward Physics is enhanced by Integrated Instruction with more teacher-dominance.

The Attitude toward Physics was further verified based on its factors, namely, Affect toward Physics, Self-defined Abilities in Learning Physics, Perception of Content/Personal Difficulties in Learning Physics, and Future Expectations on Physics. Effect of Type of Integrated Instruction on Affect toward Physics contributes to the overall attitude toward Physics for Indian students regardless of Gender. Indian females regardless of their Previous Attitude toward Physics unveil improvement in Affect toward Physics with any Type of Integrated Instruction, whereas Indian males with low Previous Attitude toward Physics make a positive impact on their Affect toward Physics with TI and FI. Findings disclose that male and female students in USA with Low Previous Attitude toward Physics possess high Affect toward Physics with instruction consisted of more teacher-dominant strategies. Indian males with previously high attitude are not impacted by any Type of Integrated Instruction on their Affect toward Physics, but on their Self-defined Abilities in Learning Physics and Perception of Content/Personal Difficulties in Learning Physics.

Indian males and females regardless of their Previous Attitude toward Physics unveil improvement in Self-defined Abilities in Learning Physics and in their perception of Content/Personal Difficulties in Learning Physics upon receiving Teacher-dominant Integration and Fair Integration. While Indian females reveal improvement in Future Expectations on Physics with the same types of Integrated Instruction, male students in India do not make any impact on Future Expectations on Physics with Integrated Instruction. It is worth noting that female students regardless of Nationality revealed higher Future Expectations on Physics with teacher-dominant instruction than those who had student-dominant instruction. In other words, for female students in India, integrated instruction with teacher-dominant strategies contributes to high Attitude toward Physics through improved future expectations on Physics.

Effect of Integrated Instruction on Student Achievement in Physics

After establishing the effect of Type of Integrated Instruction on students' Attitude toward Physics, the effect of Integrated Instruction was investigated on their Achievement in Physics.

The influence of Integrated Instruction on post-test scores of Achievement in Physics after controlling for their level of Previous Achievement in Physics was studied in male and female students separately among higher secondary students in Kerala (India) and South Carolina (USA) through a planned sequence of factorial ANOVAs and One Way ANOVAs.

Main and interaction effects of the moderator variables, namely, Gender, Nationality, and Previous Achievement in Physics were investigated. Different combinations of the independent variable with different moderator variables interact one another to create the effect. In order to confirm the progression of the interaction effect, the analysis has been further conducted by investigating the effect of the independent variable by successively withdrawing the moderator variables as a factor from the model. Then the interaction effects of the remaining variables were investigated in appropriate subsamples till the main effect of Type of Integrated Instruction on achievement in Physics is reached.

As a preliminary step, the means and standard deviations of Achievement in Physics of Male and Female students with high and low levels of Previous Achievement in Physics by Nationality are provided in Table 38.

Table 38

Mean and Standard Deviation of Achievement in Physics of Male and Female students with high and low levels of Previous Achievement in Physics by Nationality

Type of Integrated Instruction	Kerala (India) Level of Previous Achievement in Physics				South Carolina (USA) Level of Previous Achievement in Physics				Total
	Low		High		Low		High		
	Male	Female	Male	Female	Male	Female	Male	Female	
Incompetent Teaching (IT)	7.02 (2.31)	5.71 (2.17)	6.85 (2.34)	6.11 (2.21)	8.94 (3.53)	12.19 (5.66)	15.91 (5.23)	13.50 (4.12)	9.13 (5.15)
Student-Dominant Integration (SI)	7.92 (2.95)	5.07 (2.78)	8.00 (2.90)	7.59 (3.41)	13.25 (4.03)	11.22 (3.84)	18.23 (5.90)	14.53 (3.37)	10.34 (5.98)
Teacher- Dominant Integration (TI)	8.54 (2.77)	5.70 (2.33)	7.15 (1.95)	5.44 (2.29)	17.38 (5.50)	13.21 (4.10)	18.59 (6.72)	13.23 (4.52)	10.11 (6.40)
Fair Integration (FI)	9.13 (3.13)	7.13 (3.77)	9.18 (2.94)	7.96 (3.79)	12.17 (5.91)	10.55 (3.30)	18.71 (6.95)	16.71 (7.08)	11.25 (6.62)
Total	8.06 (2.86)	6.13 (2.87)	7.78 (2.62)	6.81 (3.24)	12.03 (5.59)	11.73 (4.48)	18.03 (6.37)	14.33 (4.93)	10.21 (6.11)

Note: Values in each cell are means and standard deviations; Standard deviations are in parentheses.

The main and interaction effects of Gender and Nationality were investigated. To test the effect of Type of Integrated Instruction on Achievement in Physics, a one way ANOVA was performed in the total sample. This effect was studied in various subsamples by Previous Achievement in Physics, Gender and Nationality by exploring their 4-way interaction effect on Achievement in Physics. This was followed by two separate 3-way Interaction effects of Type of Integrated Instruction, Previous Achievement in Physics and Gender among the Indian and US students separately. Then four 2-way Interaction Effects of Type of Integrated Instruction and Gender on Achievement in Physics was performed on subsamples by Nationality and Previous Achievement in Physics. This led to eight distinct one-way ANOVAs to figure out the effect of Type of Integrated Instruction on Achievement in Physics among male and female higher secondary students in India and USA who had low and high Previous Achievement in Physics.

Effects of Nationality and Gender on Achievement in Physics

The main effects of Gender and Nationality on Achievement in Physics were investigated along with their interaction effect among higher secondary students in Kerala (India) and South Carolina (USA). This will indicate if Gender or Nationality influence Achievement in Physics when controlled for the type of instruction. The results are shown in Table in 39.

Table 39

Result of 2x2 ANOVA of Achievement in Physics by Gender and Nationality of Higher Secondary Students

Source of Variance	Sum of Squares	df	Mean Square	F	ηp^2
Intercept	107221.60	1	107221.60	5645.17	------
Nationality	13574.76	1	13574.76	714.71**	0.431
Gender	1680.18	1	1680.18	88.46**	0.086
Nationality * Gender	254.38	1	254.38	13.39**	0.014
Error	17948.88	945	18.99		
Total	134243.00	949			

**p<.01

The effect of Nationality on Achievement in Physics is significant [F (1, 947) = 714.71, $p<.01$], with a large effect size ($\eta p^2=0.43$) when controlled for the type of instruction. The effect of Gender on Achievement in Physics is significant [F (1, 947) = 88.46, $p<.01$], with a medium effect size ($\eta p^2=0.09$) when controlled for the type of instruction. The main effects of Nationality and Gender are shown in Figure 36.

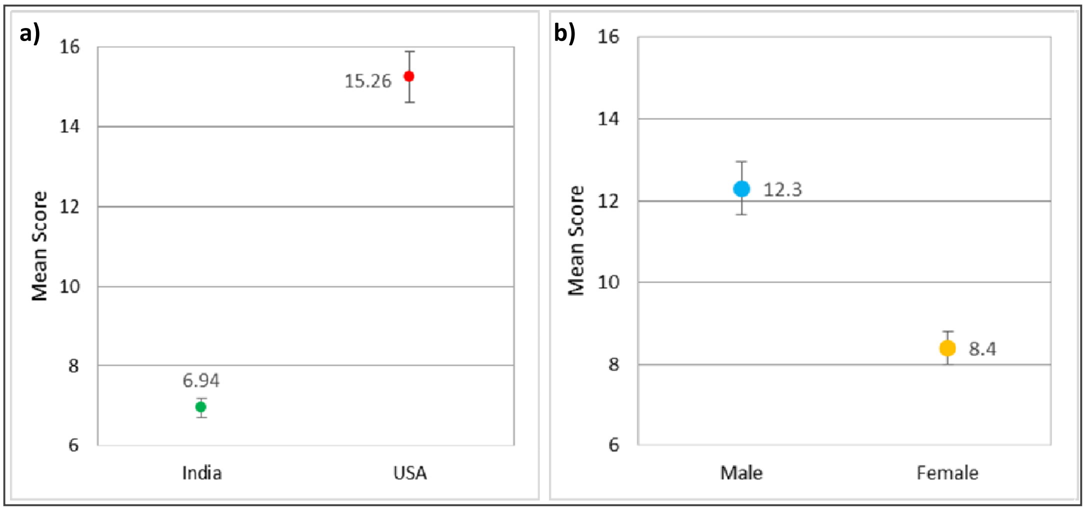

Figure 36. Mean plots (with 95% confidence interval error bars) of achievement in Physics by a) Nationality and b) Gender of higher secondary students in Kerala (India) and South Carolina (USA)

As can be seen in Table 39, a significant interaction effect of Nationality and Gender [F (1, 947) =13.39, *p*<.01], of small size (ηp^2=0.01) was revealed on Achievement in Physics of the higher secondary students of Kerala (India) and South Carolina (USA). A graphical representation of the interaction effect is provide in Figure 37.

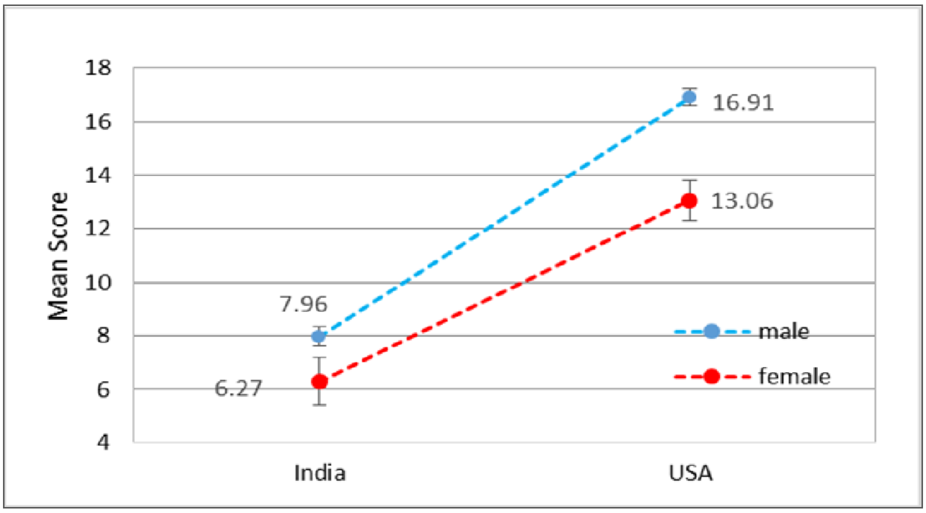

Figure 37. Mean plots (with 95% confidence interval error bars) of achievement in Physics by the interaction of Gender and Nationality among the higher secondary students in Kerala (India) and South Carolina (USA)

Achievement in Physics differs by Nationality among both males (India: M=7.96, SD=2.78, N=226; USA: M=16.91, SD=6.65, N=213, t=18.58, *p*<.01) and females (India: M=6.27, SD=2.96, N=350; USA: M=13.06, SD=4.88, N=160, t=19.38, *p*<.01).

Achievement in Physics varies also by Gender in India (male: M=7.96, SD=2.78, N=226; female: M=6.27, SD=2.96, N=350, t=6.85, p<.01) and USA (male: M=16.91, SD=6.65, N=213; female: M=13.06, SD=4.88, N=160, t=6.17, *p*<.01).

Effect of Type of Integrated Instruction on Achievement in Physics

The effect of Type of Integrated Instruction (IT, SI, TI, and FI) on Achievement in Physics among students in the selected 24 classrooms in Kerala (India) and South Carolina (USA) was verified using One-way ANOVA as shown in Table 40.

Table 40

ANOVA of Achievement in Physics of Higher Secondary Students by Type of Integrated Instruction

Source of Variance	Sum of Squares	df	Mean Square	F	ηp^2
Intercept	98651.225	1	98651.225	2677.64	------
Type of Integrated Instruction	545.792	3	181.931	4.94**	0.015
Error	34816.313	945	36.843		
Total	134243.000	949			

$^{**}p<.01$

As shown in Table 40, a significant effect of Type of Integrated Instruction has been observed on Achievement in Physics [F (3, 945) =4.94, $p<.01$; $\eta p^2=.02$].

In order to verify the effect of each Type of Integrated Instruction on Achievement in Physics, t-test of independent samples was performed as a follow up. The descriptive statistics data of Achievement in Physics by Type of Integrated Instruction for the total sample along with a comparison of means using t-test are shown in Table 41.

Table 41

Comparison of Means of Achievement in Physics by Type of Integrated Instruction for the Total Sample

Sample	Types of Integration	Descriptive Statistics			t values obtained for Comparison of Means against the group		
		Mean	SD	N	SI	TI	FI
Students in India and USA	Incompetent Teaching (IT)	9.13	5.15	237	-2.33*	-1.85	-3.91**
	Student-Dominant Integration (SI)	10.34	5.98	222	-	0.41	-1.55
	Teacher-Dominant Integration (TI)	10.11	6.4	247	-	-	-1.94
	Fair Integration (FI)	11.25	6.62	243	-	-	-

$^{*}p<.05$; $^{**}p<.01$

A significant effect of Type of Integrated Instruction was revealed on the Achievement in Physics. Effect of IT (M=9.13, SD=5.15) is significantly lower compared to SI (M= 10.34, SD= 5.98, t=2.33, $p<.05$) and FI (M= 11.25, SD= 6.62, t=3.91, $p<.01$).

Mean scores also show that there is no significant difference of Achievement in Physics for students receiving SI (M= 10.34, SD= 5.98) with students receiving TI (M= 10.11, SD= 6.40, t=0.41 $p>.05$) and FI (M= 11.25, SD= 6.62, t=1.55, $p>.05$). Figure 38 shows the graphical representation of this effect.

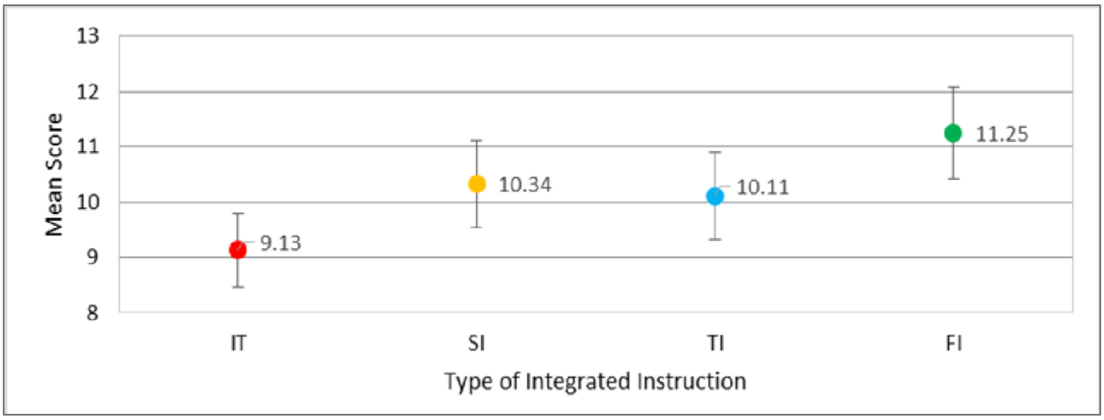

Figure 38. Mean plots with 95% confidence interval error bars of Achievement in Physics of higher secondary students in Kerala (India) and South Carolina (USA) by Type of Integrated Instruction

Four-way Interaction Effect of Type of Integrated Instruction, Previous Achievement in Physics, Gender and Nationality on Achievement in Physics

The combined effect of the independent variable, Type of Integrated Instruction along with the moderator variables namely, Previous Achievement in Physics, Gender, and Nationality on Achievement in Physics has been verified using a 4x2x2x2 factorial ANOVA as shown in Table 42.

Table 42

Summary of Four-way ANOVA of Achievement in Physics by Type of Integrated Instruction, Previous Achievement in Physics, Gender and Nationality of Higher Secondary Students

Source of Variance	Sum of Squares	df	Mean Square	F	ηp^2
Intercept	70693.45	1	70693.45	4221.78	------
Type of Integrated Instruction * Gender * Nationality * Previous Achievement in Physics	20006.98	31	645.38	38.54**	0.566
Error	15355.12	917	16.74		
Total	134243.00	949			

**p<.01

A significant interaction effect of Type of Integrated Instruction, Previous Achievement in Physics, Gender and Nationality [F (31, 917) =38.54, $p<.01$] of large size ($\eta p^2 = 0.57$) has been observed on Achievement in Physics. Figure 39 shows the graphical representation of this effect.

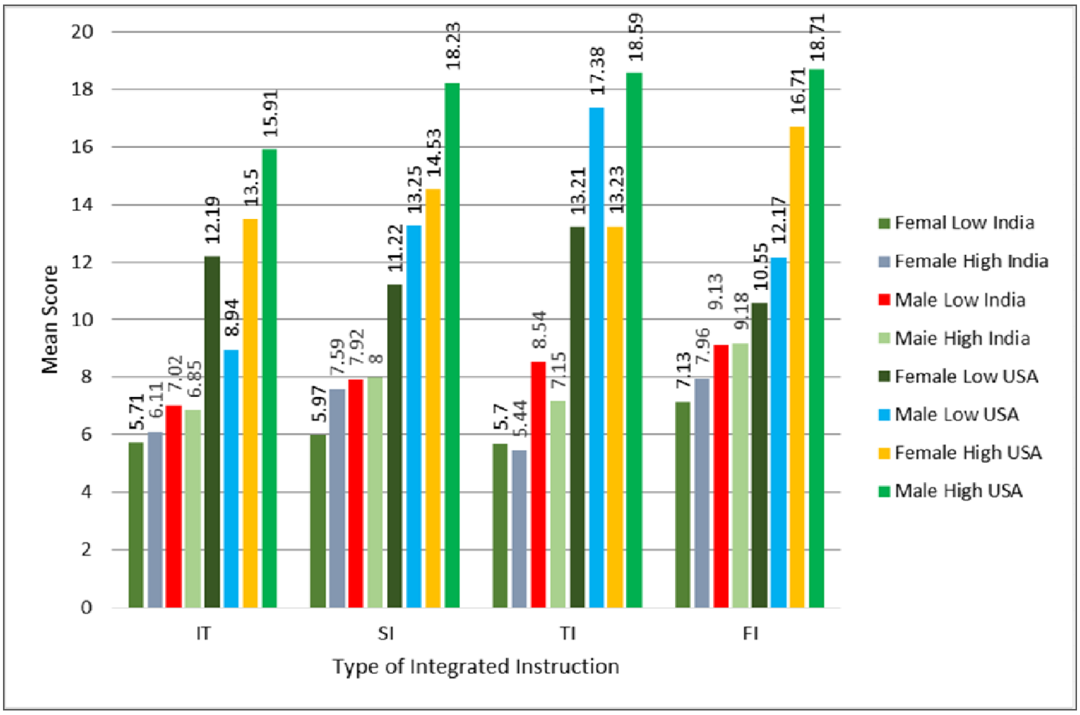

Figure 39. The Four-way interaction effect of Type of Integrated Instruction, Previous Achievement in Physics and Gender on Achievement in Physics among the higher secondary students in Kerala (India) and South Carolina (USA)

Figure 39 shows that students in India scored lower achievement in Physics compared to those in USA regardless of the Type of Integrated Instruction. Fair Integration (FI) made a positive impact on students in India regardless of their Previous Achievement in Physics. Among the students in USA, the previously low achieving male as well as female performed higher with Teacher-dominant Integration, whereas the previously high achieving students in USA did not show a noticeable effect with a specific Type of Integrated Instruction except the females performed high with FI. It is worth mentioning that the Achievement in Physics of students is greatly impacted by a balanced integration of student-centered and teacher-centered strategies.

In the next step, 3- way interaction effect of Type of Integrated Instruction, Previous Achievement in Physics and Gender was studied separately for Indian and US students.

Three-way Interaction Effects of Type of Integrated Instruction, Previous Achievement in Physics and Gender on Achievement in Physics among the Indian and US students

Two different factorial (3-way) ANOVAs were performed for confirming the effect of Type of Integrated Instruction, Gender, and Previous Achievement in Physics with a 4x2x2 design, on Indian and US samples. The results are shown in Table 43.

Table 43

Summary of Three-way ANOVAs of Achievement in Physics by Type of Integrated Instruction, Previous Achievement in Physics, and Gender among Higher Secondary Students in India and USA

Nationality	Source of Variance	Sum of Squares	df	Mean Square	F	ηp^2
India	Intercept	20782.86	1	20782.86	2627.69	------
	Type of Integrated Instruction x Gender x Previous Achievement in Physics	762.62	15	50.84	6.43*	0.147
	Error	4429.12	560	7.90		
	Total	32914.00	576			
USA	Intercept	50591.24	1	50591.24	1653.03	------
	Type of Integrated Instruction x Gender x Previous Achievement in Physics	3573.29	15	238.21	7.78*	0.246
	Error	10926.00	357	30.60		
	Total	101329.00	373			

*$p<.05$

Significant interaction effect of Type of Integrated Instruction, Previous Achievement in Physics and Gender on Achievement in Physics of higher secondary students is observed both in Kerala (India) [F (15, 560) = 6.43, $p<.05$; $\eta p^2=0.147$] and in South Carolina (USA) [F (15, 357) = 7.78, $p<.05$; $\eta p^2=0.246$]. Figure 40 shows the graphical representation of interaction effect of Type of Integrated Instruction, Previous Achievement in Physics and Gender on Achievement in Physics among the higher secondary students in Kerala (India) and South Carolina (USA).

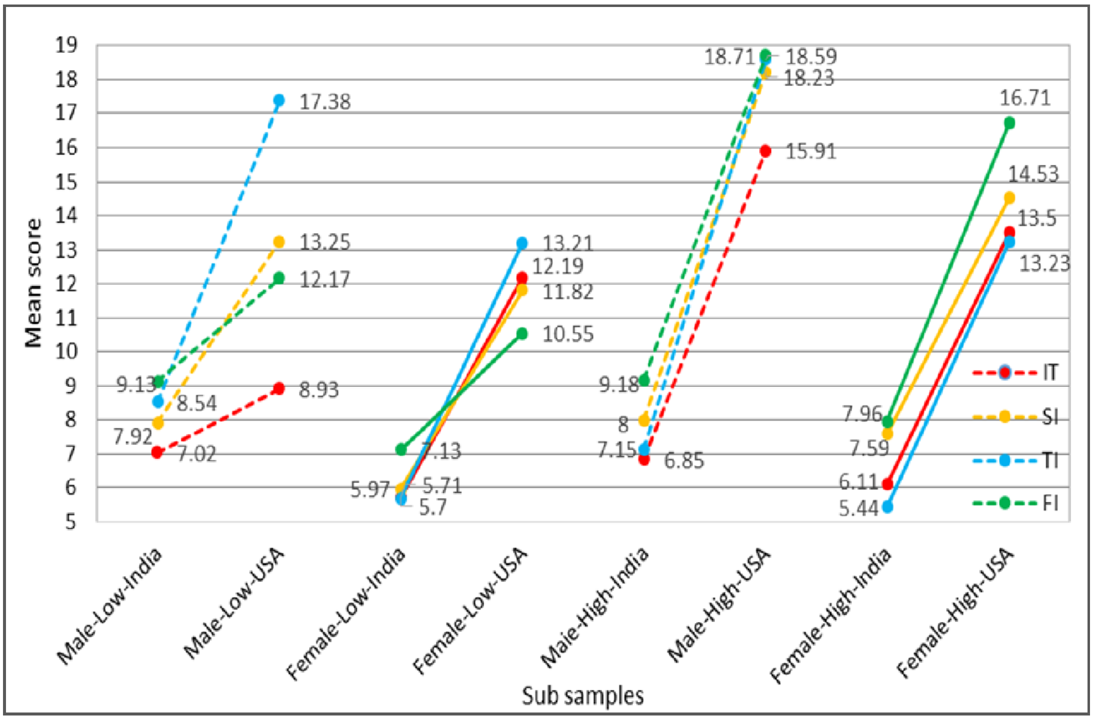

Figure 40. The interaction effect of Type of Integrated Instruction, Previous Achievement in Physics and Gender on Achievement in Physics among the higher secondary students in a) Kerala (India) and b) South Carolina (USA)

As can be seen from Figure 40, Indian male students with low Previous Achievement in Physics do not have a significant impact on Integrated Instruction, whereas the females score high for Fair Integration compared to other types of integration.US male students with low Previous Achievement in Physics reveal a progressive interaction effect, with the highest score with Teacher-dominant integration. Male and female students in India with high Previous Achievement in Physics show similar trend with the impact of Integrated Instruction, with Student-dominant and Fair Integration scoring high. US males with high Previous Achievement in Physics score higher for Student-dominant, Teacher-dominant and Fair Integration, whereas the female students in USA score significantly high with Fair and student-dominant Integration.

Overall, the findings reveal that the effect of Type of Integrated Instruction on Achievement in Physics is impacted by students' Previous Achievement in Physics. In order to examine the specific effects, the effect of Type of Integrated Instruction and Gender on Achievement in Physics were analyzed using Two-way ANOVAs among previously high-achieving and low-achieving students in Kerala (India) and South Carolina (USA) separately.

Two-way Interaction Effects of Type of Integrated Instruction and Gender on Achievement in Physics of High and Low Previous Achievers in Kerala (India) and South Carolina (USA)

Four different factorial (2-way) ANOVAs were performed for confirming the effect of Type of Integrated Instruction and Gender on achievement in Physics with a 4x2 design among Indian and US higher secondary students who achieved low and high previously. The results are shown in Table 44.

Table 44

Summary of Two-way ANOVAs of Achievement in Physics by Type of Integrated Instruction and Gender among Previously Low and High Achieving Higher Secondary Students in India and USA

Subsample by Nationality and Previous Achievement in Physics		Source of Variance	Sum of Squares	df	Mean Square	F	ηp^2
India	Low	Intercept	19501.65	1	19501.65	2473.79	------
		Type of Integrated Instruction x Gender	550.69	7	78.67	9.98*	0.144
		Error	3279.45	416	7.88		
		Total	23474.00	424			
	High	Intercept	7172.94	1	7172.94	898.43	------
		Type of Integrated Instruction x Gender	184.40	7	26.34	3.30*	0.138
		Error	1149.67	144	7.98		
		Total	9440.00	152			
USA	Low	Intercept	13286.79	1	13286.79	633.34	------
		Type of Integrated Instruction x Gender	458.92	7	65.56	3.13*	0.166
		Error	2307.68	110	20.97		
		Total	19282.00	118			
	High	Intercept	56960.39	1	56960.39	1632.48	------
		Type of Integrated Instruction x Gender	1087.40	7	155.34	4.45*	0.112
		Error	8618.31	247	34.89		
		Total	82047.00	255			

*p<.05

The interaction effects of Type of Integrated Instruction and Gender on Achievement in Physics were found significant irrespective of the level of Previous Achievement in Physics among higher secondary students in Kerala (India) and South Carolina (USA). For students with low Previous Achievement in Physics, interaction effects of Type of Integrated Instruction and Gender on Achievement in Physics are significant in India [F (7, 416) = 9.98, p<.05] and USA [F (7,110) =

3.13, $p<.05$]. Likewise, for students with high Previous Achievement in Physics, interaction effects of the Type of Integrated Instruction and Gender on Achievement in Physics are significant both in India [F (7, 144) = 3.30, $p<.05$] and USA [F (7, 247) = 4.45, $p<.05$]. The size of the interaction effect is large in Previously Low-achieving students both in India ($\eta p^2=0.144$) and USA ($\eta p^2=0.166$), whereas it is of medium size for the Previously High-achieving students in India ($\eta p^2=0.138$) and USA ($\eta p^2=0.112$). Figure 41 shows the graphical representation of this effect.

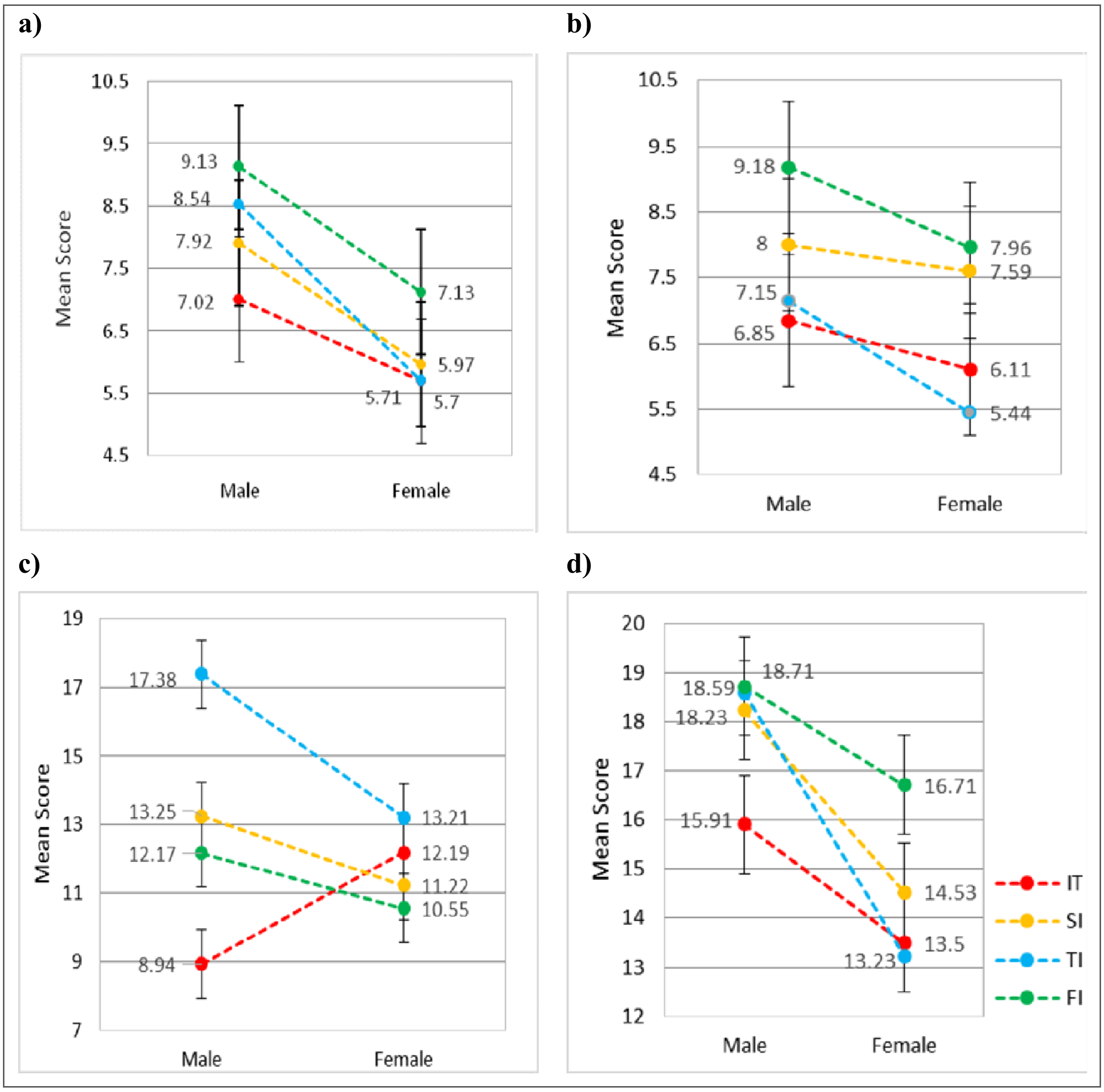

Figure 41. The 4x2 interaction effects of Type of Integrated Instruction and Gender on Achievement in Physics among the previously (a) low-achieving Indian students; (b) high-achieving Indian students; (c) low-achieving US students; (d) high-achieving US students

The factorial (Two-way) ANOVA findings reinstated the statistical significance of the interaction effect of Type of Integrated Instruction and Gender on Achievement in Physics of the higher secondary school students in Kerala (India) and South Carolina (USA). Indian students irrespective of Previous Achievement in Physics, along with students in USA with high Previous Achievement in Physics revealed the interaction effect of Type and Integration and Gender on Achievement in Physics in a similar pattern, with higher Achievement in Physics with FI. The US students with low Previous Achievement in Physics scored high upon receiving Teacher-dominant Integration (TI). Male students in India regardless of their Previous Achievement in Physics along with male students in USA with high Previous Achievement in Physics scored higher when received TI as opposed to the performance of the females. Findings of this analyses indicate an interaction effect of Gender with Type of Integrated Instruction on Achievement in Physics.

In order to further analyze the effect of Type of Integrated Instruction on Achievement in Physics, One-way ANOVAs were performed among previously high-achieving and low-achieving male and female students in Kerala (India) and South Carolina (USA) separately.

Effect of Type of Integrated Instruction on Achievement in Physics of Higher Secondary students by Previous Achievement in Physics, Nationality and Gender

Eight One-way ANOVAs were performed to figure out the effect of Type of Integrated Instruction on Achievement in Physics among male and female higher secondary students in Kerala (India) and South Carolina (USA) with low and high Previous Achievement in Physics. The results are shown in Table 45.

Table 45

Summary of One-way ANOVAs of Achievement in Physics by Type of Integrated Instruction (in subsamples by Previous Achievement in Physics, Nationality and Gender)

Sub sample by Previous Achievement in Physics, Nationality and Gender			Sources of Variance	Sum of Squares	df	Mean Square	F	ηp²
Low	India	Male	Intercept	9769.19	1	9769.19	1269.38	------
			Type of Integrated Instruction	92.530	3	30.84	4.01**	0.077
			Error	1115.92	145	7.69		
			Total	10889.00	149			
		Female	Intercept	10277.64	1	10277.64	1287.36	------
			Type of Integrated Instruction	97.021	3	32.34	4.05**	0.043
			Error	2163.52	271	7.98		
			Total	12585.00	275			
	USA	Male	Intercept	5137.74	1	5137.74	222.51	------
			Type of Integrated Instruction	387.74	3	129.24	5.60**	0.318
			Error	831.22	36	23.09		
			Total	7003.00	40			
		Female	Intercept	10331.33	1	10331.33	517.81	------
			Type of Integrated Instruction	68.88	3	22.96	1.15	0.450
			Error	1476.45	74	19.95		
			Total	12279.00	78			
High	India	Male	Intercept	4381.66	1	4381.66	684.12	------
			Type of Integrated Instruction	55.69	3	18.56	2.90*	0.106
			Error	467.54	73	6.40		
			Total	5183.00	77			
		Female	Intercept	2918.44	1	2918.44	303.7	------
			Type of Integrated Instruction	93.26	3	31.08	3.24*	0.120
			Error	682.12	71	9.60		
			Total	4257.00	75			
	USA	Male	Intercept	53519.70	1	53519.70	1331.65	------
			Type of Integrated Instruction	183.60	3	61.20	1.52	------
			Error	6792.18	169	40.19		
			Total	63244.00	173			
		Female	Intercept	16916.92	1	16916.92	722.57	------
			Type of Integrated Instruction	139.98	3	46.66	1.99	0.071
			Error	1826.13	78	23.41		
			Total	18803.00	82			

*$p<.05$; **$p<.01$

Findings in Table 45 are interpreted under eight sections for the Indian and US male and female samples who achieved low and high previously. The t-test of comparison of means for independent samples has been carried out as the follow up in order to specifically verify the effect of Type of Integrated Instruction on Achievement in Physics.

Effect of Integrated Instruction on Achievement in Physics among Previously Low-achieving Male and Female Students in India

Among students in India with low Previous Achievement in Physics, the effect of Type of Integrated Instruction on Achievement in Physics is significant both in males [$F (3, 145) = 4.01$, $p<.01$; $\eta p^2=0.08$] and females [$F (3, 271) = 4.05$, $p<.01$; $\eta p^2=0.04$]. The descriptive statistical data and comparison of means using t-test are provided in Table 46.

Table 46

Comparison of Means of Achievement in Physics by Type of Integrated Instruction among Previously Low-achieving Male and Female Students in India

Gender	Types of Integration	Descriptive Statistics			t values obtained for Comparison of Means against the group		
		Mean	SD	N	SI	TI	FI
Male	Incompetent Teaching (IT)	7.02	2.308	44	1.55	-2.61**	-3.22**
	Student-Dominant Integration (SI)	7.92	2.954	38	-	-0.93	-1.65
	Teacher- Dominant Integration (TI)	8.54	2.769	35	-	-	-0.8
	Fair Integration (FI)	9.13	3.129	32	-	-	-
Female	Incompetent Teaching (IT)	5.71	2.17	73	-0.6	0.02	-2.74**
	Student-Dominant Integration (SI)	5.97	2.781	61	-	0.58	-2.02*
	Teacher- Dominant Integration (TI)	5.7	2.326	71	-	-	-2.69**
	Fair Integration (FI)	7.13	3.772	70	-	-	-

*$p<.05$; **$p<.01$

As shown in Table 46, among male students in India with low Previous Achievement in Physics, those with IT (M=7.02, SD=2.31) achieved significantly less than those with TI (M=8.54, SD=2.77, t=2.61, *p*<.05) and FI (M=9.13, SD= 3.13, t=3.22, *p*<.01). Students with SI (M=7.92, SD=2.95) did not show any significant difference in Achievement in Physics with the other three instructional types of integrated instruction (p>.05). Male students in India with low Previous Achievement in Physics scored higher with instructional strategies consisted of increased teacher involvement (TI and FI) than those with minimum teacher-centered strategies (IT and SI). The graphical representation of the mean plots and the cumulative frequency distribution of Achievement in Physics by Type of Integrated Instruction among Indian males with low Previous Achievement in Physics are shown in Figure 42.

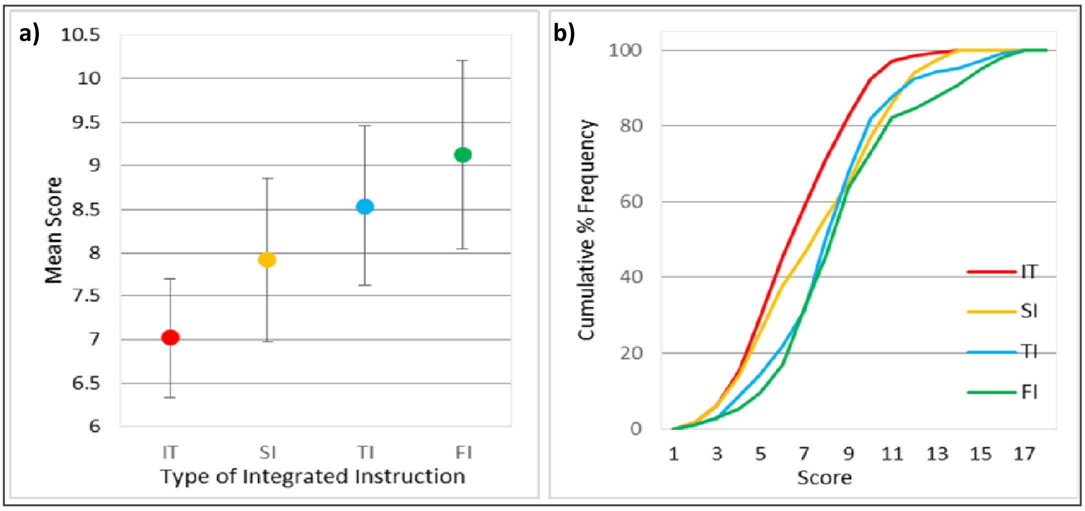

Figure 42. (a) Mean plots with 95% confidence interval error bars of achievement in Physics in four groups by Type of Integrated Instruction (b) The cumulative frequency distribution of achievement in Physics for the four groups by Type of Integrated Instruction among the male students in India with previously low achievement

Among the female students in India with low Previous Achievement in Physics, those with FI (M=7.13, SD=3.77) achieved significantly higher than IT (M=5.71, SD=2.17, t=2.74, *p*<.01), SI (M=5.97, SD= 2.78, t=2.02, *p*<.05), and TI (M=5.70, SD=2.33, t=2.69, *p*<.01). None of the comparisons among IT, SI, and TI revealed significant difference in Achievement in Physics. Unlike male students in India with low Previous Achievement in Physics, the female students scored higher with instructional strategies consisted of teacher and student involvements in a balanced manner (FI) than those with minimum or non-equivalent integration. The graphical representation of the mean plots and the cumulative frequency distribution are shown in Figure 43.

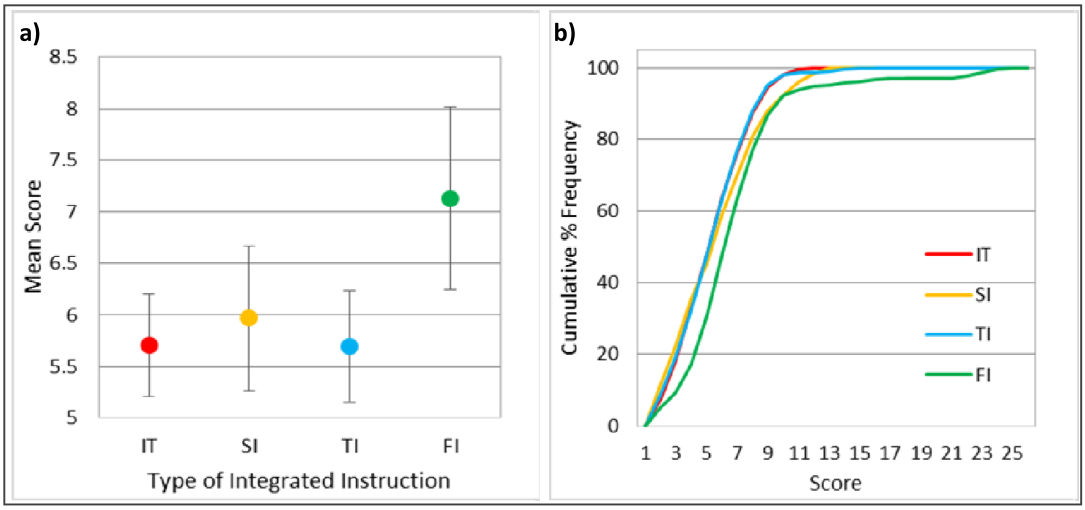

Figure 43. (a) Mean plots with 95% confidence interval error bars of achievement in Physics in four groups by Type of Integrated Instruction (b) The cumulative frequency distribution of achievement in Physics for the four groups by Type of Integrated Instruction among the female students in India with previously low achievement

Effect of integrated instruction on Achievement in Physics among Previously Low-achieving Male and Female Students in USA

As shown in Table 45, among the students in USA with low Previous Achievement in Physics, the effect of Type of Integrated Instruction on Achievement in Physics is significant in males [F (3, 36) = 5.60, p<.01; ηp^2=0.32], whereas, no significant difference was observed in females [F (3, 74) = 1.15, p>.05]. However, the effect size (ηp^2=0.045) was found medium for the females with low Previous Achievement in Physics, hence their mean scores were included in the follow-up analysis along with those of the male students. The descriptive statistics data along with a comparison of means using t-test are shown in Table 47.

Table 47

Comparison of Means of Achievement in Physics by Type of Integrated Instruction for Previously Low-achieving Male and Female Students in USA

Gender	Types of Integration	Descriptive Statistics			t values obtained for Comparison of Means against the group		
		Mean	SD	N	SI	TI	FI
Male	Incompetent Teaching (IT)	8.94	3.53	16	-1.96[a]	-3.95**	-1.68
	Student-Dominant Integration (SI)	13.25	4.031	4	-	-1.47	0.41
	Teacher- Dominant Integration (TI)	17.38	5.502	8	-	-	2.01[b]
	Fair Integration (FI)	12.17	5.906	12	-	-	-
Female	Incompetent Teaching (IT)	12.19	5.657	26	0.67	-0.66	1.23
	Student-Dominant Integration (SI)	11.22	3.843	18	-	-1.4	0.56
	Teacher- Dominant Integration (TI)	13.21	4.098	14	-	-	2.02*
	Fair Integration (FI)	10.55	3.3	20	-	-	-

Note: a, for df of 8, $t \geq 2.10$ and b, for df of 22, $t \geq 2.07$
*$p<.05$;**$p<.01$

The comparison of means using t-test shows that the low-achieving male students in USA achieved significantly higher with TI (M=17.38, SD=5.50) than IT (M=8.94, SD=3.53, t= 3.95, *p*<.05), but not significantly different from those receiving SI (t=1.47, p>.05) and FI (t=0.41, p>.05). Male students in USA who achieved low previously did not reveal a clear distinction between the three types of integration namely, SI, TI and FI. This finding is similar to that of the previously low-achieving male students in India. The graphical representation of the mean plots and the cumulative frequency distribution are shown in Figure 44.

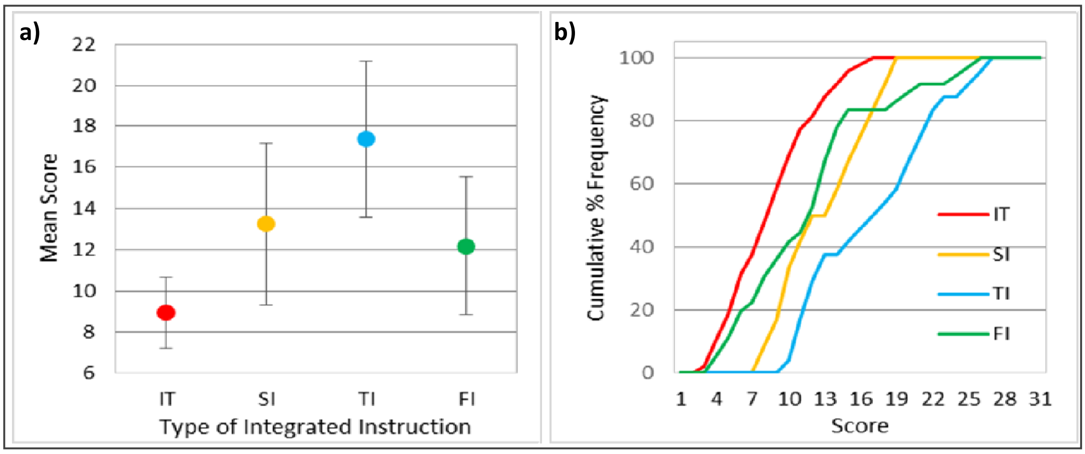

Figure 44. (a) Mean plots with 95% confidence interval error bars of achievement in Physics in four groups by Type of Integrated Instruction (b) The cumulative frequency distribution of achievement in Physics for the four groups by Type of Integrated Instruction among the male students in USA with previously low achievement

From comparison of mean scores, it is evident that low-achieving female students in USA achieve significantly higher with TI (M=13.21, SD=4.10) than FI (M=10.55, SD=3.3, t=2.02, p<.05). No significant difference in achievement was found with TI and SI in the comparison of mean scores (t=1.4, p>.05). The graphical representation of the mean plots and the cumulative frequency distribution are shown in Figure 45.

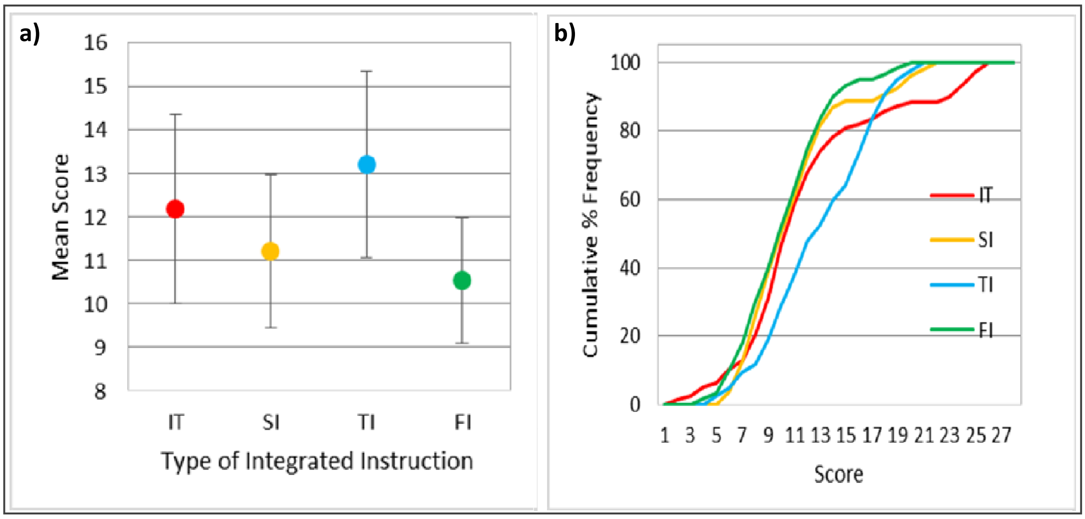

Figure 45. (a) Mean plots with 95% confidence interval error bars of achievement in Physics in four groups by Type of Integrated Instruction (b) The cumulative frequency distribution of achievement in Physics for the four groups by Type of Integrated Instruction among the female students in USA with previously low achievement

It is worth noticing that previously low-achieving male and female students in USA achieved significantly higher with TI, scoring high with instructional strategies consisting more teacher involvement, in the cumulative distribution. Mean plots and cumulative frequency distribution demonstrate that male and female students in USA with low Previous Achievement in Physics achieve high upon receiving TI in 2nd and 3rd quartiles of the distribution and not limited to the mean scores of the groups.

Effect of Type of Integrated Instruction on Achievement in Physics among Previously High-achieving Male and Female Students in India

As shown in Table 45, among the previously high-achieving students in India, the effect of Type of Integrated Instruction on Achievement in Physics is significant both in males [$F(3, 73) = 2.90$, $p<.05$; $\eta p^2=0.11$] and females [$F(3, 71) = 3.24$, $p<.05$; $\eta p^2=0.12$]. The descriptive statistics data along with a comparison of means using t-test are shown in Table 48.

Table 48

Comparison of Means of Achievement in Physics by Type of Integrated Instruction for Previously High-achieving Male and Female Students in India

Gender	Types of Integration	Descriptive Statistics			t values obtained for Comparison of Means against the group		
		Mean	SD	N	SI	TI	FI
Male	Incompetent Teaching (IT)	6.85	2.34	13	-1.27	-0.41	-2.42*
	Student-Dominant Integration (SI)	8	2.898	21	-	1.14	-1.23
	Teacher- Dominant Integration (TI)	7.15	1.953	26	-	-	-2.50*
	Fair Integration (FI)	9.18	2.942	17	-	-	-
Female	Incompetent Teaching (IT)	6.11	2.205	9	-1.34	0.76	-1.73
	Student-Dominant Integration (SI)	7.59	3.411	17	-	2.27*	-0.33
	Teacher- Dominant Integration (TI)	5.44	2.293	25	-	-	-2.80**
	Fair Integration (FI)	7.96	3.793	24	-	-	-

*$p<.05$; **$p<.01$

Table 48 shows that the Indian male students with high Previous Achievement in Physics achieved significantly higher with FI (M=9.18, SD=2.94) compared to IT (M=6.85, SD=2.34, t=2.42, p<.05) and TI (M=7.15, SD=1.95, t=2.50, p<.05). A similar finding was revealed by the Indian males with low Previous Achievement in Physics as well. In other words, integration with student-centered and teacher-centered strategies in a balanced way (FI) makes a significant impact on Achievement in Physics regardless of their Previous Achievement in Physics. The graphical representation of the mean plots and the cumulative frequency distribution are shown in Figure 46.

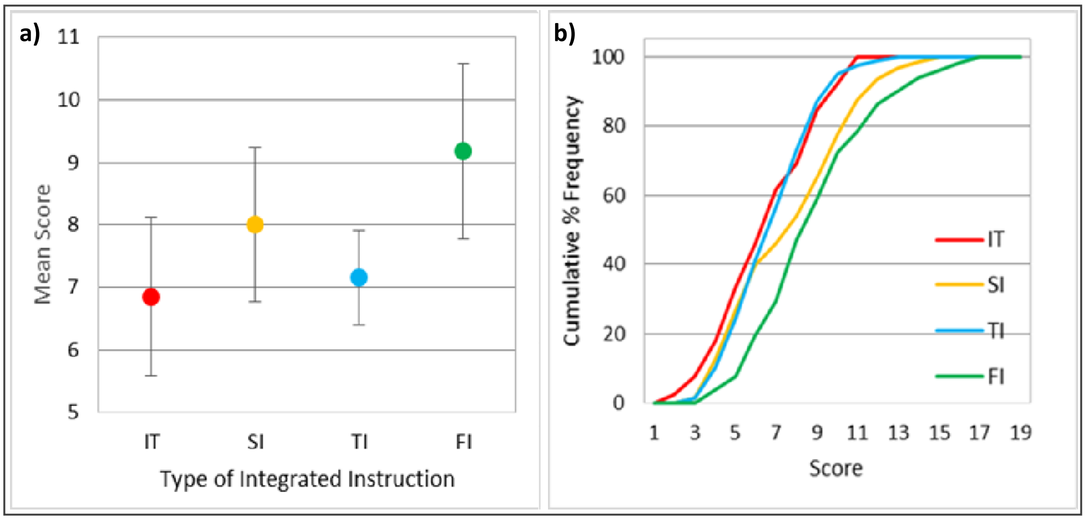

Figure 46. (a) Mean plots with 95% confidence interval error bars of achievement in Physics in four groups by Type of Integrated Instruction (b) The cumulative frequency distribution of achievement in Physics for the four groups by Type of Integrated Instruction among the male students in India with previously high achievement

The high achieving Indian female students achieved significantly lower after TI (M=5.44, SD=2.29) compared to FI (M=7.96, SD=3.79, t=2.80, p<.05) and SI (M=7.59, SD=3.41, t=2.27, *p*<.05). This finding is similar to that of the achievement of the previously low-achieving female students in India. Hence, Indian female students irrespective of their Previous Achievement in Physics achieve high when receiving instruction with increased student-centered strategies. The graphical representation of the mean plots and the cumulative frequency distribution are shown in Figure 47.

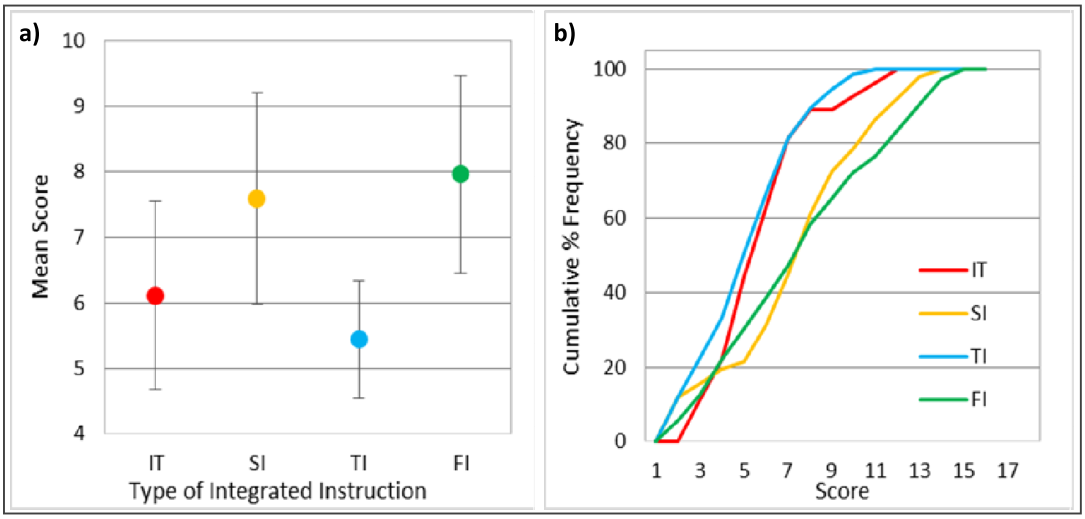

Figure 47. (a) Mean plots with 95% confidence interval error bars of achievement in Physics in four groups by Type of Integrated Instruction (b) The cumulative frequency distribution of achievement in Physics for the four groups by Type of Integrated Instruction among the female students in India with previously high achievement

Therefore, it is obvious that the Indian students regardless of the differences in Gender and Previous Achievement in Physics, score high with integrated instruction. More specifically, Indian students achieve high with a balanced combination of teacher-centered as well as student-centered strategies. Mean plots and cumulative frequency distribution demonstrate that male and female students in India with high Previous Achievement in Physics achieve high upon receiving SI and FI in 2^{nd} and 3^{rd} quartiles of the distribution and not limited to the mean scores of the groups.

Effect of Type of Integrated Instruction on Achievement in Physics among Previously High-achieving Male and Female Students in USA

As shown in Table 45, among students in USA with Previously High Achievement in Physics, the effect of Type of Integrated Instruction on Achievement in Physics is not significant in both males [$F(3, 169) = 1.52$, $p>.05$], and females [$F(3, 78) = 1.99$, $p>.05$]. However, a follow-up analysis has been performed by comparing means using the t-test since a medium effect size of 7.1%

was noticed in the female group. The descriptive statistics data along with a comparison of means using t-test are shown in Table 49.

Table 49

Comparison of Means of Achievement in Physics by Type of Integrated Instruction for Previously High-achieving Male and Female Students in USA

Gender	Types of Integration	Descriptive Statistics			t values obtained for Comparison of Means against the group		
		Mean	SD	N	SI	TI	FI
Male	Incompetent Teaching (IT)	15.91	5.232	32	-1.81	-1.98*	-2.09*
	Student-Dominant Integration (SI)	18.23	5.902	44	-	-0.27	-0.36
	Teacher- Dominant Integration (TI)	18.59	6.718	46	-	-	-0.09
	Fair Integration (FI)	18.71	6.949	51	-	-	-
Female	Incompetent Teaching (IT)	13.5	4.118	24	-0.9	0.21	-1.68
	Student-Dominant Integration (SI)	14.53	3.373	19	-	1.05	-1.16
	Teacher- Dominant Integration (TI)	13.23	4.524	22	-	-	-1.77
	Fair Integration (FI)	16.71	7.078	17	-	-	-

$^{*}p<.05$; $^{**}p<.01$

Male students in USA with high Previous Achievement in Physics achieved significantly lower with IT (M=15.91, SD=5.2) compared to TI (M=18.59, SD=6.72, t= 1.98, p<.05) and FI (M=18.71, SD=6.95, t=2.09, p<.05). This finding is very similar to that of the achievement of the Indian male students with low Previous Achievement in Physics. Additionally, the impact of SI on Achievement in Physics is not found significantly different from TI and FI (*p*>.01). The graphical representation of the mean plots and the cumulative frequency distribution are shown in Figure 48.

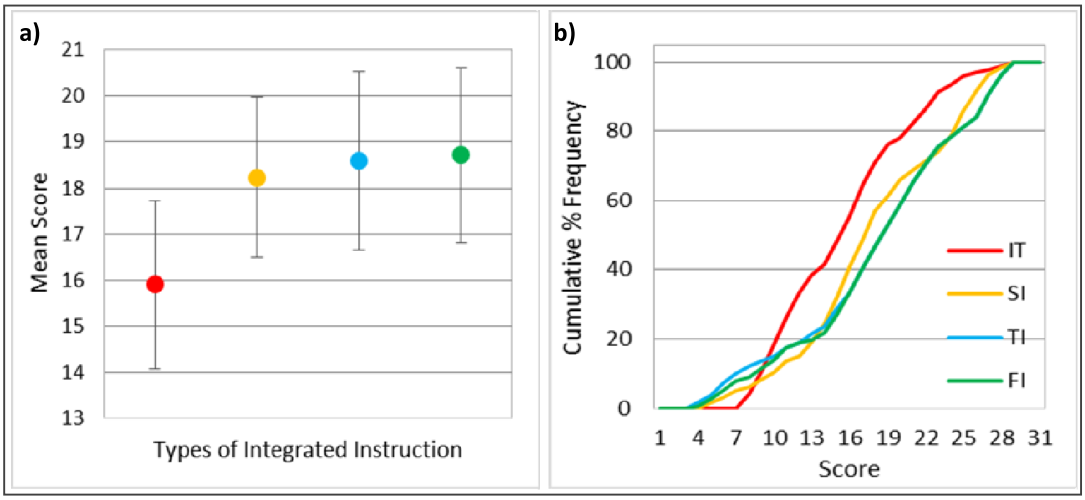

Figure 48. (a) Mean plots with 95% confidence interval error bars of achievement in Physics in four groups by Type of Integrated Instruction (b) The cumulative frequency distribution of achievement in Physics for the four groups by Type of Integrated Instruction among the male students in USA with previously high achievement

The female students did not show any significant difference with any of the types of integration as revealed by the One-way ANOVA on the achievement in Physics due to the Type of integrated Instruction. However, a large effect size (ηp^2=0.072) was observed during the analysis of variance. Therefore, a follow-up test was conducted on the sample. The graphical representation of the mean plots and the cumulative frequency distribution are shown in Figure 49, showing an effect of FI on Achievement in Physics.

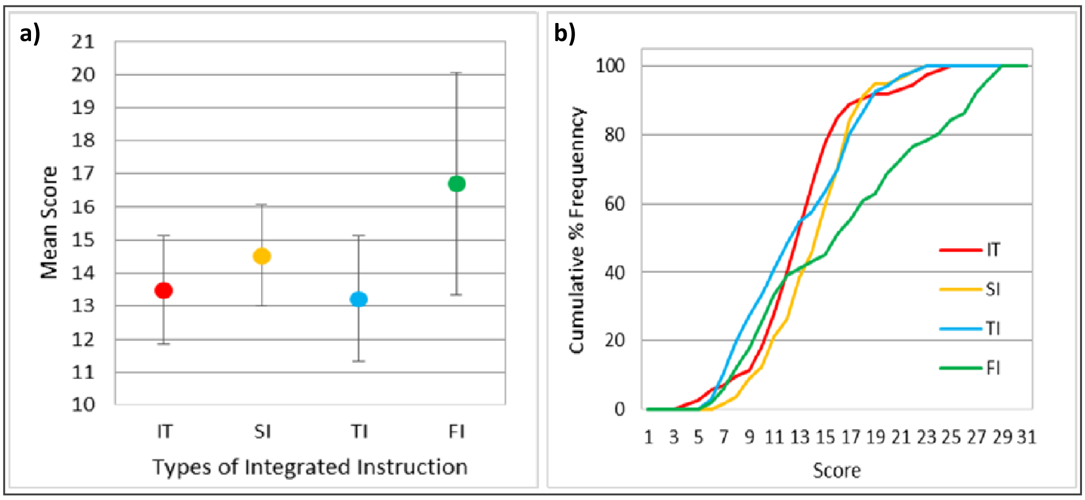

Figure 49. (a) Mean plots with 95% confidence interval error bars of achievement in Physics in four groups by Type of Integrated Instruction (b) The cumulative frequency distribution of achievement in Physics for the four groups by Type of Integrated Instruction among the female students in USA with previously high achievement

Interestingly, comparison of mean scores showed significant findings in the high-achieving male students, not in females. The effect of FI among US females with high achievement in Physics is visible only in 3rd and 4th quartiles of the cumulative frequency distribution and not limited to the mean scores of the groups. Meanwhile, the effect of SI and FI are evident throughout the distribution for US males with high Previous Achievement in Physics.

Summary of the Effect of Type of Integrated Instruction on Achievement in Physics

Achievement in Physics of higher secondary students in Kerala (India) and South Carolina (USA) was analyzed based on Types of Integrated Instruction. It was theorized that there would be a significant effect of Type of Integrated Instruction on the Achievement in Physics of higher secondary students of Kerala (India) and South Carolina (USA). The finding are summarized as follows.

Type of Integrated Instruction	India				USA			
	Previous Achivement				Previous Achievement			
	Low		High		Low		High	
	Male	Female	Male	Female	Male	Female	Male	Female
Incompetent Teaching (IT)	7.02	5.71	6.85	6.11	8.93	12.19	15.91	13.50
Student-Dominant Integration (SI)	7.92	5.97	8.00	7.59	13.25	11.82	18.23	14.53
Teacher- Dominant Integration (TI)	8.54	5.70	7.15	5.44	17.38	13.21	18.59	13.23
Fair Integration (FI)	9.13	7.13	9.18	7.96	12.17	10.55	18.71	16.71
Overall M (SD)	8.06 (2.56)	6.12 (2.87)	7.78 (2.62)	6.81 (3.24)	12.13 (5.59)	11.73 (4.48)	18.03 (6.37)	14.33 (4.93)

Figure 50. The individual impact of each Type of Integrated Instruction on achievement in Physics among the students in Kerala (India) and South Carolina (USA)

There exists significant effect of Type of Integrated Instruction on Achievement in Physics of higher secondary students in Kerala (India), and South Carolina (USA). Previously low-achieving male and female students in USA achieved significantly higher with FI, scoring high with instructional strategies consisting of more teacher involvement. Previously high-achieving Indian males along with previously low-achieving Indian females showed higher achievement with FI alone, whereas the Indian males with previously low achievement had higher achievement with both TI and FI. Previously high-achieving Indian females showed higher achievement with SI and FI, previously high-achieving Indian males showed higher achievement with TI and FI. Previously high-achieving males in USA unveil improvement in Achievement in Physics upon receiving any Type of Integrated Instruction, whereas the females in USA did not have any impact of Integrated Instruction on Achievement in Physics. Both males and females in USA with previously low Achievement scored high with Teacher-dominant Integration.

Tenability of the Hypotheses

The tenability of the hypotheses formulated for the study has been verified in view of the findings and are mentioned below.

1. Hypothesis 1 states that "there is no significant difference between Attitude toward Physics of higher secondary students of Kerala (India), and South Carolina (USA)".

   One-way ANOVA reveals that there is significant effect of Nationality on Attitude of Physics of the higher secondary students in Kerala (India) and South Carolina (USA) at the survey phase [F (1, 1364) =39.33, $p<.01$].

   Hence, the hypothesis stating that "there is no significant difference between Attitude toward Physics of higher secondary students of Kerala (India), and South Carolina (USA)" is rejected.

2. Hypothesis 2 states that "there is significant difference in Attitude toward Physics by Gender among higher secondary students of Kerala (India), and South Carolina (USA)".

   A 2x2 ANOVA of the data reveals that there is a significant interaction effect of Nationality and Gender on Attitude of Physics of the higher secondary students in Kerala (India) and South Carolina (USA) [F (1, 1364) =17.97, *p*<.01].

Hence, the hypothesis stating that "there is significant difference in Attitude toward Physics by Gender among higher secondary students of Kerala (India), and South Carolina (USA)" is accepted.

3. Hypothesis 3a states that "there exists significant difference between higher secondary Physics teachers in Kerala (India), and South Carolina (USA) in the extent of Student-centeredness in instructional strategies".

   Comparison of mean scores reveals that the higher secondary Physics teachers in USA have significantly higher student-centeredness than that the Indian teachers have (t=3.29, p<.01).

   Hence, the hypothesis stating that "there exists significant difference between higher secondary Physics teachers in Kerala (India), and South Carolina (USA) in the extent of Student-centeredness in instructional strategies" is accepted.

- Hypothesis 3b states that "there exists significant difference between higher secondary Physics teachers in Kerala (India), and South Carolina (USA) in the extent of Teacher-centeredness in instructional strategies".

  Comparison of mean scores reveals that there is no significant difference between the higher secondary Physics teachers in India and USA in the extent of Teacher-centeredness in instructional strategies (t=0.12, p>.05).

  Hence, the hypothesis stating that "there exists significant difference between higher secondary Physics teachers in Kerala (India), and South Carolina (USA) in the extent of Teacher-centeredness in instructional strategies" is rejected.

4. Hypothesis 4 states that "there exists significant effect of Integrated Instruction on Attitude toward Physics of higher secondary students in Kerala (India), and South Carolina (USA)".

   A One-Way ANOVA of data reveals that there is a significant effect of Integrated Instruction [$F (3, 945) = 23.77$, $p<.01$] on Attitude toward Physics of the higher secondary students in India and USA. Following up of the findings by comparing the mean scores specifically discloses that the effect of TI (M= 67.55, SD=11.75, N=247) and FI (M=65.97, SD=14.01, N=243) are significantly higher compared to the effects of SI (t=4.68 & 3.01) and IT (t=7.92 & 6.05). Effects of TI and FI are not significantly different (t=1.36, $p>.05$).

   Hence, the hypothesis stating that "there exists significant effect of Integrated Instruction on Attitude toward Physics of higher secondary students in Kerala (India), and South Carolina (USA)" is accepted.

5. Hypothesis 5 states that "Gender, Nationality and Previous Attitude toward Physics significantly interact with the effect of Integrated Instruction on Attitude toward Physics among higher secondary students of Kerala (India), and South Carolina (USA)".

   A 4x2x2x2 ANOVA using the data reveals that Gender, Nationality and Previous Attitude toward Physics significantly interact with the effect of Integrated Instruction on Attitude toward Physics [$F (31, 917) = 8.58$, $p<.01$] of the higher secondary students in India and USA. A series of factorial ANOVAs and t-tests were performed to examine each of the moderator variables with the effect of Integrated Instruction on Attitude toward Physics of higher secondary students in Kerala (India) and South Carolina (USA) individually and in different possible combinations.

Hence, the hypothesis stating that “Gender, Nationality, and Previous Attitude toward Physics interact significantly with the effect of Integrated Instruction on Attitude toward Physics of the higher secondary students in Kerala (India) and South Carolina (USA)” is accepted.

6. Hypothesis 6 states that “there exists significant effect of Integrated Instruction on Achievement in Physics of higher secondary students of Kerala (India), and South Carolina (USA)”.

   A One-Way ANOVA of data reveals that there is a significant effect of Integrated Instruction [F (3, 945) =4.94, p<.01] on Achievement in Physics of the higher secondary students in India and USA.

   A significant effect of Type of Integrated Instruction was revealed on the Achievement in Physics. Effect of IT (M=9.13, SD=5.15) is significantly lower compared to SI (M= 10.34, SD= 5.98, t=2.33, p<.05) and FI (M= 11.25, SD= 6.62, t=3.91, p<.01). Mean scores also show that there is no significant difference of Achievement in Physics for students receiving SI (M= 10.34, SD= 5.98) with students receiving TI (M= 10.11, SD= 6.40, t=0.41 p>.05) and FI (M= 11.25, SD= 6.62, t=1.55, p>.05).

   Hence, the hypothesis stating that “there exists significant effect of Integrated Instruction on Achievement in Physics of higher secondary students in Kerala (India), and South Carolina (USA)” is accepted.

7. Hypothesis 7 states that “Gender, Nationality and Previous Achievement in Physics significantly interact with the effect of Integrated Instruction on Achievement in Physics among higher secondary students of Kerala (India), and South Carolina (USA)”.

   A 4x2x2x2 ANOVA using the data reveals that Gender, Nationality and Previous Achievement in Physics significantly interact with the effect of

Integrated Instruction on Achievement in Physics [F (31, 917) =38.54, $p<.01$] of the higher secondary students in India and USA. A series of factorial ANOVAs and t-tests were performed to examine each of the moderator variables with the effect of Integrated Instruction on Achievement in Physics of higher secondary students in Kerala (India) and South Carolina (USA) individually and in different possible combinations.

Hence, the hypothesis stating that “Gender, Nationality, and Previous Attitude toward Physics interact significantly with the effect of Integrated Instruction on Attitude toward Physics of the higher secondary students in Kerala (India) and South Carolina (USA)” is accepted.

Chapter V

SUMMARY, FINDINGS AND CONCLUSION

- *Restatement of the Problem*
- *Variables in the Study*
- *Methodology*
- *Major Findings*
- *Conclusion*
- *Implications*
- *Limitations of the Study*
- *Future Research*

Summary, Findings, And Conclusion

This chapter presents the major milestones during the implementation of this study. Major findings, their relevance in the fields of research and practice for both educators and experts in physics education at higher secondary level were explored. Apart from summarizing results and drawing conclusions, this chapter provides prominent implications of the study and suggestions for future research in a compact way.

Restatement of the Problem

This study was entitled as **"Influence of Integrated Instruction on Attitude toward Physics and Achievement in Physics among Higher Secondary Students of Kerala in India and South Carolina in the United States"**

Subsequent to the examination of the proposition that higher secondary school male and female students in India and United States differ on their perception of physics and attitude towards physics, this study investigated whether higher secondary school physics teachers in India and United States differ in the extent of their practice of teacher-centered and student-centered strategies in classroom; then examined whether such differences in their teacher's instructional practices, denoted as type of Integrated Instruction, effected Attitude toward Physics and Achievement in Physics of higher secondary students; to end with, verifying how those effects of Integrated Instruction interacted with student's Gender, Nationality and Previous levels of the attitude and the achievement.

The specific questions for which this study sought answers were:

1. Do higher secondary students of Kerala (India), and South Carolina (USA) differ in their Attitude toward Physics?
2. Does Gender affect Attitude toward Physics regardless of Nationality of higher secondary students in Kerala (India) and South Carolina (USA)?
3. Do higher secondary physics teachers in Kerala (India), and South Carolina (USA) differ in the extent of Student-centeredness and Teacher-centeredness in their instruction?
4. Does Integrated Instruction in physics affect Attitude toward Physics of higher secondary school students in Kerala (India), and South Carolina (USA)?
5. Does the effect of Integrated Instruction on Attitude toward Physics among higher secondary students in Kerala (India), and South Carolina (USA) vary by Gender, and if so, to what extent?
6. Does the effect of Integrated Instruction on Attitude toward Physics higher secondary students in Kerala (India), and South Carolina (USA) vary by Nationality, and if so, to what extent?
7. Does Integrated Instruction affect Achievement in Physics of higher secondary school students in Kerala (India), and South Carolina (USA)?
8. Is there an effect of Integrated Instruction due to Gender on Achievement in Physics of higher secondary students in Kerala (India), and South Carolina (USA)?
9. Is there an effect of Integrated Instruction due to Nationality on Achievement in Physics of higher secondary students in Kerala (India), and South Carolina (USA)?

Variables in the Study

The independent and dependent variables of the study are as follows:

I. The major independent variable in the study is Integrated Instruction in phase 3.

Integrated Instruction is categorized as having four levels.

i. Teaching with minimal integration (Incompetent Teaching or IT),

ii. Teaching with average integration with increased concentration on student-centered tactics (Student-dominant Integration or SI),

iii. Teaching with average integration with increased concentration on teacher-centered tactics (Teacher-dominant Integration or TI)

iv. Teaching with maximum and balanced integration (Fair Integration or FI).

In addition, Student-centered Instruction and Teacher-centered Instruction were studied by nationality in phase 2.

Two dependent variables in the study are:

1) Attitude toward Physics (with four components of Affect toward Physics, Self-defined abilities, Perception on Content/Personal difficulties, and Future expectations on Physics)
2) Achievement in Physics.

The moderator variables used were:

1) Gender
2) Nationality
3) Previous level of Attitude towards Physics
4) Previous level of Achievement in Physics

Methodology

The study progressed through distinct though complementary phases, which used a mixed methods research with an exploratory sequential design. The initial phases required more open and flexible qualitative data which were then used to develop more structured data collection instruments and procedures appropriate for quantitative analysis. The study was mixed of qualitative and quantitative methods, which used interviews, questionnaires, attitude scaling, an inventory and achievement testing as research tools.

Three phases in the study required multiple samples drawn by multiphase multistage sampling in a time span of three consecutive academic years.

Sample

Higher secondary students and teachers of two countries, India and USA from the states of Kerala and South Carolina, respectively, were the selected populations for the study. Kerala (India) and South Carolina (USA) states were chosen to represent their respective countries with the assumption that they are typical yet relatively comparable states of the two nations. The teacher and student samples used in the three phases of this study are related; as the data was collected repeatedly from the same cohort of teachers and their students in these two states. Randomness was applied in choosing the districts and schools within each district.

In phase 1, pilot studies were performed among students and teachers, on random samples of 121 students drawn from 3 schools from one district each of Kerala and South Carolina, and 82 physics teachers randomly chosen from 57 schools in three districts each of Kerala and South Carolina including those from the 6 schools used for pilot study among students.

In phase 2, surveys among students and teachers were conducted. A total of 1368 students were drawn by stratified random sampling from 24 randomly drawn schools from the previously chosen 57 schools (3 from each district: 2x3x4 =24 schools) in Kerala and South Carolina. The teacher sample in phase 2 consisted of 106 teachers drawn by stratified random sampling from randomly chosen 9 districts including all previously chosen districts each of Kerala and South Carolina for pilot study among teachers.

In phase 3, student sample for ex post facto phase consisted of 949 students of 24 classrooms, of which 12 classrooms each in Kerala and South Carolina, who were taught by the select 24 teachers from the previous pool of 106 teachers. Teacher sample for ex post facto phase consisted of select sample of 24 teachers (12 per nation), who were considered typical of the 4 types of integration (3 teachers for each type of integrated instruction) from Kerala and South Carolina.

Research Instruments used for the Study

A total of six research instruments were used to measure the dependent variables in this study. All instruments except the Achievement Test were developed during the study. The tools used for the study are:

1) Structured Interview schedule for Students
2) Questionnaire on Student Attitude toward Physics
3) Scale of Attitude toward Physics
4) Structured Interview schedule for Teachers
5) Physics Classroom Practices Inventory, and
6) The Force Concept Inventory (developed by Hestenes, Wells & Swackhamer, 1992).

Statistical Techniques used in the Study

Apart from qualitative analysis, a variety of statistical techniques were used in this study including descriptive statistics and graphical summaries and comparisons, Chi-Square Test of Homogeneity, One-way ANOVA, Factorial ANOVA, Test of Significance of Difference between Means, Exploratory and Confirmatory Factor Analyses (SPSS version 24), and Effect Size as Partial Eta squared.

Major Findings

The major findings are described in the order of the phases (pilot study, survey of students and teachers, and prospective ex post facto study) used in this study. Based on the findings from the qualitative analysis in the initial part, this study drew valuable information on students' and teachers' perspectives on learning physics.

The following are the noteworthy findings emerged from this study on Integrated Instruction of student-centered and teacher-centered strategies and its influence on Attitude toward Physics and Achievement in Physics among higher secondary students in Kerala (India) and South Carolina (USA).

1. ***Though both teachers and students agree on the desirability of more direct and constructivist strategies, students still perceive domination of lecturing in their physics classrooms.***

   i. More students than their teachers perceive lecturing in physics classrooms [$\chi^2(1, N=121) = 14.42, p<.01$]; but less students than their teachers perceive Interactive Lecture Demonstration [$\chi^2(1, N = 82) = 31.01, p<.01$], Hands-on Learning [$\chi^2 (1, N=82) = 50.39, p<.01$] and Problem-Based Learning ($\chi^2(1, N = 82) = 9.37, p<.01$)in physics classrooms.

ii. Both teachers and students equally prefer Problem-Based Learning (χ^2(1, N = 82) = 0.51, p>.05), Hands-on Learning (χ^2(1, N = 82) = 3.17, p>.05), Interactive Lecture Demonstration (χ^2(1, N = 82) = 3.04, p>.05) over lecturing (χ^2(1, N = 82) = 0.08, p>.05).

2. *Higher Student-centered strategies need not necessarily secure a concomitantly higher Attitude toward Physics among students; female students, especially those in USA possess comparatively lower Attitude towards Physics*

2.1. Student-centered instructional strategies are significantly and consistently higher among teachers in USA than in India

i. Student-centered instructional strategies in physics is significantly higher among teachers in USA (M=57.76, SD=7.27) than among Indian teachers (M=53.13, SD=7.25, t=3.29, p<.01].

ii. There is no significant difference between the extents of using teacher-centered instructional strategies by teachers in Kerala (India) (M=55.93, SD=7.48) and South Carolina (USA) (M=56.14, SD=10.33, t=0.12, *p*>.05].

2.2. Significantly more Indian teachers use Teacher-dominant Integration (TI);more of those in USA use Fair Integration (FI)

i. Incidence of Type of Integrated Instruction differ by nationality, [($\chi 2$ (3, N = 106) = 10.20, p<.01].

ii. More Indian teachers use teacher-dominant integration (TI) [($\chi 2$ (1, N = 106) = 5.30, p<.05], whereas more of those in USA use Fair Integration (FI) [($\chi 2$ (1, N = 106) = 4.72, p<.05].

iii. There is no significant difference by Nationality in incidence of Incompetent Teaching (IT) [($\chi 2$ (1, N=106) = 2, p<.05] and Student-dominant Integration (SI) [($\chi 2$ (1, N = 106) = 1.66, p<.05].

2.3. Indian female higher secondary students have higher Attitude toward Physics than females in USA, but male students of India and USA do not differ.

i. Main effects of Nationality [F (1, 1364) =39.33, p<.01] and Gender [F (1, 1364) =26.67, p<.01] and their interaction effect [F (1, 1364) =17.97, p<.01], on Attitude toward Physics are found significant.

ii. There is no significant difference between the Attitude toward Physics of the male students in India (M=16.20, SD=4.07) and USA (M=15.69, SD=3.73, t=1.66; p>.05]. However, the Attitude toward Physics is found significantly higher among the female students in India (M=15.97, SD=3.47) compared to their counterparts in USA (M=13.34, SD=4.12, t=6.86; p<.01].

3. Integrated Instruction advances Attitude toward Physics of higher secondary students

i. Effect of Type of Integrated Instruction on Attitude toward Physics is significant [F (3, 945) =23.77, p < .01].

3.1. Attitude toward Physics is higher for students receiving Teacher-dominant Integration and Fair Integration compared to those receiving Incompetent Teaching and Student-dominant Integration.

i. Mean score of Attitude toward Physics after IT (M=58.15, SD=14.28, N=237, *p*<.01) is significantly lower compared to those after SI (M= 62.15, SD= 13.27), TI (M= 67.55, SD= 11.75, *p*<.01), and FI (M= 65.97, SD=14.01, *p*<.01).

ii. Mean score of Attitude towards Physics after SI is significantly less than those after TI (t=4.68, p<.01) and FI (t=3.01, p<.01).

iii. There is no significant difference between Attitude toward Physics of students receiving TI and FI (t= 1.36, p>.05)

4. Fair Integration and Teacher-dominant Integration enhance Attitude toward Physics of students with previously low attitude

4.1. Fair Integration and Teacher-dominant Integration adds to Attitude towards Physics of previously low attitude students in US irrespective of gender and such male students in India ; but they enhance(only) Future Expectations on Physics in Indian female students

i. Attitude toward Physics with TI (Mean=65.16, SD=12.10) is significantly higher than that with IT (Mean=56.23, SD=10.43, t=2.65, p<.01) and SI (Mean=51.84, SD=12.50, t=3.55, p<.01) for US males with previously low Attitude toward Physics.

ii. US males with previously low Attitude toward Physics after Fair Integration (Mean=58.74, SD=16.68) had no significant difference in Attitude toward Physics in comparison with Teacher-dominant Integration (Mean=65.16, SD=12.10, t=1.43, p>.05).

iii. Among females in USA with previously low attitude, Attitude toward physics after TI (Mean=65.67, SD=9.37) was significantly higher than that after IT (Mean=51.50, SD=12.26, t= 3.69, p<.01) and SI (Mean=52.77, SD=15.32, t= 2.71, p<.01).

iv. US females received FI Type of Integrated Instruction (Mean=57.88, SD=16.79), in comparison to TI type of integration, had no significant difference in Attitude towards Physics (t=1.49, p>.05).

v. Attitude toward Physics with FI (M=65.30, SD=9.79) is significantly higher than that with IT (M=56.76, SD=12.43, t= 2.66, $p<.01$) and SI (M=56.10, SD=9.48, t=3.29, $p<.01$) for Indian male students with previously low Attitude toward Physics.

vi. Effects of TI and FI on students' Attitude toward Physics did not show any significant difference for this group (t=1.22, $p>.05$).

vii. Among the female students in India with previously low attitude, Attitude toward Physics after IT (Mean=55.29, SD=14.88) is significantly lower than those after SI (Mean=61.40, SD=8.89, t=2.22, $p<.05$), TI (Mean=64.08, SD=10.54, t=3.19, $p<.01$), and FI (Mean=63.28, SD=11.61, t=2.55, $p<.05$). None of the comparisons among SI, TI and FI revealed significant difference in Attitude toward Physics.

4.2. Type of Integrated Instruction does not significantly affect Attitude toward Physics of the US male as well as female students with previously high attitude.

i. Attitude toward Physics of US males with previous high Attitude toward Physics do not differ by type of Integrated Instruction [F (3, 112) = .347, $p>.05$]. Mean scores show no statistical difference with IT (Mean=67.95, SD=15.31), SI (Mean=71.57, SD=8.50), TI (Mean=69.23, SD=11.97), and FI (Mean=70.06, SD=12.84).

ii. Attitude toward Physics of US females with previous high attitude toward Physics do not differ by type of integrated Instruction [F (3, 48) = .104, $p>.05$]. Mean scores do not show significant difference for IT (Mean=69.00, SD=6.50), SI (Mean=67.50, SD=10.31), TI (Mean=68.42, SD=10.22), and FI (Mean=66.58, SD=15.91).

4.3. *Fair Integration and Teacher-dominant Integration enhance Self-defined Abilities and Perception of Content/Personal Difficulties in Learning Physics among Indian males.*

i. Among the male students in India, effect of FI (M=18.51, SD=3.45, 2.72) on Self-defined Abilities in Learning Physics is found significantly higher compared to SI (M=17.02, SD=3.42, t=2.25, $p<.05$). Those with IT (M=16.51, SD=4.05) revealed significantly lower Self-defined Abilities in Learning Physics than those with FI (M=18.51, SD=3.45, 2.72, $p<.01$) and TI (M=18.15, SD= 3.41, t=2.39, $p<.05$)). Effects of TI and FI did not show any significant difference for the Indian males ($p>.05$).

ii. Mean scores of *Perception of Content/Personal Difficulties in Learning Physics* of Indian male students with SI and TI did not show any significant difference compared to those with FI ($p>.05$).Male students in India receiving IT (Mean=7.95, SD=5.00) had significantly lower *Perception of Content/Personal Difficulties in Learning Physics* than those with FI (Mean=10.51, SD=4.35, t= 2.80, $p<.01$) and TI (Mean=9.79, SD= 4.59, t= 2.09, $p<.01$).

4.4. *Teacher-dominant Integration improves Future Expectations on Physics of female students in India and USA.*

i. Among the US females, those with TI (Mean=19.72, SD=3.67) were found to have significantly higher Future Expectations on Physics than those with IT (Mean=16.32, SD=4.40, t= 3.79, $p<.01$), SI (Mean=16.22, SD=5.55, t=3.17, $p<.01$) and FI (Mean=17.38, SD=4.42, t=2.46, $p<.01$). The effects of SI and FI did not show any significant difference (t=1.00, $p>.05$).

ii. Among the Indian females, compared to those with IT (M=17.83, SD=3.85) students with FI (M=19.72, SD=3.21, t= 3.56, p<.01), TI (M=20.31, SD= 3.09, t=4.77, p<.01) and SI (M=19.28, SD= 2.82, t=2.72, p<.01) possessed significantly higher Future Expectations on Physics. Effects of SI and FI did not show any significant difference for this group (t=0.95, p>.05).

iii. There is no significant difference in the effect of Type of Integrated Instruction on Future Expectations on Physics among the male students in India [F (3, 222) = 1.89, p>.05] and USA [F (3, 209) = 2.05, p>.05].

4.5. Integrated Instruction has significant impact on Attitude toward Physics or its factors in higher secondary students except of previously high attitude US male students.

i. Among US males with high Previous Attitude toward Physics, the effect of Type of Integrated Instruction on Attitude toward Physics is not significant [F (3, 112) = .347, *p*>.05]

5. Gender and Nationality difference exists in the Achievement in Physics in favor of males and US students despite comparable type of instruction.

i. The effect of Nationality on Achievement in Physics is significant [F (1, 947) = 714.71, *p*<.01], with a large effect size (ηp^2=0.43) when controlled for the type of instruction.

ii. There is significant interaction effect of Nationality and Gender [F (1, 947) = 13.39, *p*<.01], on Achievement in Physics.

iii. Achievement in Physics differs by Nationality among both males (India: M=7.96, SD=2.78, N=226; USA: M=16.91, SD=6.65, N=213, t=18.58, *p*<.01) and females (India: M=6.27, SD=2.96, N=350; USA: M=13.06, SD=4.88, N=160, t=19.38, *p*<.01).

iv. The effect of Gender on Achievement in Physics is significant [F (1, 947) = 88.46, *p*<.01], with a medium effect size (ηp^2=0.09) when controlled for the type of instruction. Achievement in Physics varies also by Gender in India (male: M=7.96, SD=2.78, N=226; female: M=6.27, SD=2.96, N=350, t=6.85, p<.01) and USA (male: M=16.91, SD=6.65, N=213; female: M=13.06, SD=4.88, N=160, t=6.17, *p*<.01).

6. ***Integrated Instruction has significant impact on Achievement in Physics among higher secondary students of India and USA.***

   i. Type of Integrated Instruction has a significant effect on students' Achievement in Physics [F (3, 945) =4.94, p <.01].

6.1. Influence of Integrated Instruction at all levels (SI, TI, and FI) were found equally effective on students' Achievement in Physics.

   i. Mean score of Achievement in Physics after IT (M=9.13, SD=5.15) is significantly less than those after SI (M= 10.34, SD= 5.98, t=2.33, *p*<.05), and FI (M= 11.25, SD= 6.62, t=3.91, *p*<.01).

   ii. There is no significant difference in the Achievement in Physics among students receiving FI (M= 11.25, SD= 6.62) compared to those receiving SI (M= 10.34, SD= 5.98, t=1.55, *p*>.05) and TI (M= 11.25, SD= 6.62, t=1.94, *p*>.01).

6.2. Fair Integration makes a positive impact on the Achievement in Physics of Indian students, irrespective of gender and previous achievement.

   i. Among previously low-achieving male students in India, those with IT (Mean=7.02, SD=2.31) achieved significantly less than FI (Mean=9.13, SD= 3.13, t=3.22, *p*<.05). Students with FI were not significantly different from those with SI (Mean=7.92, SD=2.95, t=1.65, $p>.05$) and TI (Mean=8.54, SD=2.77, t=.80, $p>.05$.

ii. Among previously low-achieving female students in India, those with FI (M=7.13, SD=3.77) achieved significantly higher than SI (M=5.97, SD= 2.78, t=2.02, $p<.05$), and TI (M=5.70, SD=2.33, t=2.69, $p<.05$).

iii. High-achieving Indian male students achieved significantly higher with FI (M=9.18, SD=2.94, $p<.05$) compared to IT (M=6.85, SD=2.34, t=2.42, $p<.05$) and TI (M=7.15, SD=1.95, t=2.50, $p<.05$).

iv. High achieving Indian female students achieved significantly higher after FI (M=7.96, SD=3.79) than TI (M=5.44, SD=2.29, t=2.80, $p<.05$).

6.3. Teacher-dominant Integration is effective on Achievement in Physics for previously low achievers in USA irrespective of Gender.

i. Achievement in Physics of previously low-achieving male in USA after Teacher dominant Integration (M=17.38, SD= 5.50) is almost significantly higher than that after Fair Integration (M=12.17, SD= 5.91, t=2.01; tabled value 2.10 for $p=.05$).

ii. Achievement in Physics of Previously Low-achieving Female in USA after Teacher dominant Integration (M=13.21, SD= 4.10) is significantly higher than that after Fair Integration (M=10.55, SD= 3.3, t=2.02, $p<.05$).

6.4. For formerly high achieving Indian females instruction with Student-dominant Integration is equally effective as that with Fair Integration.

i. Achievement in Physics of previously high-achieving females in India receiving SI is equally effective as that of FI (M=7.96, SD= 3.79, t=0.33, p>.05). Indian males in this group with FI did not significantly differ from those with SI (M=8.00, SD=2.90, t=1.23, *p*>.05).

6.5. Integrated instruction is not found adding to Achievement in Physics of previous high achievers of USA, irrespective of Gender.

i. Among Previous high achievers in USA, the effect of Type of Integrated Instruction on Achievement in Physics is neither significant in males [F (3, 169) = 1.52, p>.05], nor in females [F (3, 78) = 1.99, p>.05].

The status of hypotheses formulated for the study in view of the above findings are as follows.

1. Hypothesis 1 that "there is no significant difference between Attitude toward Physics of higher secondary students of Kerala (India), and South Carolina (USA)" is rejected.
2. Hypothesis 2 that "there is significant difference in Attitude toward Physics by Gender among higher secondary students of Kerala (India), and South Carolina (USA)" is accepted.
3. Hypothesis 3a that, "there exists significant difference between higher secondary physics teachers in Kerala (India), and South Carolina (USA) in the extent of Student-centeredness in instructional strategies" is accepted.

   Hypothesis 3b that, "there exists significant difference between higher secondary physics teachers in Kerala (India), and South Carolina (USA) in the extent of Teacher-centeredness in instructional strategies" is rejected.
4. Hypothesis 4 that "there exists significant effect of Integrated Instruction on Attitude toward Physics of higher secondary students in Kerala (India), and South Carolina (USA)" is accepted.

5. Hypothesis 5 that “Gender, Nationality, and Previous Attitude toward Physics interact significantly with the effect of Integrated Instruction on Attitude toward Physics of the higher secondary students in Kerala (India) and South Carolina (USA)” is accepted.
6. Hypothesis 6 that “there exists significant effect of Integrated Instruction on Achievement in Physics of higher secondary students in Kerala (India), and South Carolina (USA)” is accepted.
7. Hypothesis 7 that “Gender, Nationality, and Previous Achievement in Physics interact significantly with the effect of Integrated Instruction on Achievement in Physics of the higher secondary students in Kerala (India) and South Carolina (USA)” is accepted.

Conclusion

Findings based on a careful analysis led to the following concluding remarks.

Teacher-centered and student-centered instructional strategies are not mutually exclusive

The direct relationship of students’ attitude toward school science with classroom environment and learning activities has already been a debated issue for the last few decades (Piburn, 1993; Myers & Fouts, 1992; Simpson & Oliver, 1990; Talton & Simpson, 1987).Therefore, major objectives of this study were to highlight the strength of Integrated Instruction in higher secondary physics to emphasize that teacher-centered and student-centered instructional strategies are not mutually exclusive; they constitute a continuum. Findings of the study reinstate the role of the instructor in a student-centered learning environment which is likewise for two nationalities that are diverse in many aspects. As indicated by Frazer (2017), diversity has been identified as a critical factor for the success of education. However, studies on diverse groups of students, interactions between student attributes, and teaching methods are not very common in physics education research. There is room for developing such studies since cross-national studies add to this diversity in physics education in terms of student attributes and teaching methods (Frazer, 2017).

Perceptions of students and teachers are not complementary

Effect of integrated instructional strategies on students' Attitude toward Physics and Achievement in Physics during a semester of an academic year is studied among students from Kerala (India) and South Carolina (USA). Qualitative analysis of responses from both students and teachers indicated that perceptions of students and teachers on currently adopted classroom practices are not complementary, whereas they agree well on preferred instructional strategies for improved outcomes in learning physics. Ramsey, Nemeth, and Haberkorn (2013) report that predominant teaching practices like lecturing with demonstration and hands-on activities are commonly used by the teachers regardless of the demographic differences. Nonetheless, findings of this study show that such practices are not commonly implemented in Indian physics classrooms agreeing to reports by Sharma et al. (2013) and Varghese (2008) that the existing practices in the Indian classrooms lack an active component of student engagement in the learning process.

Instructional strategies could be culture-specific

The Extent of teacher-centeredness in classroom practices does not significantly differ between teachers of India and USA. But, student-centered instructional strategies is significantly and consistently higher among teachers in

USA than in India. Type and extent of integration of student-centeredness and teacher-centeredness varies among physics teachers. Analysis of the extents of integration of student-centeredness and teacher-centeredness of teachers reveals that more Indian teachers use teacher-dominant integration (TI), whereas more of those in USA use Fair Integration (FI), agreeing with Ramsey, Nemeth, and Haberkorn (2013) indicating that there were differences in practices related to all faces of teaching and learning based on demographics.

Responses from higher secondary school physics teachers in India and US reveal that there is a firm difference between their classroom practices with respect to nationality. However, impact of those strategies on students' Attitude toward Physics and Achievement in Physics has not been investigated before. Chai, Friedler, Wolff, Li and Rhea (2015) indicate that there could be an effect for a particular instructional strategy on a specific culture. They suggest that conducting cross-national studies in the field of education is advantageous as the educator community all over the world receive information on alternative strategies, and feedback on existing approaches.

In case of students with previously high attitude, although integration of any type makes a positive impact irrespective of Nationality and Gender of students, a specific effect among Student-dominant, Teacher-dominant and Fair integration is not evident. It is noteworthy that Integrated Instruction significantly impacts Attitude toward Physics or its factors among higher secondary students in both the countries. This finding agrees with the observation of Pollock, Finkelstein and Kost (2007) that it is crucial to examine how the interactive techniques are enacted by students and instructors, and to understand the broader class culture that structures the practices.

Effect of gender and nationality on Attitude toward Physics

There is a conspicuous interaction effect of Gender and Nationality on Attitude toward Physics among higher secondary students of India and USA. Difference in Attitude toward Physics between the females in India and USA indicated that the difference could be due to the difference of teacher dominance in instruction. However, findings of this study reveal that female students improve their future expectations upon receiving a balanced combination of student-centered and teacher-centered instructional strategies. Bates, Galloway, Loptson, and Slaughter (2011) suggest that student attitude could be reproducible and positively correlated to their future aspirations.

Novice learners require direct instructional guidance on concepts and procedures

Findings of this study are in well agreement with Hazari, Tai, and Sadler (2007) notice that female high school physics pedagogy has an influence in students' future performance to a great extent. Learning experiences often negatively impact students toward pursuing physics for higher studies because the learning activities often create confusion and lack clarity at this grade level. Findings of this study suggest that learners should not be left to discover information by themselves, but receive direct instructional guidance on concepts and procedures (Klahr & Nigam, 2004; Mayer, 2004; Cronbach & Snow, 1977; Shulman & Keisler, 1966).

Prominent teacher involvement for students with low attitude

The interaction of Previous Attitude toward Physics (low and high), Gender (male and female), and Nationality (India and USA) with the effect of the Type of Integrated Instruction on students' Attitude toward Physics has been verified. More specific effects of Type of Integrated Instruction, in interaction with Previous

Attitude toward Physics, and Gender were studied subsequently. Attitude toward Physics of the male students in India and USA and that of US female students, all with low Previous Attitude toward Physics, has been found enhanced by teacher dominant integration. This finding is in agreement with other studies that suggested prominent teacher involvement during the implementation of inquiry-based instructional strategies for students with low attitude (Al-Mutawah & Fateel, 2018; Hofer et al., 2018; Sheldrake, Mujtaba, & Reiss, 2017).

Integration with teacher dominance enhances Self defined abilities and ease learning difficulties

Effect of Type of Integrated Instruction on specific factors of the Attitude toward Physics was also studied. Students' Affect toward Physics contributes to their overall Attitude toward the subject to a great extent regardless of Gender and Nationality. Integration with teacher dominance enhances Self defined abilities and ease Perception of Content/Personal Difficulties in Learning Physics among Indian males. Teacher-dominant integration specifically improves the Future Expectations on Physics of female students in India and USA. Female students irrespective of Nationality exhibit improvement in their Future Expectations in learning physics after integrated instruction with Teacher-dominance`. This finding is well coordinated with the observation by Bates et al. (2011) among high school students in UK that student attitude is positively correlated to their future aspirations.

Higher secondary level is critical for female students

The overall attitude toward physics was found to be the lowest among the US females. The existing student-centeredness without adequate teacher-centeredness could have affected the overall Attitude of female students in USA adversely. Reemphasizing the element of teacher-dominant practices in Fair

Integration reported by the US teachers could strengthen the attitude of US female students. As indicated by Hazari, Sadler, and Tai (2008), males and females do not experience physics in the same way. Due to this difference in experience, most females find higher secondary level problematic at which females begin to opt out at much higher rates than males.

Significance of integrated instruction based on students' needs

The significantly higher extent of teacher-centeredness of the Indian physics teachers compared to the US teachers, could have benefited Indian female students to have a high overall Attitude toward Physics. As indicated in the major findings, any level of integration improves their Attitude toward Physics in terms of affect, abilities, and, overcoming difficulties, whereas Teacher-dominant Integration and Fair Integration with a prominent teacher component improves their future expectations. A thoughtful combination of student-centered and teacher-centered strategies was found to be effective in developing a positive attitude (Kaur et al., 2017). Finding of this study agrees with the conclusion of Kaur et al. and reminds the significance of integrating the student-centered and teacher-centered practices based on students' needs.

A balanced combination of teacher-centered and student-centered instructional strategies (FI) positively impact on students' achievement regardless of Nationality, Gender, and Previous Achievement in Physics. While previously low-achieving male and female students in USA had higher achievement with TI alone, previously high-achieving US males do not reveal any specific impact on any level of integration, but scored significantly higher compared to Incompetent Teaching. Based on the report of the authors of the Force Concept Inventory, a score of 60% reveals the minimal proficiency in Newtonian Mechanics concepts. Previously high-achieving males in USA who received Integrated Instruction is the only group that attained this proficiency, SI (M=18.23; SD=5.90), TI (M=18.59; SD=6.72), and FI (M=18.71; SD=6.95). Their previous achievement might have contributed to the neutral impact of integration on their Achievement in Physics.

Attitude of the Indian students could be attributed to the extent of teacher-centeredness they receive

Higher attitude of US males compared to the attitude of females could be attributed to the ability of male students to perform better with Fair integrated instruction, which is practiced more in USA, when Teacher-dominant integrated instruction is not received; attitude of the females in USA is specifically attributed to the teacher-dominance in instruction. US students with low pre-attitude exhibit specifically higher attitude with teacher dominance and lower attitude with student dominance during integrated instruction. The difference in perceiving teacher dominance could be due to the difference among Indian and US students in their affect toward physics. The comparatively higher attitude of the Indian students could be attributed to the extent of teacher-centeredness they receive. However, further study is required to investigate what other factors are attributed to the attitude of Indian students.

Attitude toward Physics is independent of gender, which is in decent agreement with the notion that achievement in physics and attitude toward physics are independent of each other. This finding is in disparity with several research findings stating that achievement and attitude are related (Thompson et al., 2001; Magno, 2003; Sharma, Rosemary & Wilson, 2006). Effect of Integrated Instruction on student's Attitude toward Physics could amend other studies revealing that interest in physics, especially among girls, is found to be the lowest among secondary school students (Walper, Lange, Kleickmann, & Möller, 2014; Gafoor, 2013; Martin, Mullis, & Foy, 2008; Osborne, Simon, & Collins, 2003).

Pedagogies seem to be gender-specific

Female students in India had the higher attitude toward physics, but the lowest achievement in physics conceptual understanding. Findings of this study agree well with Azizi, Jamaluddin, and Yusof (2000) and Issacs, Visser, Friedrich and Brijlal (2007) claiming that students possess positive attitude without achieving high, but disagree with other conclusions that students in the developed countries have lower attitude and those in the developing countries have higher attitude (Potvin & Hasni, 2014; Baram-Tsabari, Sethi, Bry, & Yarden, 2006). Our finding indicated that the attitude is highest for the Indian males, and the lowest for the US females. Therefore, it is inferred that there could be a factor other than the socio-economic status of a country and differences in gender and nationality that influences attitudes among students. The finding is also in agreement with other findings that pedagogies influence male and female students differently (Gillibrand et al., 1999; Haussler & Hoffmann, 2002). Despite the fact that the content of physics challenges every student in a high school setting, it has also been observed that female students lag even behind male students in learning and excelling physics concepts (Musasia, Abacha, & Biyoyo, 2012).

A distinct gender gap on achievement within the nationalities

The ability of learning physics concepts by female students has been a topic of research for more than two decades (Williams, 2001; Ivie & Ray, 2005). A persistent gender difference is revealed in achievement. Findings of this study reveal a distinct gender gap on achievement within the nationalities, which is supportive of many other studies in India and USA (Siddiqui, Khan & Akhtar, 2016; Singh & Imam, 2014; Walper, 2014; Gafoor, 2013; Sharma et al., 2013; Finkelstein, 2010).

Findings of this study emphasizes the need to further investigate the gender wise difference in physics education.

Lack of adequate student dominance affect achievement of Indian students

Effectiveness of instruction lies on improvement of students' learning outcomes, especially those with previously lower level of learning outcomes. In case of physics instruction, female students require further attention due to the existence of the wide gender gap. Therefore, this study investigated the effect of different extents of student-centeredness and teacher-centeredness of teachers on their students' attitude toward, and achievement in physics. The study was performed among students from India and USA, two nationalities considered to be different in their teaching strategies and classroom practices. However, it is worth noticing that though student-centeredness and teacher-centeredness are not equivalent, both have advantages and disadvantages in physics instruction. Students' attitude has been impacted positively, irrespective of gender and nationality, by teacher dominance upon implementing integrated instruction. However, a balanced way of integrating both student-centered and teacher-centered strategies made significantly positive impact on students' achievement. It was also noticed that there is a gender gap in both attitude and achievement, of which the attitude toward physics among the US females was the lowest. The lowest attitude among the US females could be attributed to the lack of teacher dominance in the classroom practices in USA. Correspondingly, the lack of adequate student dominance affect the achievement of the Indian students. The positive correlation between attitude toward physics and achievement in physics is not completely conclusive in this study.

Pure student-centered strategies could be neither effective nor an optimal way of learning

A number of instructional strategies have been implemented and tested in physics for the last few decades (do Carmo & Hönnicke, 2018; Cahyadi, 2007; Langley & Eylon, 2006; Napoli, 2004; Jonassen, 1991). New strategies are mostly constructed independent of existing strategies and thereby fail to be complete and successful in their pedagogical aspects. A teaching strategy that works for one situation may not be effective in another environment (Ramsden, 1992). In addition, pure student-centered strategies are neither effective in all subject areas nor an optimal way of learning for all types of learners (Napoli, 2004).Therefore, a debate on accepting student-centered vs. teacher-centered learning is one of the key issues among educators.

Despite the difference in attitudes and achievements, the study makes an argument that the nature of physics is perceived similarly by students all over the world with respect to the effect of Integrated Instruction. A pedagogical approach in which instruction takes place with a teacher guiding her students through certain practices to help them develop internal sensations like positive attitude, which is made possible through a careful combination of constructivist and non-constructivist instructional strategies (Trninic, 2018).Therefore, a thoughtful design of curriculum and activities with an efficient combination of teacher-centered and student-centered classroom practices could make an improvement in students' attitude toward the subject and better achievement. In future, the authors anticipate to investigating specific levels and type of integrated instructional strategies on specific topics and concepts in physics to see the effect on students' attitude and understanding.

Implications

As mentioned above, the findings of this study imply that the nature of physics is perceived similarly by students all over the world, though student preferences for instructional environments may vary by their abilities, strengths and weaknesses, previous experiences and teacher supports they have. Therefore, a thoughtful design of curriculum and activities with an efficient combination of teacher-centered and student-centered classroom practices could make an improvement in students' attitude toward the subject and better achievement. The direction of changes required in physics curricular practices and class room instruction in order to primarily strengthen students' attitude towards physics and achievement in physics, with particular focus on higher secondary schooling in India and USA, as implied by the findings of this study are indicated below.

1. Adopt Integrated Instruction for physics learners

Higher secondary physics teachers and students disagree on current instructional practices that they perceive in classrooms, but agree on instructional strategies required to improve physics learning. As Campbell (2011) suggests, there is still an increased urge for inquiry-based instructional techniques which are predominantly student-centered in elementary and secondary schools all over the world. Additionally, the traditional mode of revising textbooks, curricular materials, and assessment techniques often puts the teachers in dilemma on what specific strategy they should choose. As a result, the positive effects of these student-centered strategies happen to be the results of certain research studies conducted on a few groups, topics or goals (Brown, 2003; Blumberg, 2004).This drawback can be rectified by adopting Integrated Instruction for physics learners anywhere in the world as this strategy could also affect other aspects of the pedagogical activities such as teaching, learning, and assessment. There seems to be a strong need of revolutionizing curriculum and pedagogy to have a more activity-oriented learning environment in the Indian classrooms (Dagar & Yadav, 2016; Sharma et al., 2013; Varghese, 2008).

2. Temper teacher-dominant instruction in India with more student-centeredness

The most important finding of this study suggests Physics instruction could be balanced with fair amount of teacher-centeredness and student-centeredness. Integrated instruction defined in this study could be utilized to temper teacher-dominant instruction in India with more student-centeredness. It is worthless to discourage teacher-centeredness in Indian teachers; it may lead to decline in student attitudinal edge. The task lies in empowering Indian teachers with student-centered strategies without losing teacher-centered repertoire. Likewise, more teacher-dominant practices in US physics classrooms might improve the attitude especially among the females. Findings of this research support those of several other researches that novice learners in USA are significantly impacted by instructional strategies with more defined and prominent teacher involvement (Walper et al., 2014; Kock et al., 2013; Owen et al., 2008; Kirschner et al., 2006; Langley & Eylon, 2006). It is worth mentioning that the instructor has an important role in facilitating learning by guiding, clarifying and even lecturing in an inductive method (Prince & Felder, 2006).

3. Teacher-dominant practices in physics classrooms do not weaken attitude and achievement of students

Integrated Instruction is found effective for students in physics classrooms to improve their attitude and achievement. An integration of constructivist and non-constructivist pedagogical approaches has been suggested in recent researches (Bakker, 2018; Chase & Abrahamson, 2018; Trninic, 2018; Arsal, 2017; Lehtinen, 2017).The argument is that reconceptualization of repetitive activities can be implemented as exploratory practices in which direct instruction strategies are intimately integrated. Findings of this study is in absolute agree studies ment with these arguments. More teacher-dominant practices in physics classrooms could improve the attitude and achievement of students regardless of their gender, nationality, and difference in infrastructure.

The notion of integrating both teacher-centered (direct) and student-centered (inquiry-based) instructional practices developed during this study aligns well with the argument of von Glasersfeld, one of the pioneers of radical constructivism that the primary goal of instruction is to make students aware of knowledge and understanding. For implementing student-centered learning activities, previous studies suggest inquiry as the platform with a constructivist approach (Schwartz et al., 2004; Hakkarainen, 2003; Chang & Mao, 1999). However, there is a lack of evidence for improved student outcome since teachers feel discomfort directing or controlling student inquiry in its purest form.

4. Modify instructional strategies to have an improved attitude toward physics

The findings of this study indicate the importance of modifying instructional strategies to have an improved attitude toward physics. It is supported by several studies conducted in this area previously (Gillibrand et al., 1999; Beatty et al., 2006; Haussler & Hoffmann, 2002; Adams et al., 2006; Çalışkan, Selçuk, & Erol, 2010). Affect toward Physics among US females that get worse with Student-dominant Integration can be balanced with more teacher-centeredness.

5. Student epistemological beliefs are amenable to instruction

Self-defined abilities in learning physics among Indian females (more than males) can be encouraged through Teacher-dominant or Fair Integration. Felt content difficulties especially among Indian males are reduced if they receive teaching with Fair Integration. In both India and USA, positive attitudes emanating from future expectations in physics is impacted through Teacher-dominant Integration, especially among females.

6. Emphasize conceptual understanding in physics

The higher achievement of students in USA leads to the importance of conceptual understanding in physics (NRC, 1996; Hestenes & Halloun, 1995). There is a strong need to emphasize the importance and significance of conceptual understanding along with developing problem-solving skills among students, especially in India. The fact that students could achieve high without proper conceptual understanding should be accentuated to both students and teachers. Internationally accepted tool like Force Concept Inventory should be introduced among teachers, teacher educators and students of teacher education frequently. There is a strong need for highlighting the quality of teaching rather than yielding to the inadequacies of infrastructure and facilities (Gafoor, Farooque & Munavvir, 2013). Findings of this study could be a wakeup call for higher secondary school physics teachers to make themselves accountable for their teaching by improving student attitude along with conceptual understanding.

7. Teachers can improve student attitude toward physics by creating an apt learning environment

Most of the instruction-related modifications can be controlled by teachers, and the suggestions made by students support the implementation of a unified instructional strategy to create a learning environment that improve their attitude toward physics. The responses from both students and teachers indicate Integrated Instruction in physics classrooms. The following are specific implications in this regard.

8. Teach with a balance of being a demonstrator or delegator

As noticed by Mulholland and Turnock (2012), teachers in an environment of Integrated Instruction communicate with their students, show the same enthusiasm as that of the learners, and actively participate in every classroom activity while having command of the whole class. They find a good balance by being a demonstrator or delegator rather than being just a facilitator or an instructor of formal authority. Incompetence to provide emphasis on both disciplinary content and pedagogical practices often tend educators not to teach the discipline in its full fledge (Rudolph & Meshoulam, 2014).

9. Engage students in the role of a co-learner

There are several teaching strategies like Legacy Cycle Lesson Plan, Workshop, Studio or Multimedia Modules similar to the 5E Instructional Model that can be modified as an integrated strategy in which teachers are able to present themselves with confidence and at the same time engage their students in the role of a co-learner in an inquiry-based platform. Appropriate 5E model activities that can be adopted to teach the topic of "Vectors" were developed during this research. The suggested activities for the topic of vectors are provided along with the summary of the proposed activities for 5E are provided in Appendix F.

10. Balance student-centeredness or teacher-centeredness as required

It is worth noticing that during the initial phase of this study, US students preferred a prominent teacher involvement, whereas the Indian students preferred a homogeneous combination of student-centered and teacher-centered strategies. Findings of this study reinstate students' preferences with the effect of types of integration among students in India and USA. This finding supports previous studies that Indian students would perform better by adopting research-based strategies that are student-centered and inquiry-based in addition to the existing ones (Sharma et al., 2013), whereas the effectiveness of purely student-centered instructional strategies in developing positive attitude is debatable in the case of the US students as stated by many studies in the US context (Walper et al., 2014; Owen, Dickson, Stanisstreet, & Boyes, 2008; Borghi, De Ambrosis, Lamberti, & Mascheretti, 2005).

Teachers of India and USA could be more balanced in their approach by adopting 5E Instructional Model activities from two different directions. Providing appropriate classroom practices could balance the extents of Student-centeredness or Teacher-centeredness. A few possible suggestions on classroom practices for Indian and US teachers to balance their student-centeredness or teacher-centeredness are as follows.

Teachers in India can engage their students by letting them work in groups to realize the underlying concept of a problem or by introducing a project using a challenging problem during in-class discussions. In the same way, the US teachers can engage their students by providing major directions on conducting an experiment to avoid alternate conceptions among students or by indicating quantities and variables for testing in a lab activity.

While Indian teachers make their students explore by letting them brainstorm and reinforce conceptual understanding in small groups or explore the major concepts online prior to covering them in class, the US teachers could provide in-class demonstrations to reinforce concepts, hold a discussion on major concepts using videos or animations, or make students work on lab in groups with their supervision.

To balance their classroom practices with more student-centeredness in the explanation component, Indian teachers could make their students work in small groups on problems and difficult concepts or let students discuss the major characteristics of the problem within the group. For increasing the teacher-centeredness, the US teachers could give explanations and examples orally and in writing or introduce major concepts using electronic slides or handouts, or supervise and assist students' work in small groups on problems.

The elaborating activities for the Indian teachers could be letting students demonstrate problem-solving steps using appropriate activities, providing opportunity to test the accuracy of the problem, use web-based resources for problems and graphical analyses or facilitating discussions to come up with a problem having real-life application. The teachers in USA could solve textbook problems of various difficulty levels in class, assist students in finding recourses and applying information, or hold help sessions to work on difficult homework problems and concepts.

As the activities for evaluation, Indian teachers could concentrate on letting students prepare lab reports by analyzing obtained results in class, making students present their work public before experts in the relative fields, using alternative assessment techniques available online, or adopting popular testing instruments that are accepted internationally. Teachers in USA could include quizzes and tests that are conducted in a traditional manner, introduce and brainstorm the rubric for the group projects or adopt the testing materials from other parts of the world that are found effective among students of various ethnicities.

11. Teachers face challenges in responding to multitude of student interests

Instructional practices become more critical when teachers have difficulty in responding to multitude of student interests due to shortage of resources available in a constructivist environment (Boethel & Dimock, 2000). However, there is lack of evidence for improved student outcomes since teachers feel discomfort directing or controlling student inquiry (Kock, 2013; Hodgson, 2010). The lack of effectiveness could be due to the mode of administering the research-based approaches in classrooms. Instructors often modify or discontinue the use of these strategies significantly, resulting in the absence of a major change in the actual classroom practice (Dancy & Henderson, 2010). However, (Docktor, Strand, Mestre, and Ross (2015) suggest that teachers are comfortable in integrating research-based instructional strategies into their curricula if they provide significant empirical evidence. Conducting such empirical studies in an international platform become inevitable as social desirability cannot be overruled in preferring instructional strategies (Baram-Tsabari, Sethi, Bry, &Yarden, 2006).

12. Promote cross national Studies on student attributes and teaching methods in physics

Studies on diverse groups of students, interactions between student attributes, and teaching methods are not very common in physics education research. There is room for developing such studies. Cross-national studies add to this diversity in physics education in terms of student attributes and teaching methods. For instance, Scale of Attitude toward Physics is a research instrument that could be further made compatible with other international tools like CLASS (Colorado Learning Attitudes about Science Survey) and MPEX (Maryland Physics Expectations Survey) to measure physics attitude.

13. ***Model Fair Integration to student teachers.***

Emphasize teacher education and related research to focus on ways to integrate teacher-centeredness and student-centeredness in Indian and US contexts. Physics Classroom Practices Inventory could help teacher educators to identify and mentor teachers who are strong in this respect. Physics Classroom Practices

Inventory can also be used to determine the type of integrated instruction in science classrooms. The relevance of 5E Instructional Model could be made applicable to physics instructors by using the scheme of integration developed during this research as shown in Appendices D1-D3.

14. Strengthen teachers' pedagogical knowledge and disposition

Teacher's content knowledge and curriculum background can have a major impact on student attitude toward physics (House & Telese, 2008). As findings of this study indicates, despite exemplary knowledge in the content area, teachers' pedagogical knowledge and disposition in implementing various classroom practices are worth investigating. In this scenario, this study calls for the implementation of an instructional strategy which is effective, motivating, useful and manageable with the existing facilities. As mentioned earlier, a thoughtful and properly designed instructional strategy based on students' perceptions on teaching and learning physics could benefit them in changing or modifying beliefs and attitudes toward the subject.

Limitations of the Study

This study was performed with utmost care, detailed planning and development of valid and objective instruments and ensuring representativeness of the population of higher secondary students in Kerala and South Carolina. However, a few of the elements of this study might have an impact of the generalizability of its findings and are listed below.

The perception of students was found different from that of the teachers on usual classroom practices in the initial phase of the study. Teachers intentionally tried to deemphasize teacher-centeredness and highlight student-centeredness. Therefore, additional measures were taken by incorporating multiple aspects of classroom practices while developing the inventory on classroom practices.

The Force Concept Inventory (FCI) was chosen as the achievement test for the student sample in India and USA in order to evaluate the conceptual understanding in Newtonian Mechanics. However, the researcher noticed some disparity in answering these questions based on the students' familiarity in answering purely conceptual questions. Therefore, the scores obtained in the achievement Test might not be a complete reflection of students' conceptual understanding of Newtonian Mechanics.

Students of three teachers in each category were used for this study. Selection and inclusion of several teachers in each category would increase the generalizability of the data. However, it was practically difficult to include more than three teachers in each section from each country for this study.

There were a few external variables that could not be manipulated in this study such as classroom infrastructure and facilities, fluctuation in test situation, different teachers, and indexes of integration reported by teachers, reading comprehension levels of students. These factors could have affected the data on attitude toward Physics and achievement in physics of students in India and USA.

Future Research

This study was on the influence of Integrated Instruction on Attitude toward Physics and Achievement in Physics of higher secondary students in Kerala (India) and South Carolina (USA). During the various phases of this study, a collection of findings were drawn that are critical in the pedagogical and epistemological aspects of learning physics. Based on the scope, findings, and implications of this study, to reinvent and reinstate the findings and to rectify some of the limitations of the study, following further researches may be taken up.

1. Physics Education Research (PER) has been developing and implementing a variety research-based instructional strategies for physics classrooms. However, most of them are meant for college level physics students and are mostly tested and proved significant in experimental environments. Therefore, this study could be pursued in the higher secondary level as future work in establishing an integrated instructional strategy for the global community in physics education. In order to further proceed with this research, the effect of integrated instruction on all topics in physics rather than concentrating on Newtonian Mechanics by conducting research on various parts of the world.

2. The influence of integrated instruction is constructive among students regardless of their cultural or demographic difference. Despite this promising result, there is scope for future research on further investigating the types of integration at various sub levels of students such as gifted and talented, slow learners, high achievers and learners with special needs in and beyond the discipline of physics. The extent of teacher immersion in each of these types of integration and the way of responding would be another area of further research.

3. The research instruments developed during this study will be published internationally and seek attention from the science education community internationally on their use. Physics Attitude Scale is a research instrument could be considered compatible with other international tools like CLASS (Colorado Learning Attitudes about Science Survey) and MPEX (Maryland Physics Expectations Survey) to measure physics attitude. There is no research instrument like the Physics Classroom Practices Inventory to the best of the investigator's knowledge. Therefore, a future study could shed

light on improving these instruments for other disciplines and for educators for all levels.

4. While investigating the classroom practices, there was indication of gender effect of teachers in India and USA but not investigated in this study. There are a few studies available on the gender effect of physics teachers related to the achievement and motivation of students. A future study would explore the gender effect of physics educators on various dimensions of integrated instruction, and its application on students' attitude and achievement, at various grade levels.

5. There are a few studies available in the literature on physics achievement among students of the Eastern and western hemispheres. Nonetheless, there is no such studies directly addressing their attitude toward physics. More cross national studies will provide better insight into this area by performing research in various countries from the East and West.

6. Male students in USA scored significantly higher than the Indian female students in the achievement test. However, the US males did not have a significantly lower attitude among the males and females in India and USA. Therefore, finding of the study refute the report by Trends in International Mathematics and Science Study (TIMMS) and Relevance of Science Education (ROSE) project revealing that the higher the average student achievement, the less positive is their attitude toward science (Turner & Peck, 2009; Osborne & Dillon, 2008). Further study is required to investigate these findings.

7. In this cross-national study, students' conceptual understanding was found to have a wide gap between India and USA. The effect size for nationality (43.1%) is found significantly higher than that for gender (8.6%). However,

there are many other factors such as culture difference in culture, social beliefs, attitude beliefs, level of motivation, parental involvement to be investigated to better interpret this difference. This could be the difference in how students are set with educational goals and implications prior to introduce the topics in classrooms. Further study is required to make a definite conclusion in this regard.

8. It is worth noticing that students across culture and traditions possess a uniform achievement and attitude pattern with the types of instructional strategies. This study agrees well with the finding that an activity-oriented instructional strategy with proper guidance make substantial improvement in physics conceptual understanding (Kock, Taconis, Bolhuis, & Gravemeijer, 2013). In conclusion, physics being a difficult subject for students of all nationalities, the significance of instructional strategies has been found noticeable, which leads to future researches for designing and developing integrated instructional strategies and to make instructors worldwide aware of the effect of the integration on learning physics.

REFERENCES

References

Abraham, M.R., Grzybowski, E.B., Renner, J.W., & Marek, E.A. (1992). Understandings and misunderstandings of eighth graders of five chemistry concepts found in textbooks. *Journal of Research in Science Teaching*, *29*(2), 105-120.

Abrahamson, D., & Chase, K. (2015). Interfacing practices: Domain theory emerges via collaborative reflection. *Reflective Practice*, *16*(3), 372-389.

Abrahamson, D., & Kapur, M. (2018). Reinventing discovery learning: A field-wide research program. *Instructional Science*, *46*(1), 1-10.

Adams, W. K., Perkins, K. K., Podolefsky, N. S., Dubson, M., Finkelstein, N. D., & Wieman, C. E. (2006). New instrument for measuring student beliefs about physics and learning physics: The Colorado learning attitudes about science survey. *Physical Review Special Topics-Physics Education Research*, *2*(1), 010101.

Adams, W. K., Perkins, K. K., Podolefsky, N. S., Dubson, M., Finkelstein, N. D., & Wieman, C. E. (2006). New instrument for measuring student beliefs about physics and learning physics: The Colorado Learning Attitudes about Science Survey. *Physical Review Special Topics-Physics Education Research*, *2*(1), 010101.

Adorno, D. P., Pizzolato, N., & Fazio, C. (2018). Long term stability of learning outcomes in undergraduates after an open-inquiry instruction on thermal science. *Physical Review Physics Education Research*, *14*(1), 010108.

Afshar-Oromieh, A., Malcher, A., Eder, M., Eisenhut, M., Linhart, H. G., Hadaschik, B. A.,... & Haberkorn, U. (2013). PET imaging with a [68 Ga] gallium-labelled PSMA ligand for the diagnosis of prostate cancer: biodistribution in humans and first evaluation of tumour lesions. *European Journal of Nuclear Medicine and Molecular Imaging*, *40*(4), 486-495.

Agbaje, R. O., & Alake, E. M. (2014). Students' variables as predictor of secondary school students' academic achievement in science subjects. *International Journal of Scientific and Research*, *4*(9), 1-5.

Akinbobola, A.O. (2015). Enhancing transfer of knowledge in physics through effective teaching strategies. *Journal of Education and Practice*, *6*(16), 37-44.

Ali, M.S., & Awan, A.S. (2013). Attitude towards science and its relationship with students' achievement in science. *Interdisciplinary Journal of Contemporary Research in Business 4*(10).

Al-Mutawah, M. A., & Fateel, M. J. (2018). Students' achievement in math and science: How grit and attitudes influence?. *International Education Studies*, *11*(2), 97.

American Association for the Advancement of Science (AAAS). (1993). *Benchmarks for science literacy*. Washington DC: The National Academic Press.

Ancell, C., Guttersrud, Ø., Henriksen, E. K., & Isnes, A. (2004). Physics: Frightful, but fun. *Science Education*, *88*(5), 683-706.

Arsal, Z. (2017). The impact of inquiry-based learning on the critical thinking dispositions of pre-service science teachers. *International Journal of Science Education*, *39*(10), 1326-1338.

Atkin, J. M., &Karplus, R. (1962). Discovery or invention?. *The Science Teacher*, *29*(5), 45-51.

Azizi, Y., Jamaluddin, R., &Yusof, B. (2000). *Sumbangan Sikap Terhadap Pencapaian Pelajar Dalam Matapelajaran Matematik: Sejauhmanakah Hubungan Ini Relevan*? Fakulti Pendidikan, Universiti Teknologi Malaysia.

Bakeman, R. (2005). Recommended effect size statistics for repeated measures designs. *Behavior Research Methods*, *37*(3), 379-384.

Bakker, A. (2018). Discovery learning: Zombie, phoenix, or elephant?. *Instructional Science*, *46*(1), 169-183.

Balta, N., Mason, A. J., & Singh, C. (2016). Surveying Turkish high school and university students' attitudes and approaches to physics problem solving. *Physical Review Physics Education Research*, *12*(1), 010129.

Bao, L., & Redish, E. F. (2001). Concentration analysis: A quantitative assessment of student states. *American Journal of Physics*, *69*(S1), S45-S53.

Baram-Tsabari, A., Sethi, R. J., Bry, L., & Yarden, A. (2006). Using questions sent to an Ask-A-Scientist site to identify children's interests in science. *Science Education, 90*(6), 1050–1072.

Barber, J.P. (2009). *Integration of learning: Meaning making for undergraduates through connection, application, and synthesis*, Unpublished Doctoral Thesis, University of Michigan, USA.

Barmby, P., & Defty, N. (2006). Secondary school pupils' perceptions of physics. *Research in Science & Technological Education*, *24*(2), 199-215.

Bates, S. P., Galloway, R. K., Loptson, C., & Slaughter, K. A. (2011). How attitudes and beliefs about physics change from high school to faculty. *Physical Review Special Topics-Physics Education Research*, *7*(2), 020114.

Bauer, M. W., Shukla, R., & Allum, N. (Eds.). (2012). *The culture of science: How the public relates to science across the globe*. London: Routledge.

Beatty, I. D., Leonard, W. J., Gerace, W. J., & Dufresne, R. J. (2006). Question driven instruction: Teaching science. *Audience response systems in higher education: Applications and cases*, 96.

Beichner, R.J. (1994). Testing student interpretation of kinematics graphs. *American Journal of Physics*, *62*(8), 750-762.

Beichner, R.J. (1996). "The impact of video motion analysis on kinematics graph interpretation skills," *Am. J. Physics 64,* 1272.

Beichner, R.J. (2009). An introduction to physics education research. *Getting Started in Per*, *2*(1), 1-25.

Beichner, R.J., & Saul, J.M. (2003). Introduction to the SCALE-UP (Student-centered activities for large enrollment undergraduate programs) project. *Proceedings of the International School of Physics* "Enrico Fermi". Italy: Varenna.

Beichner, R.J., Saul, J.M., Abbott, D. S., Morse, J.J., Deardorff, D., Allain, R.J., ...& Risley, J. S. (2007). The student-centered activities for large enrollment undergraduate programs (SCALE-UP) project. *Research-based Reform of University Physics*, *1*(1), 2-39.

Bennett, J. (2003).*Teaching and learning science: A guide to recent research and its applications.* London: Contium.

Beothel, M., & Dimock, K.V. (2000). *Constructing knowledge with technology*. Austin, TX: Southwest Educational Development Laboratory.

Bernstein, P. L., & Bernstein, P. L. (1996). *Against the gods: The remarkable story of risk* (pp. 1269-1275). New York: Wiley.

Best, J. W., & Kahn, J. V. (2012). *Research in education*. New Delhi: Prentice Hall.

Blumberg, P. (2004). Beginning journey toward a culture of learning centered teaching. *Journal of Student Centered Learning, 2*(1), 68-80.

Bøe, M. V., Henriksen, E. K., & Angell, C. (2018). Actual versus implied physics students: How students from traditional physics classrooms related to an innovative approach to quantum physics. *Science Education*. https://doi.org/10.1002/sce.21339.

Borghi, L., De Ambrosis, A., Lamberti, N., & Mascheretti, P. (2005). A teaching–learning sequence on free fall motion. *Physics Education*, *40*(3), 266.

Bransford, J. D., & Donovan, M. S. (2005). Scientific inquiry and how people learn. *How students learn: History, mathematics, and science in the classroom*, 397-420.

Bransford, J., Brown, A. L., & Cocking, R. R. (2000). *How people learn: Brain, mind, experience, and school.* Commission on Behavioral and Social Sciences and Education: National Research Council.

Brewe, E., Sawtelle, V., Kramer, L. H., O'Brien, G. E., Rodriguez, I., & Pamelá, P. (2010). Toward equity through participation in Modeling Instruction in introductory university physics. *Physical Review Special Topics-Physics Education Research*, *6*(1), 010106.

Brooks-Gunn, J., & Duncan Johnson, A. (2006). G. Stanley Hall's contribution to science, practice and policy: The child study, parent education, and child welfare movements. *History of Psychology*, *9*(3), 247.

Brown, B. A., & Spang, E. (2008). Double talk: Synthesizing everyday and science language in the classroom. *Science Education*, *92*(4), 708-732.

Brown, K. L. (2003). From teacher-centered to learner-centered curriculum: Improving learning in diverse classrooms. *Education*, *124*(1), 49.

Bryant, F. B., Yarnold, P. R., & Michelson, E. A. (1999). Statistical Methodology. *Academic Emergency Medicine*, *6*(1), 54-66.

Buccheri, G., Gurber, N. A., & Bruhwiler, C. (2011). The impact of gender on interest in science topics and the choice of scientific and technical vocations. *International Journal of Science Education, 33*(1), 159–178.

Bybee, R. W. (1987). Science education and the science-technology-society (S-T-S) theme. *Science Education*, *71*(5), 667-683.

Bybee, R. W. (2008). Scientific literacy, environmental issues, and PISA 2006: The 2008 Paul F-Brandwein lecture. *Journal of Science Education and Technology*, *17*(6), 566-585.

Bybee, R. W., Taylor, J. A., Gardner, A., Van Scotter, P., Powell, J. C., Westbrook, A., & Landes, N. (2006). The BSCS 5E instructional model: Origins and effectiveness. *Colorado Springs, Co: BSCS*, *5*, 88-98.

Cahill, M. J., McDaniel, M. A., Frey, R. F., Hynes, K. M., Repice, M., Zhao, J., & Trousil, R. (2018). Understanding the relationship between student attitudes and student learning. *Physical Review Physics Education Research*, *14*(1), 010107.

Cahyadi, V. (2007). *Improving teaching and learning in introductory physics*. Unpublished Ph.D. Thesis, University of Canterbury, New Zealand.

Cajas, F. (2001). The science/technology interaction: Implications for science literacy. *Journal of Research in Science Teaching*, *38*(7), 715-729.

Çalışkan, S., Selçuk, G. S., & Erol, M. (2010). Effects of the problem solving strategies instruction on the students' physics problem solving performances and strategy usage. *Procedia-Social and Behavioral Sciences*, *2*(2), 2239-2243.

Campbell, D. T., & Stanley, J. C. (1963). Experimental and quasi-experimental designs for research. *Handbook of research on teaching. Chicago, IL: Rand McNally*.

Campbell, J. B., & Wynne, R. H. (2011). *Introduction to remote sensing*. Guilford Press.

Campbell, T., Zhang, D. & Neilson, D. (2011). Model based inquiry in the high school physics classrooms: An exploratory study of implementation and outcomes. *Journal of Science Education and Technology*, *20*(3), 258-269.

Carbone, A., Hurst, J., Mitchell, I., & Gunstone, D. (2009). An exploration of internal factors influencing student learning of programming. In *Proceedings of the Eleventh Australasian Conference on Computing Education-Volume 95*(pp. 25-34). Australian Computer Society, Inc.

Chai, J., Friedler, L. M., Wolff, E. F., Li, J., & Rhea, K. (2015). A cross-national study of calculus. *International Journal of Mathematical Education in Science and Technology*, *46*(4), 481-494.

Chang, C. Y., & Mao, S. L. (1999).Comparison of Taiwan science students' outcomes with inquiry-group versus traditional instruction. *The Journal of Educational Research*, *92*(6), 340-346.

Chase, K., & Abrahamson, D. (2018). Searching for buried treasure: Uncovering discovery in discovery-based learning. *Instructional Science*, 1-23.

Cohen, J. B., & Reed, A. (2006). A multiple pathway anchoring and adjustment (MPAA) model of attitude generation and recruitment. *Journal of Consumer Research*, *33*(1), 1-15.

Coleman, E. B. (1998). Using explanatory knowledge during collaborative problem solving in science. *Journal of the Learning Sciences*, *7*(3-4), 387-427.

Collins, A. (1998). National science education standards: A political document. *Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching*, *35*(7), 711-727.

Collins, J.P., White, G. R., & Mantell, C. D. (1997). Selection of medical students: an affirmative action programme. *Medical Education*, *31*(2), 77-80.

Comrey, A. L., & Lee, H. B. (2013). *A first course in factor analysis*. London, UK: Psychology Press.

Conway, A. R., Cowan, N., & Bunting, M. F. (2001). The cocktail party phenomenon revisited: The importance of working memory capacity. *Psychonomic Bulletin & Review*, *8*(2), 331-335.

Cotton, K. (1991). *Teaching thinking skills*. Northwest Regional Educational Laboratory, School Improvement Program.

Cowan, N. (2001). Meta theory of storage capacity limits. *Behavioral and Brain Sciences*, *24*(1), 154-176.

Craker, D. E. (2006). Attitudes toward science of students enrolled in introductory level science courses at UW-La Crosse. *UW-L Journal of Undergraduate Research, IX*, 1-6.

Creswell, J. W., Hanson, W. E., Plano, V.L.C., & Morales, A. (2007). Qualitative research designs: Selection and implementation. *The Counseling Psychologist*, *35*(2), 236-264.

Cronbach, L. J., & Snow, R. E. (1977). Aptitudes and instructional methods: A handbook for research on interactions. New York: Irvington.

Crouch, C. H., & Mazur, E. (2001). Peer instruction: Ten years of experience and results. *American Journal of Physics*, *69*(9), 970-977.

Crouch, R., & Haines, C. (2004). Mathematical modelling: Transitions between the real world and the mathematical model. *International Journal of Mathematical Education in Science and Technology*, *35*(2), 197-206.

Crowl, T. K. (1993). *Fundamentals of educational research*. Madison, WI: WCB Brown and Benchmark Publishers.

Dagar, V., & Yadav, A. (2016). Constructivism: A paradigm for teaching and learning. *Arts Social Scientific Journal, 7*(4) 1-4. doi: 10.4172/2151-6200.1000200.

Dancy, M., & Henderson, C. (2010). Pedagogical practices and instructional change of physics faculty. *American Journal of Physics*, *78*(10), 1056-1063.

Davison, D. M., Miller, K. W., & Metheny, D.L. (1995). What does integration of science and mathematics really mean?. *School Science and Mathematics*, *95*(5), 226-230.

Dawson, C. (2000). Upper primary boys’ and girls’ interests in science: Have they changed since 1980*? International Journal of Science Education, 22*(6), 557–570.

Denzin, N. K., & Lincoln, Y. S. (Eds.). (2011). *The Sage Handbook of Qualitative Research*. Beverly Hills, CA: Sage.

Deslauriers, L., Schelew, E., & Wieman, C. (2011). Improved learning in a large-enrollment physics class. *Science*, *332*(6031), 862-864.

Dewey, J., & Small, A. W. (1897). *My pedagogic creed, 1* (25). EL Kellogg & Company.

Ding, L. (2014). Verification of causal influences of reasoning skills and epistemology on physics conceptual learning. *Physical Review Special Topics-Physics Education Research*, *10*(2), 023101.

doCarmo, E., & Hönnicke, M. G. (2018). Simple methodologies to estimate the energy amount stored in a tree due to an explosive seed dispersal mechanism. *Physics Education*, *53*(3), 035008.

Docktor, J. L., Dornfeld, J., Frodermann, E., Heller, K., Hsu, L., Jackson, K. A., & Yang, J. (2016). Assessing student written problem solutions: A problem-solving rubric with application to introductory physics. *Physical Review Physics Education Research*, *12*(1), 010130.

Docktor, J. L., Strand, N. E., Mestre, J. P., & Ross, B. H. (2015). Conceptual problem solving in high school physics. *Physical Review Special Topics-Physics Education Research*, *11*(2), 020106.

Drechsel, B., Carstensen, C., & Prenzel, M. (2011). The role of content and context in PISA Interest Scales: A study of the embedded interest items in the PISA 2006 Science Assessment. *International Journal of Science Education, 33*(1), 73–95.

Ebenezer, J. V., & Zoller, U. (1993). Grade 10 students' perceptions of and attitudes toward science teaching and school science. *Journal of Research in Science Teaching*, *30*(2), 175-186.

Elby, A. (2011). Getting started with research on epistemologies and expectations. *Getting Started in PER*, *2*, 1.

Elliott, J. (2018). The use of behavioural objectives as a means of holding teachers to account for their students learning. Does this render student assessment 'fit for purpose?'. *European Journal of Education*, *53*(2), 133-137.

Elster, J. (2007). *Explaining social behavior: More nuts and bolts for the social sciences*. New York: Cambridge University Press.

Emarat, N., Arayathanitkul, K., Soankwan, C., Chitaree, R., & Johnston, I. (2012, November). The effectiveness of the Thai traditional teaching in the introductory physics course: A comparison with the US and Australian approaches. In *Proceedings of the Australian Conference on Science and Mathematics Education (formerly UniServe Science Conference)* (Vol. 8).

Erdemir, N. (2009). Determining students' attitude towards physics through problem-solving strategy. In *Asia-Pacific Forum on Science Learning and Teaching* (Vol. 10, No. 2, pp. 1-19). The Education University of Hong Kong, Department of Science and Environmental Studies.

Erinosho, S.Y. (2013). How do students perceive the difficulty of physics in secondary school? An exploratory study in Nigeria. *International Journal for Cross-disciplinary Subjects in Education (IJCDSE)*, *3*(3), 1510-1515.

Fagen, A. P., Crouch, C. H., & Mazur, E. (2002). Peer instruction: Results from a range of classrooms. *The Physics Teacher*, *40*(4), 206-209.

Firestone, W.A., & Herriott, R.E. (1984). Multisite qualitative policy research: Some design and implementation issues. In D.M. Fetterman (Ed.), *Ethnography in educational evaluation*(pp. 63–88). Beverly Hills, CA: Sage.

Fishbein, M., & Raven, B. H. (1962). The AB scales: An operational definition of belief and attitude. *Human Relations*, *15*(1), 35-44.

Flavell, J. H. (1963). The developmental psychology of Jean Piaget. NJ: Princeton.

Fogarty, R., &Stoehr, J. (1995). Integrating curricula with multiple intelligences. Arlington Heights, II. IRI/Skylight Training & Publishing.

Folashade, A., & Akinbobola, A. O. (2009). Constructivist problem based learning technique and the academic achievement of physics students with low ability level in Nigerian secondary schools. *Eurasian J. Phys. Chem. Educ*, *1*(1), 45-51.

Foote, K. T., Neumeyer, X., Henderson, C., Dancy, M. H., & Beichner, R. J. (2014). Diffusion of research-based instructional strategies: The case of SCALE-UP. *International Journal of STEM Education*, *1*(1), 10.

Fraser, J. M., Timan, A. L., Miller, K., Dowd, J. E., Tucker, L., & Mazur, E. (2014). Teaching and physics education research: Bridging the gap. *Reports on Progress in Physics*, *77*(3), 032401.

Frazer, L. (2017). *Diversity in physics education research: A decade of inclusion and future challenges.* Retrieved from https://arxiv.org/pdf/1710.07863.pdf.

Fredlund, T., Airey, J., & Linder, C. (2012). Exploring the role of physics representations: An illustrative example from students sharing knowledge about refraction. *European Journal of Physics*, *33*(3), 657.

Fredlund, T., Linder, C., Airey, J., & Linder, A. (2014). Unpacking physics representations: Towards an appreciation of disciplinary affordance. *Physical Review Special Topics-Physics Education Research*, *10*(2), 020129.

Gafoor, K. A. (2013). Differences in students' interest in physics by gender and stage of schooling in Kerala. *Journal of Indian Education, 39* (2), 99-107.

Gafoor, K. A., Farooque, T.K.U., & Munavvir, T.J. (2013). Perception of the stakeholders on constructivist curricular practices in Kerala schools. *Jamshedpur Research Review*, *1*(2), 7-13.

Garg, G., & Kothari, C.R. (2014). *Research methodology: Methods and techniques*. New Delhi: New Age International Publishers.

Garg, K. C., & Gupta, B. M. (2003). Decline in science education in India-A case study at+2 and undergraduate level. *Current Science-Bangalore*, *84*(9), 1198-1201.

George, R. (2006). A cross-domain analysis of change in students' attitudes toward science and attitudes about the utility of science. *International Journal of Science Education*, *28*(6), 571-589.

Georgiou, H., & Sharma, M.D. (2014). Does using active learning in thermodynamics lectures improve students' conceptual understanding and learning experiences?. *European Journal of Physics*, *36*(1), 015020.

Gilbert, J. K., & Boulter, C. (1993). Models and modelling in science education. *Hatfield, Herts: Association for Science Education*.

Gillibrand, E., Robinson, P., Brawn, R., & Osborn, A. (1999). Girls' participation in physics in single sex classes in mixed schools in relation to confidence and achievement. *International Journal of Science Education*, *21*(4), 349-362.

Gillibrand, E., Robinson, P., Brawn, R., & Osborn, A. (1999). Girls' participation in physics in single sex classes in mixed schools in relation to confidence and achievement. *International Journal of Science Education*, *21*(4), 349-362.

Gillibrand, E., Robinson, P., Brawn, R., & Osborn, A. (1999). Girls' participation in physics in single sex classes in mixed schools in relation to confidence and achievement. *International Journal of Science Education*, *21*(4), 349-362.

Glasersfeld, E.V. (2006). A constructivist approach to experiential foundations of mathematical concepts revisited. *Constructivist Foundations*, *1*(2), 61-72.

Glaze, A. L. (2018). Teaching and learning science in the 21st century: Challenging critical assumptions in post-secondary Science. *Education Sciences*, *8*(1), 12.

Gonen, S., & Basaran, B. (2008). The new method of problem solving in physics education by using SCORM-compliant content package. *Online Submission*, *9*(3), 112-120.

Gorsuch, R. L. (1983). *Factor analysis Lawrence Erlbaum Associates*. NJ: Hillsdale.

Guskey, T. R. (2003). Analyzing lists of the characteristics of effective professional development to promote visionary leadership. *NASSP Bulletin*, *87*(637), 4-20.

Güzel, H. (2004). The relationship between students' success in physics and mathematics lessons and their attitudes towards mathematics. *Journal of Turkish Science Education*, *1*(1), 28.

Hadzigeorgiou, Y., & Schulz, R. M. (2017). What really makes secondary school students "want" to study physics?. *Education Sciences*, *7*(4), 84.

Hair Jr, J.F., Anderson, R.E., Tatham, R.L., & Black, W.C. (1995), *Multivariate data analysis with readings*. New Jersey, NJ: Prentice Hall.

Hakkarainen, K. (2003). Progressive inquiry in a computer-supported biology class. *Journal of Research in Science Teaching*, *40*(10), 1072-1088.

Hammer, D. (1995). Epistemological considerations in teaching introductory physics. *Science Education*, *79*(4), 393-414. Herriott, R. E., & Firestone, W. A. (1984). Two images of schools as organizations: A refinement and elaboration. *Educational Administration Quarterly*, *20*(4), 41-57.

Hammer, D. (2000). Student resources for learning introductory physics. *American Journal of Physics*, *68*(S1), S52-S59.

Hammer, D., & Elby, A. (2002). On the form of a personal epistemology. *Personal epistemology: The psychology of beliefs about knowledge and knowing*, 169-190.

Hammer, D., & Elby, A. (2002). On the form of a personal epistemology. *Personal epistemology: The psychology of beliefs about knowledge and knowing*, *169190*.

Hannon, G. J. (2002). RNA interference. *Nature*, *418*(6894), 244.

Hannon, P., Umble, K. E., Alexander, L., Francisco, D., Steckler, A., Tudor, G., & Upshaw, V. (2002). Gagne's and Laurillard's Models of Instruction Applied to Distance Education: A theoretically driven evaluation of an online curriculum in public health. *The International Review of Research in Open and Distributed Learning*, *3*(2).

Hanuscin, D. L., & Lee, M. H. (2008). Mentoring new teachers. *Science and Children*, *45*(9), 56.

Hänze, M., & Berger, R. (2007). Cooperative learning, motivational effects, and student characteristics: An experimental study comparing cooperative learning and direct instruction in 12th grade physics classes. *Learning and Instruction*, *17*(1), 29-41.

Häussler, P., & Hoffmann, L. (2002). An intervention study to enhance girls' interest, self-concept, and achievement in physics classes. *Journal of Research in Science Teaching*, *39*(9), 870-888.

Hazari, Z., Potvin, G., Tai, R. H., & Almarode, J. (2010). For the love of learning science: Connecting learning orientation and career productivity in physics and chemistry. *Physical Review Special Topics-Physics Education Research*, *6*(1), 010107.

Hazari, Z., Sonnert, G., Sadler, P. M., & Shanahan, M. C. (2010). Connecting high school physics experiences, outcome expectations, physics identity, and physics career choice: A gender study. *Journal of Research in Science Teaching*, *47*(8), 978-1003.

Hazari, Z., Tai, R. H., & Sadler, P. M. (2007). Gender differences in introductory university physics performance: The influence of high school physics preparation and affective factors. *Science Education*, *91*(6), 847-876.

Heiss, E. D., Obourn, S., & Hoffman, C. W. (1950). *Modern science teaching.* New York: The MacMillan Company.

Heitin, L. (2016). Physics not offered at 2 in 5 high schools, analysis finds. *Education Week*, *6*, 22.

Henson, R. K. (2001). Understanding internal consistency reliability estimates: A conceptual primer on coefficient alpha. *Measurement and evaluation in counseling and development*, *34*(3), 177.

Henson, R. K., & Roberts, J. K. (2006). Use of exploratory factor analysis in published research: Common errors and some comment on improved practice. *Educational and Psychological Measurement*, *66*(3), 393-416.

Herbart, J. F. (1901). *Letters and lectures on education*. Swan Sonnenschein & Company.

Hestenes, D., & Halloun, I. (1995). Interpreting the force concept inventory: A response to March 1995 critique by Huffman and Heller. *The Physics Teacher*, *33*(8), 502-502.

Hestenes, D., & Halloun, I.A. (1985). The initial knowledge state of college physics students. *American Journal of Physics*, *53*(11), 1043-1055.

Hestenes, D., Wells, M., & Swackhamer, G. (1992). Force concept inventory. *The Physics Teacher*, *30*(3), 141-158.

Hodgson, C., & Pyle, K. (2010). *A literature review of assessment for learning in science*. Slough: Nfer.

Hofer, S. I., Schumacher, R., Rubin, H., & Stern, E. (2018). Enhancing physics learning with cognitively activating instruction: A quasi-experimental classroom intervention study. *Journal of Educational Psychology*........

Hoffer, T. B., Quin, P., & Suter, L. E. (1996). *High school seniors' instructional experiences in science and mathematics.* Washington, DC: National Center for Educational Statistics. NCES 95-278.

Hull, M. M., Kuo, E., Gupta, A., & Elby, A. (2013). Problem-solving rubrics revisited: Attending to the blending of informal conceptual and formal mathematical reasoning. *Physical Review Special Topics-Physics Education Research*, *9*(1), 010105.

Ingersoll, R. M., & Smith, T. M. (2003). The wrong solution to the teacher shortage. *Educational Leadership*, *60*(8), 30-33.

Isaacs, E., Visser, K., Friedrich, C., & Brijlal, P. (2007). Entrepreneurship education and training at the Further Education and Training (FET) level in South Africa. *South African Journal of Education*, *27*(4), 613-629.

Ivie, R., & Ray, K. N. (2005). *Women in Physics and Astronomy, 2005*. Melville, NY: American Institute of Physics.

Jackson, J., Dukerich, L., & Hestenes, D. (2008). Modeling instruction: An effective model for science education. *Science Educator*, *17*(1), 10.

Johnson, K., & Willoughby, S. (2018). Changing epistemological beliefs with nature of science implementations. *Physical Review Physics Education Research*, *14*(1), 010110.

Johnston, A. (2008). Demythologizing or dehumanizing? A response to Settlage and the ideals of open inquiry. *Journal of Science Teacher Education*, *19*(1), 11-13.

Jonassen, D. H. (1991). Objectivism versus constructivism: do we need a new philosophical paradigm? *Educational Technology Research and Development, 39* (3), 5-14.

Jonassen, D., Davidson, M., Collins, M., Campbell, J., & Haag, B. B. (1995). Constructivism and computer-mediated communication in distance education. *American Journal of Distance Education*, *9*(2), 7-26.

Jones, M. G., Howe, A., & Rua, M. J. (2000). Gender Differences in Students' Experiences, Interests, and Attitudes toward Science and Scientists. Science Education, 84(2), 180–192.

Karplus, R., & Thier, H. D. (1967). *A new look at elementary school science: Science curriculum improvement study*. USA: Rand McNally.

Kaur, D., & Zhao, Y. (2017). Development of Physics Attitude Scale (PAS): An Instrument to Measure Students' Attitudes toward Physics. *The Asia-Pacific Education Researcher*, *26*(5), 291-304.

Kaur, T., Blair, D., Burman, R., Stannard, W., Treagust, D., Venville, G., & Perks, D. (2017). Evaluation of 14 to 15 year old students' understanding and attitude towards learning Einstenian physics. Retrieved from https://arxiv.org/abs/1712.02063.

Kaya, H., & Boyuk, U. (2011). Attitude towards physics lessons and physical experiments of the high school students. *European Journal of Physics Education*, *2*(1), 23-31.

Kerlinger, F.N., & Rint, N. (1986). *Foundations of behaviour research*. London: Winston Inc.

Kim, S. Y., & Irving, K. E. (2010). History of science as an instructional context: Student learning in genetics and nature of science. *Science & Education*, *19*(2), 187-215.

Kirschner, P. A., Sweller, J., & Clark, R. E. (2006). Why minimal guidance during instruction does not work: An analysis of the failure of constructivist, discovery, problem-based, experiential, and inquiry-based teaching. *Educational Psychologist*, *41*(2), 75-86.

Kişoğlu, M. (2018). An examination of science high school students' motivation towards learning biology and their attitude towards biology lesson. *International Journal of Higher Education*, *7*(1), 151.

Klahr, D., & Nigam, M. (2004). The equivalence of learning paths in early science instruction: Effects of direct instruction and discovery learning. *Psychological Science, 15*, 661–667.

Klein, J. T. (2005). Integrative learning and interdisciplinary studies. *Peer Review*, *7*(4), 8-10.

Kliebard, H. M. (2004). *The struggle for the American curriculum, 1893-1958*. Psychology Press.

Knight, J. K., & Wood, W. B. (2005). Teaching more by lecturing less. *Cell Biology Education*, *4*(4), 298-310.

Koballa Jr, T. R., & Glynn, S. M. (2013). Attitudinal and motivational constructs in science learning. In *Handbook of research on science education* (pp. 89-116). London, UK: Routledge.

Kock, Z. J., Taconis, R., Bolhuis, S., & Gravemeijer, K. (2013). Some key issues in creating inquiry-based instructional practices that aim at the understanding of simple electric circuits. *Research in Science Education*, *43*(2), 579-597.

Kokkonen, T. (2017). *Concepts and Concept Learning in Physics: The systemic view*. Retrieved from https://helda.helsinki.fi/bitstream/handle/10138/228478/CONCEPTS.pdf?sequence=1

Korang-Yeboah, M., Akhtar, S., Siddiqui, A., Rahman, Z., & Khan, M. A. (2016). Application of NIR chemometric methods for quantification of the crystalline fraction of warfarin sodium in drug product. *Drug Development and Industrial Pharmacy*, *42*(4), 584-594.

Korur, F., & Eryılmaz, A. (2012). Teachers' and students' perceptions of effective physics teacher characteristics. *EğitimAraştırmaları-Eurasian Journal of Educational Research, 46,* 101-120.

Krapp, A., & Prenzel, M. (2011). Research on interest in science: Theories, methods, and findings. *International Journal of Science Education*, *33*(1), 27-50.

Lachman, S. J. (1997). Learning is a process: Toward an improved definition of learning. *The Journal of Psychology*, *131*(5), 477-480.

Langley, D., & Eylon, B. S. (2006). Probing High School Physics Students' Views and Concerns about Learning Activities. *International Journal of Science and Mathematics Education*, *4*(2), 215-239.

Lasry, N., Rosenfield, S., Dedic, H., Dahan, A., & Reshef, O. (2011). The puzzling reliability of the Force Concept Inventory. *American Journal of Physics*, *79*(9), 909-912.

Lavonen, J., Byman, R., Juuti, K., Meisalo, V., &Uitto, A. (2005). Pupil interest in physics: A survey in Finland. *Nordic Studies in Science Education*, *1*(2), 72-85.

Lavonen, J., Krzywacki-Vainio, H., Aksela, M., Krokfors, L., Oikkonen, J., & Saarikko, H. (2007). Pre-service teacher education in chemistry, mathematics and physics. *How Finns Learn Mathematics and Science*, 49-67.

Lehtinen, A. (2017). Pre-service teachers and guided inquiry-based science teaching with simulations. *Jyväskylä Studies in Education, Psychology and Social Research,* 591.

Lewin, T. (2013). Dartmouth stops credits for excelling on AP test. *New York Times*. Retrieved from https://www.nytimes.com/2013/01/18/education/dartmouth-stops-credits-for-excelling-on-ap-test.html.

Lising, L., & Elby, A. (2005). The impact of epistemology on learning: A case study from introductory physics. *American Journal of Physics*, *73*(4), 372-382.

Loewenberg B. D., Thames, M. H., & Phelps, G. (2008). Content knowledge for teaching: What makes it special?. *Journal of Teacher Education*, *59*(5), 389-407.

Logan, M., & Skamp, K. (2008). Engaging students in science across the primary secondary interface: Listening to the students' voice. *Research in Science Education*, *38*(4), 501-527.

Lombardi, M. M. (2007). Authentic learning for the 21st century: An overview. *Educause Learning Initiative*, *1*(2007), 1-12.

Long, J. S. (1983). *Confirmatory factor analysis: A preface to LISREL* (Vol. 33). Beverly Hills, CA: Sage Publications.

Lorenzo, M., Crouch, C. H., & Mazur, E. (2006). Reducing the gender gap in the physics classroom. *American Journal of Physics*, *74*(2), 118-122.

Mack, N., Woodsong, C., MacQueen, K. M., Guest, G., & Namey, E. (2005). *Qualitative research methods: A data collector's field guide.* Research Triangle Park, NC: Family Health International.

Magno, C. (2003). Relationship between attitude towards technical education and academic achievement in mathematics and science of the first and second year high school students, Caritas Don Bosco School, SY 2002-2003. *Online Submission*.

Malik, A., Setiawan, A., Suhandi, A., Permanasari, A., Samsudin, A., Safitri, D., Lisdiani S. A.S., Sapriadil, S., & Hermita, N. (2018). Using hot lab to increase pre-service physics teacher's critical thinking skills related to the topic of RLC circuit. In *Journal of Physics: Conference Series, 1013* (1), 20-23. IOP Publishing.

Martin, M., Mullis, I., & Foy, P. (2008). TIMSS 2007. *International Science Report. TIMSS & PIRLS International Study Center, Boston College*.

Martin-Hansen, L. (2002). Defining inquiry. *The Science Teacher*, *69*(2), 34.

May, D. B., & Etkina, E. (2002). College physics students' epistemological self-reflection and its relationship to conceptual learning. *American Journal of Physics*, *70*(12), 1249-1258.

Mayer, R. E. (2004). Should there be a three-strikes rule against pure discovery learning?. *American Psychologist*, *59*(1), 14.

McCallum, J. (2007). The debate in favour of using simulation education in pre-registration adult nursing. *Nurse Education Today*, *27*(8), 825-831.

McCord, R., & Matusovich, H. M. (2013). Developing an instrument to measure motivation, learning strategies and conceptual change. In *120th ASEE Annual Conference & Exposition, Atlanta, GA*.

McDermott, K. B. (1996). The persistence of false memories in list recall. *Journal of Memory and Language*, *35*(2), 212-230

McDermott, L. C., & Redish, E. F. (1999). Resource letter: PER-1: Physics education research. *American Journal of Physics*, *67*(9), 755-767.

McDermott, L. C., Shaffer, P. S., & Constantinou, C. P. (2000). Preparing teachers to teach physics and physical science by inquiry. *Physics Education*, *35*(6), 411.

Montero, I., & León, O. G. (2007). A guide for naming research studies in Psychology. *International Journal of Clinical and Health Psychology*, *7*(3).

Mottmann, J. (1999). Innovations in physics teaching- A cautionary tale. *The Physics Teacher*, *37*(2), 74-77.

Motz, L.L., Biehle, J.T., & West, S.S. (2007). *NSTA guide to planning school science facilities*. NSTA Press.

Mulholland, J., & Turnock, C. (2012). *Learning in the workplace: A toolkit for facilitating learning, and assessment in health, and social care settings*. Routledge.

Musasia, A.M., Abacha, O.A., & Biyoyo, M.E. (2012). Effect of practical work in physics on girls' performance, attitude change and skills acquisition in the form two-form three secondary schools' transition in Kenya. *International Journal of Humanities and Social Sciences*, *2*(23), 151-166.

Myers, R. E., & Fouts, J. T. (1992). A cluster analysis of high school science classroom environments and attitude toward science. *Journal of Research in Science Teaching*, *29*(9), 929-937.

Napoli, R.D. (2004).*What is student-centered learning?* Educational Initiative Centre, University of Westminster.

Narmadha, U., & Chamundeswari, S. (2013). Attitude towards learning of science and academic achievement in science among students at the secondary level. *Journal of Sociological Research*, *4*(2), 114-124.

National Council of Educational Research and Training. (2018). *Rationale for Class XI-XII Physics*. New Delhi: NCERT. Retrieved from ncert.nic.in.

National Research Council. (1996). *National science education standards*. NRC: National Academies Press.

National Research Council. (2006). *National science education standards*. National Academies Press.

Next Generation Science Standards (2013). *Understanding the Standards*. Washington DC: The National Academic Press.

Nunnally, J. (1978). *Psychometric methods.* New York: McGraw Hill.

Nunnally, J.C., Bernstein, I. H., & Berge, J.M.T. (1967). *Psychometric theory* (Vol. 226). New York: McGraw-hill.

Obaidat, I., & Malkawi, E. (2009). The grasp of physics concepts of motion: Identifying particular patterns in students' thinking. *International Journal for the Scholarship of Teaching and Learning*, *3*(1), 19.

Ogunleye, A. O. (2009). Defining science from multicultural and universal perspectives: A review of research and its implications for science education in Africa. *Journal of College Teaching and Learning*, *6*(5), 57-71.

Ohaidat, I., & Malkawi, E. (2009). The grasp of physics concepts of motion: Identifying particular patterns in students' thinking. *Center for Teaching, Learning, & Scholarship at Georgia Southern University, Statesboro, Georgia, USA*.

Osborne, J., & Dillon, J. (2008). *Science education in Europe: Critical reflections* (Vol. 13). London: The Nuffield Foundation.

Osborne, J., Simon, S., & Collins, S. (2003). Attitudes towards science: A review of the literature and its implications. *International Journal of Science Education*, *25*(9), 1049-1079.

Owen, S., Dickson, D., Stanisstreet, M., & Boyes, E. (2008). Teaching physics: Students' attitudes towards different learning activities. *Research in Science & Technological Education*, *26*(2), 113-128.

Parikh, P. P., & Sukhatme, S. P. (2004). Women engineers in India. *Economic and Political Weekly*, 193-201.

Petty, R. E. (2006). A metacognitive model of attitudes. *Journal of Consumer Research*, *33*(1), 22-24.

Piburn, M. D. (1993). Evidence from Meta-Analysis for an Expertise Model of Achievement in Science.

Pollock, S. J., Finkelstein, N. D., & Kost, L. E. (2007). Reducing the gender gap in the physics classroom: How sufficient is interactive engagement?. *Physical Review Special Topics-Physics Education Research*, *3*(1), 010107.

Potvin, P., & Hasni, A. (2014). Interest, motivation and attitude towards science and technology at K-12 levels: a systematic review of 12 years of educational research. *Studies in Science Education*, *50*(1), 85-129.

Priest, A. G., & Lindsay, R. O. (1992). New light on novice—expert differences in physics problem solving. *British journal of Psychology*, *83*(3), 389-405.

Prince, M. J., & Felder, R. M. (2006). Inductive teaching and learning methods: Definitions, comparisons, and research bases. *Journal of Engineering Education*, *95*(2), 123-138.

Rai, L. P., & Kumar, N. (2018). Emerging Trends in Science Education in India. Retrieved from https://www.researchgate.net/publication/239832297_Emerging_Trends_in_Science_Education_in_India.

Ramsden, P., & Moses, I. (1992). Associations between research and teaching in Australian higher education. *Higher Education*, *23*(3), 273-295.

Ramsey, G.P., Nemeth, M.M., & Haberkorn, D. (2013). *Physics pedagogy and assessment in secondary schools in the US. arXiv preprint arXiv:1305.4576.*

Reddy, V. (2010). Cross-national achievement studies: learning from South Africa's participation in the Trends in International Mathematics and Science Study (TIMSS). *Compare: A Journal of Comparative and International Education*, *35*(1), 63-77. doi: 10.1080/03057920500033571

Redish, E.F. (1999). Millikan lecture 1998: Building a science of teaching physics. *American Journal of Physics*, *67*(7), 562-573.

Redish, E.F. (2003). *Teaching physics with the physics suite CD*. NJ: Wiley, Hoboken.

Redish, E. F. (2010). *Introducing students to the culture of physics: Explicating elements of the hidden curriculum*. *arXiv preprint arXiv:1008.0578*.

Redish, E. F., Saul, J. M., & Steinberg, R. N. (1998). Student expectations in introductory physics. *American Journal of Physics*, *66*(3), 212-224.

Redish, E.F. (1994). Implications of cognitive studies for teaching physics. *American Journal of Physics*, *62*(9), 796-803.

Ross, S. M., Morrison, G. R., & Lowther, D. L. (2010). Educational technology research past and present: Balancing rigor and relevance to impact school learning. *Contemporary Educational Technology*, *1*(1).

Roth, W.M., & Roychoudhury, A. (1994). Physics students' epistemologies and views about knowing and learning. *Journal of Research in Science Teaching*, *31*(1), 5-30.

Rudolph, J. L. (2005). Epistemology for the masses: The origins of "the scientific method" in American schools. *History of Education Quarterly*, *45*(3), 341-376.

Rudolph, J. L. (2005). Inquiry, instrumentalism, and the public understanding of science. *Science Education*, *89*(5), 803-821.

Rudolph, J. L., & Meshoulam, D. (2014). Science education in American high schools. *Ağustos*, *27*, 2015.

Sadler, P. M., & Tai, R. H. (1997). The role of high school physics in preparing students for college physics. *The Physics Teacher, 35*, 282–285.

Sadler, P. M., & Tai, R. H. (2007). Advanced Placement Exam Scores as a Predictor of Performance in Introductory College Biology, Chemistry and Physics Courses. *Science Educator*, *16*(2), 1-19.

Sadler, P. M., Coyle, H., Miller, J. L., Cook-Smith, N., Dussault, M., & Gould, R. R. (2010). The astronomy and space science concept inventory: development and validation of assessment instruments aligned with the k–12 national science standards. *Astronomy Education Review*, *8*(1), 010111.

Sadler, P. M., Sonnert, G., Hazari, Z., & Tai, R. (2012). Stability and volatility of STEM career interest in high school: A gender study. *Science Education*, *96*(3), 411-427.

Sadler, T. D., Burgin, S., McKinney, L., & Ponjuan, L. (2010). Learning science through research apprenticeships: A critical review of the literature. *Journal of Research in Science Teaching*, *47*(3), 235-256.

Sahin, M. (2010). Effects of problem-based learning on university students' epistemological beliefs about physics and physics learning and conceptual understanding of Newtonian mechanics. *Journal of Science Education and Technology*, *19*(3), 266-275.

Saleh, S. (2012). The effectiveness of brain-based teaching approach in dealing with the problems of students' conceptual understanding and learning motivation towards physics. *Educational Studies, 38*(1), 19–29.

Samuels, P. (2016). *Advice on exploratory factor analysis*. Retrieved form https://www.researchgate.net/publication/319165677_Advice_on_Exploratory_Factor_Analysis.

Sarantos, M., Killen, R. M., Sharma, A. S., & Slavin, J. A. (2008). Influence of plasma ions on source rates for the lunar exosphere during passage through the earth's magnetosphere. *Geophysical Research Letters*, *35*(4).

Schiepe-Tiska, A., Roczen, N., Müller, K., Prenzel, M., & Osborne, J. (2016). Science-related outcomes: Attitudes, motivation, value beliefs, strategies. In *Assessing Contexts of Learning* (pp. 301-329). Springer, Cham.

Schofield, J.W. (1993). Increasing the generalizability of qualitative research. In M. Hammersley (Ed.), *Educational research: Current issues* (pp. 91–113). London: Paul Chapman Publishing.

Schommer, M. (1990). Effects of beliefs about the nature of knowledge on comprehension. *Journal of Educational Psychology*, *82*(3), 498.

Schwartz, M. S., Sadler, P. M., Sonnert, G., & Tai, R. H. (2009). Depth versus breadth: How content coverage in high school science courses relates to later success in college science coursework. *Science Education*, *93*(5), 798-826.

Schwartz, R., Lederman, N., & Crawford, B. (2004) Developing views of nature of science in an authentic context: an explicit approach to bridging the gap between nature of science and scientific inquiry. *Science Education, 88*(4), 610–645.

Seth, S., Fatin, A. P., & Marlina, A. (2007). Kemahiran Metakognitif Dalam Kalangan Pelajar Sekolah Menengah di Negeri Johor Dalam Menyelesaikan Masalah Fizik. Fakulti Pendidikan Universiti Teknologi Malaysia.

Settlage, J. (2007). Demythologizing science teacher education: Conquering the false ideal of open inquiry. *Journal of Science Teacher Education*, *18*(4), 461-467.

Shah, K. (2017). *Cultural impediments to physics research in India (2017).* Retrieved from http://www.physedu.in/uploads/webspecials/42450_Physics-research-in-India.pdf.

Shanks, G., Sharma, R., Seddon, P., & Reynolds, P. (2010). The impact of strategy and maturity on business analytics and firm performance: a review and research agenda. *ACIS 2010 Proceedings*, 51.

Sharma, S., Ahluwalia, P.K., & Sharma, S.K. (2013). Students' epistemological beliefs, expectations, and learning physics: An international comparison. *Physical Review Special Topics-Physics Education Research*, *9*(1), 010117.

Shaw, K. A. (2004). The development of a physics self-efficacy instrument for use in the introductory classroom. In J. Marx, S. Franklin, & K. Cummings (Eds.), *AIP Conference Proceedings*, 720(1), 137-140. AIP.

Sheldrake, R., Mujtaba, T., & Reiss, M. J. (2017). Science teaching and students' attitudes and aspirations: The importance of conveying the applications and relevance of science. *International Journal of Educational Research*, *85*, 167-183.

Shulman, L. S. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review, 57*, 1-22.

Shulman, L., & Keisler, E. (Eds.). (1966). Learning by discovery: A critical appraisal. Chicago: Rand McNally

Siddiqui, A., Khan, M., & Akhtar, S. (2008). Supply chain simulator: A scenario-based educational tool to enhance student learning. *Computers & Education*, *51*(1), 252-261.

Simpson, R.D., & Oliver, J.S. (1990). A summary of major influences on attitude toward and achievement in science among adolescent students. *Science Education*, *74*(1), 1-18.

Singh, C. (2005). Transfer of learning in quantum mechanics. In *AIP Conference Proceedings, 790*(1), 23-26. AIP.

Singh, G. P., & Imam, A. (2014). Effect of gender, attitude towards science, parental education and family size on science achievement of secondary school students of central UP. *International Journal of Advancements in Research & Technology*, *3*(2), 47-53.

Sliško, J. A. (2016). Improving teaching design of active physics learning by using potentially helpful knowledge from other science fields. *Inovacije u nastavi-časopiszasavremenunastavu*, *29*(2), 1-14.

Snetinová, M., Kácovský, P., & Machalická, J. (2018). Hands-on experiments in the interactive physics laboratory: Students' intrinsic motivation and understanding. *Center for Educational Policy Studies Journal*, *8*(1), 55-75.

Soomro, A.Q., Qaisrani, M.N., & Uqaili, M. A. (2011). Measuring students' attitudes towards learning physics: Experimental research. *Australian Journal of Basic and Applied Sciences*, *5*(11), 2282-2288.

South Carolina Department of Education. (2018). *Standards and learning*. Columbia, SC. Retrieved from ed.sc.gov.

Splendiani, A., Sun, L., Zhang, Y., Li, T., Kim, J., Chim, C.Y.,... & Wang, F. (2010). Emerging photoluminescence in monolayer MoS2. *Nano Letters, 10*(4), 1271-1275.

Steffe, L. P., & Gale, J. E. (Eds.). (1995). *Constructivism in education* (p. 159). Hillsdale, NJ: Lawrence Erlbaum.

Strauss, S., Ziv, M., & Stein, A. (2002). Teaching as a natural cognition and its relations to preschoolers' developing theory of mind. *Cognitive Development*, *17*(3-4), 1473-1487.

Streiner, D. L. (1994). Figuring out factors: The use and misuse of factor analysis. *The Canadian Journal of Psychiatry*, *39*(3), 135-140.

Taconis, R., Ferguson-Hessler, M.G., & Broekkamp, H. (2001). Teaching science problem solving: An overview of experimental work. *Journal of Research in Science Teaching*, *38*(4), 442-468.

Talton, E. L., & Simpson, R. D. (1987). Relationships of attitude toward classroom environment with attitude toward and achievement in science among tenth grade biology students. *Journal of Research in Science Teaching*, *24*(6), 507-525.

Tavakol, M., & Dennick, R. (2011). Making sense of Cronbach's alpha. *International Journal of Medical Education*, *2*, 53.

Tebabal, A., & Kahssay, G. (2011). The effects of student-centered approach in improving students' graphical interpretation skills and conceptual understanding of kinematical motion. *Latin-American Journal of Physics Education*, *5*(2), 9.

The State Council of Educational Research and Training. (2017). *Resources for higher secondary students*. Kerala, India. Retrieved from scert.kerala.gov.in.

Thompson, M. D. (2001). Informal student-faculty interaction: Its relationship to educational gains in science and mathematics among community college students. *Community College Review*, *29*(1), 35-57.

Thomson, S., Lokan, J., Lamb, S., & Ainley, J. (2001). *Lessons from the third international mathematics and science study*. A study commissioned by the Australian Government.

Thornton, R. K., & Sokoloff, D. R. (1998). Assessing student learning of Newton's laws: The force and motion conceptual evaluation and the evaluation of active learning laboratory and lecture curricula. *American Journal of Physics*, *66*(4), 338-352.

Trigwell, K., Ellis, R. A., & Han, F. (2012). Relations between students' approaches to learning, experienced emotions and outcomes of learning. *Studies in Higher Education*, *37*(7), 811-824.

Trninic, D. (2018). Instruction, repetition, discovery: Restoring the historical educational role of practice. *Instructional Science*, *46*(1), 133-153.

Trumper, R. (2006). Factors affecting junior high school students' interest in physics. *Journal of Science Education and Technology*, *15*(1), 47-58.

Turner, S., & Peck, D. (2009). Can we do school science better? Facing the problem of student engagement. *Education Canada*, *49*(2), 54-57.

Varghese, G. (2008). Declining Trends in Science Education and Research in Indian Universities. *Universities as Centres of Research and Knowledge Creation: An Endangered Species*, 201-212.

Vaz, S., Falkmer, T., Passmore, A. E., Parsons, R., & Andreou, P. (2013). The case for using the repeatability coefficient when calculating test–retest reliability. *PLoS One*, *8*(9), e73990.

Vinovskis, M. (2015). *From a nation at risk to no child left behind: National education goals and the creation of federal education policy*. Teachers College Press.

Vistro-Yu, C. P. (2013). Cross-national studies on the teaching and learning of mathematics: where do we go from here?. *ZDM*, *45*(1), 145-151.

Von Glasersfeld, E. (Ed.). (2006). *Radical constructivism in mathematics education* (Vol. 7). New York, NY: Springer Science & Business Media.

Vygotsky, L.S. (1978). *Mind in society: The development of higher mental process.* Cambridge, MA: Harvard University Press.

Walper, L. M., Lange, K., Kleickmann, T., & Möller, K. (2014). Students' physics-related interests in the transition from primary to secondary school–How do they change and what instructional practices influence them. *E-Book Proceedings of the ESERA 2013 Conference: Science Education Research for Evidence-based Teaching and Coherence in Learning.* Retrieved from https://link.springer.com/chapter/10.1007/978-3-319-20074-3_18.

Watson, J., McEwen, A., & Dawson, S. (1994). Sixth form A level students' perceptions of the difficulty, intellectual freedom, social benefit and interest of science and arts subjects. *Research in Science & Technological Education*, *12*(1), 43-52.

Wenning, C.J. (2010). Levels of inquiry: Using inquiry spectrum learning sequences to teach science. *Journal of Physics Teacher Education Online*, *5*(4), 11-19.

Wentzel, K. R., & Watkins, D. E. (2002). Peer relationships and collaborative learning as contexts for academic enablers. *School Psychology Review*, *31*(3), 366.

White, S., & Tyler, J. (2015). *High school physics teacher preparation: Results from the 2012-13 Nation-wide survey of high school physics teachers*. Focus On. AIP Statistical Research Center.

Williams, B., Onsman, A., & Brown, T. (2010). Exploratory factor analysis: A five-step guide for novices. *Australasian Journal of Paramedicine*, *8*(3).

Williams, C., Stanisstreet, M., Spall, K., Boyes, E., & Dickson, D. (2003). Why aren't secondary students interested in physics?. *Physics Education*, *38*(4), 324.

Wilson, S. M., & Peterson, P. L. (2006). *Theories of learning and teaching: What do they mean for educators? Working Paper.* National Education Association Research Department.

Windschitl, M., Thompson, J., & Braaten, M. (2008). Beyond the scientific method: Model-based inquiry as a new paradigm of preference for school science investigations. *Science Education*, *92*(5), 941-967.

Winter, J., & Cotton, D. (2010). 'It's not just bits of paper and light bulbs': A review of sustainability pedagogies and their potential for use in higher education. In *Sustainability Education* (pp. 54-69). London: Routledge.

Wulf, R., Mayhew, L. M., & Finkelstein, N. D. (2010). Impact of informal science education on children's attitudes about science. In *AIP Conference Proceedings* (Vol. 1289, No. 1, pp. 337-340). AIP.

Yerdelen-Damar, S., & Elby, A. (2016). Sophisticated epistemologies of physics versus high-stakes tests: How do elite high school students respond to competing influences about how to learn physics?. *Physical Review Physics Education Research*, *12*(1), 010118.

Zacharia, Z., & Barton, A.C. (2004). Urban middle-school students' attitudes toward a defined science. *Science Education, 88*(2), 197–222.

Zacharia, Z.C., & Constantinou, C. P. (2008). Comparing the influence of physical and virtual manipulatives in the context of the Physics by Inquiry curriculum: The case of undergraduate students' conceptual understanding of heat and temperature. *American Journal of Physics*, *76*(4), 425-430.

Zhang, P., & Ding, L. (2013). Large-scale survey of Chinese precollege students' epistemological beliefs about physics: A progression or a regression?. *Physical Review Special Topics-Physics Education Research*, *9*(1), 010110.

Zollman, A. (2012). Learning for STEM literacy: STEM literacy for learning. *School Science and Mathematics*, *112*(1), 12-19.

Zwickl, B.M., Hirokawa, T., Finkelstein, N., & Lewandowski, H.J. (2014). Epistemology and expectations survey about experimental physics: Development and initial results. *Physical Review Special Topics-Physics Education Research*, *10*(1), 010120.

APPENDICES

Appendix A

UNIVERSITY OF CALICUT
DEPARTMENT OF EDUCATION

STRUCTURED INTERVIEW FOR STUDENTS ON PHYSICS LEARNING

Dr. K. Abdul Gafoor
Professor

Mini Narayanan
Research Scholar

Yes/No Questions
1. Do you like science?
2. Are you interested in physics?
3. Is conceptual understanding the most difficult task in learning physics?
4. Is physics different from other sciences?
5. Do you think a question can lead to a lab activity?
6. Do you have lecture and lab classes combined?
7. Do you prefer conducting lab activities rather than listening to a lecture?
Open-ended Questions
8. What is so special about science?
9. What makes physics your favorite?
10. Suppose you get a decent score on exam. Does it determine your physics aptitude? Why?
11. Is physics different from other sciences? How?
12. What could make learning physics more interesting?
13. How often do you become familiar with the background when you begin to perform a lab?
14. Do you think that a question itself can lead to a lab activity? How?
15. What different teaching methods are you exposed in your physics classes? (Check the ones that apply) a. Lecturing without demonstration   d. Problem-solving with teacher guidance b. Lecturing with demonstrations   e. Solving problem using textbooks only c. Hands-on activities without lecturing   f. Group work without teacher facilitation
16. What is your favorite strategy/ method? Why?
17. Do you have any other suggestions on techniques other than those mentioned to better learn physics concepts?

Appendix-B1

UNIVERSITY OF CALICUT
DEPARTMENT OF EDUCATION

QUESTIONNAIRE ON STUDENT ATTITUDE TOWARD PHYSICS AND PREFERRED PRACTICES

(DRAFT-ENGLISH VERSION)

Dr. K. Abdul Gafoor
Professor

Mini Narayanan
Research Scholar

Instructions

The following statements are on aspects of your belief, perception, attitude, and preferences on learning physics. Each statement is provided with two choices, A=Agree, D=Disagree OR Y=Yes, and N=No. Please check your response and indicate what you believe true by circling the right choice against each of the responses.

Name:____

Gender: Male/Female/Others____________________________

Class/Division:___________________________________

School:____

Sl. No.	Statements	A	D
Part A			
1.	Learning Physics would improve my thinking skills	A	D
2.	I am aware of the relevance of learning physics	A	D
3.	Learning Physics would improve my skill in solving real world problems	A	D
4.	Learning Physics would help me perform better in my future endeavors	A	D
5.	I am passionate about understanding Physics concepts	A	D
6.	I would consider studying Physics at college although it is not mandatory for my degree	A	D
7.	It is easy for me to obtain ambitious job opportunities if I study Physics at a higher level	A	D

Sl. No.	**Statements**	**A**	**D**
8.	I think my skills in advanced Mathematics would help understand Physics concepts better	A	D
9.	I feel that Physics concepts are more difficult than concepts in Mathematics	A	D
10.	It is the teacher that makes learning Physics interesting	A	D
11.	It is the topic that makes learning Physics interesting	A	D
12.	I think boys like Physics more than girls do	A	D
13.	I believe boys have a natural command over girls in understanding Physics concepts	A	D
14.	I believe boys start thinking and experiencing Physics concepts much earlier than girls do	A	D
15.	I think introducing Physics in earlier grade levels would help understand it better	A	D
16.	My perception on Physics has been changed *positively* since I started learning the subject	A	D
17.	My perception on Physics has been changed *negatively* since I started learning the subject	A	D
18.	Physics makes meaningful connections with everyday life	A	D
19.	I love discussing Physics concepts outside my classroom	A	D
20.	All sciences are my favorite, whereas Physics is the least favorite of all of them	A	D
21.	I consider myself as a physicist because I receive decent scores in all Physics tests	A	D
22.	I consider myself as a physicist because I can relate the laws of Physics with various Natural Phenomena	A	D
23.	I think I have to improve my reasoning skills to better understand Physics concepts	A	D
24.	I love conducting experiments in Physics but I don’t learn the concept from them	A	D
25.	I would learn Physics better if the lab activities are done parallel to the lectures	A	D
26.	I think a conceptual question can lead to a lab activity	A	D

Sl. No.	Statements	A	D
27.	I would learn Physics better if my teacher uses a variety of teaching tactics	A	D
28.	I think a lab activity done with clear objectives can make a concept thorough	A	D
29.	I think teaching at a slow pace would help me understand Physics concepts better	A	D
30.	Physics is my favorite subject. **Because**		
	a. Physics has always been my favorite subject.	A	D
	b. I will be able to know the world around me by learning Physics.	A	D
	c. I notice the application of Physics concepts in my daily activities.	A	D
	d. The laws of Physics can explain the laws of Nature.	A	D
	e. I can utilize my aptitude in Mathematics in learning physics.	A	D
31.	I hate Physics. **Because**		
	a. Many topics filled with a number of difficult concepts that are crunched together.	A	D
	b. Physics is filled with tough equations that are difficult to memorize.	A	D
	c. Physics is filled with confusing derivations and their mathematical aspects.	A	D
	d. Physics problems I learn are never applicable in real life.	A	D
	e. I never understand the concepts.	A	D
	f. I never get the right answers when solving problems.	A	D
	g. Physics deals with too much material that has been taught in a very small duration.	A	D
	h. Whenever I learn Physics, I try to hammer many concepts onto my brain without any clear understanding.	A	D
	i. I would never study Physics in my life despite the fact that I receive excellent grades in my physics tests.	A	D

Part IV (*A few classroom strategies are given in the following table. Indicate which of them are currently practiced or you would prefer practicing by your classroom instructor.*)

	In-class Strategies	**Currently Practiced**		**I prefer practicing it.**	
32.	Conduct experiments for each major concept I learn	Y	N	Y	N
33.	Hands-on activities to explore inside and outside my classroom	Y	N	Y	N
34.	Lab activities are done parallel to the lectures	Y	N	Y	N
35.	A variety of instructional methods based on the nature of each concept	Y	N	Y	N
36.	The problems solved in class are made relevant	Y	N	Y	N
37.	The concepts are made visual through demonstrations	Y	N	Y	N
38.	Problem-solving strategies are made clear	Y	N	Y	N
39.	Concepts are made applicable through problems	Y	N	Y	N
40.	Concepts and problems are well-structured and meaningful	Y	N	Y	N
41.	Problems are applicable in real life situations	Y	N	Y	N

Appendix B2

UNIVERSITY OF CALICUT
DEPARTMENT OF EDUCATION

QUESTIONNAIRE ON STUDENT ATTITUDE TOWARD PHYSICS AND PREFERRED PRACTICES

(DRAFT-MALAYALAM VERSION)

Dr. K. Abdul Gafoor
Professor

Mini Narayanan
Research Scholar

നിർദ്ദേശങ്ങൾ

താഴെ കൊടുത്തിരിക്കുന്ന പ്രസ്താവനകൾ ഫിസിക്സ് പഠനവുമായി ബന്ധപ്പെട്ട കാഴ്ചപ്പാടും മനോഭാവവും മുൻഗണനയും ആയി ബന്ധപ്പെട്ടതാണ്. അവയുമായി താങ്കൾക്ക് യോജിക്കുകയോ വിയോജിക്കുകയോ ചെയ്യാം. ഓരോ പ്രസ്താവനയോടും താങ്കൾ യോജിക്കുന്നുവെങ്കിൽ A എന്നും വിയോജിക്കുന്നുവെങ്കിൽ B എന്നും രേഖപ്പെടുത്തുക.

പേര്:...

ആൺകുട്ടി/പെൺകുട്ടി/മറ്റുള്ളവർ...

ക്ലാസ്സ്...ഡിവിഷൻ..................................

സ്കൂൾ...

ക്രമ നമ്പർ	പ്രസ്താവനകൾ	A	D
	പാർട്ട് - എ		
1.	ഊർജ്ജതന്ത്രപഠനം എന്റെ ചിന്താശക്തിയെ മെച്ചപ്പെടുത്തും.	A	D
2.	ഊർജ്ജതന്ത്രപഠനത്തിന്റെ പ്രസക്തിയെക്കുറിച്ച് ഞാൻ ബോധവാനാണ്.	A	D
3.	നമ്മുടെ ചുറ്റുമുള്ള പ്രശ്നങ്ങൾക്കു പരിഹാരം കാണുന്നതിനുള്ള എന്റെ കഴിവ് മെച്ചപ്പെടുത്താൻ ഊർജ്ജതന്ത്രപഠനം എന്നെ സഹായിക്കും.	A	D
4.	ഭാവിയിലുള്ള എന്റെ പരിശ്രമങ്ങളെ പൂർവ്വാധികം നല്ല രീതിയിൽ പ്രകടിപ്പിക്കാൻ ഊർജ്ജതന്ത്രപഠനം എന്നെ സഹായിക്കും.	A	D
5.	ഊർജ്ജതന്ത്രത്തിലെ വിവിധ ആശയങ്ങൾ മനസ്സിലാക്കുക എന്നത് എനിക്ക് വളരെയധികം താൽപര്യമുള്ള കാര്യമാണ്.	A	D
6.	ഭാവിയിലുള്ള എന്റെ ഉപരിപഠനത്തിലേക്ക് ഊർജ്ജതന്ത്രപഠനം അനിവാര്യമല്ലെന്നു വരികയും ആ വിഷയം ഇനിയും പഠിക്കാൻ ഞാൻ താൽപര്യപ്പെടുന്നു.	A	D

ക്രമ നമ്പർ	പ്രസ്താവനകൾ	A	D
7.	എന്റെ ഉപരിപഠന വിഷയങ്ങളിൽ ഊർജ്ജതന്ത്രം ഉൾപ്പെടുത്തുകയാണെങ്കിൽ ഭാവിയിൽ ഉയർന്ന രീതിയിലുള്ള തൊഴിലവസരങ്ങൾ ലഭിക്കാൻ ഞാൻ പ്രാപ്തനാകും.	A	D
8.	ഗണിതശാസ്ത്രത്തിലുള്ള എന്റെ അസാമാന്യ കഴിവ് ഊർജ്ജതന്ത്ര പഠനത്തിന് എന്നെ നിശ്ചയമായും സഹായം ചെയ്യും.	A	D
9.	എന്നെ സംബന്ധിച്ചിടത്തോളം ഊർജ്ജതന്ത്രത്തിലെ ആശയങ്ങൾ ഗണിതശാസ്ത്രത്തിലേതിനേക്കാൾ പ്രയാസകരമാണ്.	A	D
10.	ഊർജ്ജതന്ത്രപഠനം താൽപര്യമുള്ളതാക്കാൻ അതു പഠിപ്പിക്കുന്ന അധ്യാപകനോ അധ്യാപികയ്ക്കോ ഉള്ള പങ്ക് വളരെ വലുതാണ്.	A	D
11.	ഊർജ്ജതന്ത്രപഠനം താൽപര്യമുള്ളതാക്കുന്നതിൽ പഠിപ്പിക്കപ്പെടുന്ന പാഠഭാഗത്തിനു പ്രധാനപ്പെട്ട പങ്കുണ്ട്.	A	D
12.	ഊർജ്ജതന്ത്രത്തിലെ ആശയങ്ങൾ മനസ്സിലാക്കുന്നതിൽ പ്രകൃതിദത്തമായ ആധിപത്യം പെൺകുട്ടികളേക്കാൾ ആൺകുട്ടികൾക്കുണ്ടെന്നു ഞാൻ വിശ്വസിക്കുന്നു.	A	D
13.	ഊർജ്ജതന്ത്രത്തിലെ ആശയങ്ങൾ മനസ്സിലാക്കുന്നതിൽ പ്രകൃതിദത്തമായ ആധിപത്യം പെൺകുട്ടികളേക്കാൾ ആൺകുട്ടികൾക്കുണ്ടെന്നു ഞാൻ വിശ്വസിക്കുന്നു.	A	D
14.	ഊർജ്ജതന്ത്രത്തിലെ വിവിധ ആശയങ്ങളെ അടുത്തറിയാനും അനുഭവിച്ചറിയാനുമുള്ള ശ്രമം പെൺകുട്ടികളെക്കാളും ആൺകുട്ടികൽ നടത്തുന്നുവെന്നാണ് എന്റെ വിശ്വാസം.	A	D
15.	വളരെ താഴ്ന്ന ക്ലാസ്സുകളിൽ വച്ചുതന്നെ കുട്ടികളെ ഊർജ്ജതന്ത്രം പരിചയപ്പെടുത്തുന്നത് ആ വിഷയം കൂടുതൽ മനസ്സിലാക്കാൻ അവർക്ക് സഹായകമാകുമെന്ന് എനിക്കു തോന്നുന്നു.	A	D
16.	ഊർജ്ജതന്ത്രപഠനം തുടങ്ങിയതുനുശേഷം ആ വിഷയത്തോടുള്ള എന്റെ കാഴ്ചപ്പാട് മെച്ചപ്പെടുകയാണുണ്ടായത്.	A	D
17.	പഠിച്ചുതുടങ്ങിയാൽ പിന്നെ ഊർജ്ജതന്ത്രത്തോടുള്ള എന്റെ കാഴ്ചപ്പാട് മോശപ്പെടുകയാണുണ്ടായത്.	A	D
18.	നിത്യജീവിതത്തിലെ വിവിധ പ്രതിഭാസങ്ങളുമായി അർത്ഥവത്തായ ഒരു ബന്ധമുണ്ടാക്കാൻ ഊർജ്ജതന്ത്രപഠനം സഹായകമാകുന്നു.	A	D
19.	ഊർജ്ജതന്ത്രത്തിലെ ആശയങ്ങളെക്കുറിച്ച് ക്ലാസ്സിനു പുറത്തുള്ള ചർച്ചകളിൽ പങ്കെടുക്കാൻ എനിക്കിഷ്ടമാണ്.	A	D
20.	എല്ലാ ശാസ്ത്രവിഷയങ്ങളോടും എനിക്കു പ്രതിപത്തിയുണ്ടെങ്കിലും ഊർജ്ജതന്ത്രം അവയിൽ എറ്റവും ഇഷ്ടം കുറഞ്ഞതാണ്.	A	D
21.	പരീക്ഷകളിൽ ഊർജ്ജതന്ത്രത്തിനു മെച്ചപ്പെട്ട മാർക്ക് കിട്ടുന്നതിനാൽ ഞാൻ എന്നെ ഒരു ഊർജ്ജതന്ത്രജ്ഞൻ ആയി കണക്കാക്കുന്നു.	A	D
22.	ഊർജ്ജതന്ത്രത്തിലെ വിവിധ നിയമങ്ങൾ പ്രകൃതിയിലെ വിവിധ പ്രതിഭാസങ്ങളുമായി ബന്ധപ്പെടുത്താൻ എനിക്കു കഴിയുന്നതിനാലാണ് ഞാൻ ഒരു ഊർജ്ജതന്ത്രജ്ഞൻ ആയി എന്നെ കണക്കാക്കുന്നത്.	A	D

ക്രമ നമ്പർ	പ്രസ്താവനകൾ	A	D
23.	ഊർജ്ജതന്ത്രത്തിലെ വിവിധ ആശയങ്ങൾ നന്നായി മനസ്സിലാക്കാൻ എന്റെ യുക്തിപരമായ ചിന്താശക്തിയെ മെച്ചപ്പെടുത്തേണ്ടതുണ്ടെന്നു ഞാൻ കരുതുന്നു.	A	D
24.	ഊർജ്ജതന്ത്രത്തിലെ വിവിധ പരീക്ഷണനിരീക്ഷണങ്ങളിൽ മുഴുകാൻ ഞാൻ തൽപരനാണെങ്കിലും അവയിൽനിന്നും അതിലെ ആശയങ്ങ ളൊന്നുംതന്നെ ഞാൻ മനസ്സിലാക്കുന്നില്ല.	A	D
25.	ക്ലാസ്സുമുറിയിൽ അധ്യാപകൻ നടത്തുന്ന പ്രഭാഷണങ്ങളുടെ (ലക്ചർ) തുടർച്ചയായി അവയുമായി ബന്ധപ്പെട്ട പരീക്ഷണനിരീക്ഷണങ്ങളിൽ (ലാബ്) ഏർപ്പെടുന്നതുവഴി ഊർജ്ജതന്ത്രം കൂടുതലായി മനസ്സിലാക്കു വാൻ എനിക്കു സാധിക്കുമെന്നു ഞാൻ വിചാരിക്കുന്നു.	A	D
26.	ക്ലാസ്സുമുറിയിൽ അധ്യാപകൻ ചോദിക്കുന്ന ആശയപരമായി പ്രാധാന്യ മുള്ള ഒരൊറ്റ ചോദ്യത്തിലൂടെതന്നെ ഒരു പരീക്ഷണനിരീക്ഷണ പ്രവർത്ത നത്തിൽ (ലാബ്) എത്തിച്ചേരാനാകുമെന്ന് ഞാൻ കരുതുന്നു.	A	D
27.	വിവിധ രീതികളിലുള്ള അദ്ധ്യാപനരീതികൾ ഉപയോഗിക്കുന്നത് എന്റെ പഠനത്തെ വളരെ അധികം സഹായിക്കും.	A	D
28.	വ്യക്തമായ ലക്ഷ്യബോധത്തോടെയുള്ള ഒരു പരീക്ഷണനീരീക്ഷണം (ലാബ്) നിർവ്വഹിക്കുന്നതിലൂടെ അതിന് അടിസ്ഥാനമായ ഊർജ്ജതന്ത്ര ത്തിലെ ആശയം കൃത്യമായി മനസ്സിലാക്കാൻ സാധിക്കുമെന്നു ഞാൻ കരുതുന്നു.	A	D
29.	വളരെ സാവധാനത്തിൽ പഠിപ്പിക്കുകയാണെങ്കിൽ ഊർജ്ജതന്ത്രത്തിലെ ആശയങ്ങൾ വ്യക്തമായി മനസ്സിലാക്കാനാവുമെന്നു ഞാൻ കരുതുന്നു.	A	D
30.	ഊർജ്ജതന്ത്രം എന്റെ ഇഷ്ടവിഷയമാണ്. **അതിനു കാരണം**	A	D
a)	ഊർജ്ജതന്ത്രം എല്ലായ്പ്പോഴും എന്റെ ഇഷ്ടവിഷയമായിരുന്നു.	A	D
b)	ഊർജ്ജതന്ത്രപഠനത്തിലൂടെ എന്റെ ചുറ്റുമുള്ള പ്രപഞ്ചത്തെ ഞാൻ കൂടുതൽ മനസ്സിലാക്കുന്നു.	A	D
c)	എന്റെ ദൈനംദിന ജീവിതത്തിലെ വിവിധ പ്രവൃത്തികളിൽ ഊർജ്ജതന്ത്ര ത്തിലെ ആശയങ്ങൾ പ്രയോജനപ്പെടുത്തിയിരിക്കുന്നുവെന്ന് ഞാൻ അനു മാനിക്കുന്നു.	A	D
d)	ഊർജ്ജതന്ത്രത്തിലെ നിമയങ്ങൾക്ക് പ്രപഞ്ചത്തിലെ നിയമങ്ങളെ വ്യാഖ്യാനിക്കാൻ കഴിയുന്നു.	A	D
e)	ഊർജ്ജതന്ത്രം മനസ്സിലാക്കാനായി ഗണിതശാസ്ത്രത്തിലുള്ള എന്റെ കഴിവ് ഉപയോഗപ്പെടുത്താൻ എനിക്കു കഴിയുന്നു.	A	D
31.	ഞാൻ ഊർജ്ജതന്ത്രം വെറുക്കുന്നു **അതിനു കാരണം**	A	D
a)	ക്ലേശകരമായ അനവധി ആശയങ്ങൾ തിരുകി നിറച്ച ഒരു വിഷയമാണ് ഊർജ്ജതന്ത്രം	A	D

ക്രമ നമ്പർ	പ്രസ്താവനകൾ	A	D
b)	ഊർജ്ജതന്ത്രത്തിലെ വിഷമമേറിയ സമവാക്യങ്ങൾ (ഇക്വേഷൻ) മനഃപാഠ മാക്കുക നന്നേ പ്രയാസമേറിയതാണ്.	A	D
c)	കുഴപ്പിക്കുന്ന അനവധി അനുമാനങ്ങളും (ഡെറിവേഷൻ) അവയുമായി ബന്ധപ്പെട്ട ഗണിതശാസ്ത്രനിയമങ്ങളും നിറഞ്ഞതാണ് ഊർജ്ജതന്ത്രം.	A	D
d)	ഊർജ്ജതന്ത്രത്തിൽ ഞാൻ പഠിച്ച പ്രശ്നങ്ങൾക്കൊന്നുംതന്നെ നിത്യജീ വിതത്തിൽ പ്രയോഗപ്രദമായവ അല്ല.	A	D
e)	ഊർജ്ജതന്ത്രത്തിലെ ആശയങ്ങളൊന്നുംതന്നെ എനിക്കു മനസ്സിലാകാറില്ല.	A	D
f)	ഊർജ്ജതന്ത്രത്തിൽ ഞാൻ പഠിക്കുന്ന പ്രശ്നങ്ങൾക്കൊന്നും തന്നെ ശരി യുത്തരം കാണാൻ എനിക്കു കഴിയുന്നില്ല.	A	D
g)	വളരെ ചുരുങ്ങിയ സമയംകൊണ്ട് ഒരുപാടു കാര്യങ്ങൾ പഠിക്കേണ്ടിവ രുന്ന ഒരു വിഷയമാണ് ഊർജ്ജതന്ത്രം.	A	D
h)	വ്യക്തമായി മനസ്സിലാക്കാതെ അനവധി ആശയങ്ങൾ തലച്ചോറിലേക്ക് അടിച്ചേല്പ്പിക്കുകയാണ് ഊർജ്ജതന്ത്ര പഠനത്തിലൂടെ ഞാൻ ചെയ്യുന്നത്.	A	D
i)	വളരെ ഉയർന്ന നിലയിലുള്ള മാർക്ക് ലഭിക്കുന്നുവെങ്കിലും ഭാവിയിൽ ഊർജ്ജതന്ത്രം പഠിക്കാൻ ഞാൻ ആഗ്രഹിക്കുന്നില്ല.	A	D

പാർട്ട്-ബി

താഴെ കൊടുത്തിരിക്കുന്ന അദ്ധ്യാപനരീതികളിൽ
താങ്കളുടെ അഭിപ്രായം രേഖപ്പെടുത്തുക

Y = അതെ

N = അല്ല

ക്രമ. നമ്പർ	അദ്ധ്യാപനരീതി	അദ്ധ്യാപകൻ ഉപയോഗിക്കുന്നു		അദ്ധ്യാപകൻ ഉപയോഗിച്ചുകാണാൻ താല്പര്യപ്പെടുന്നു.	
32.	ഞാൻ പഠിക്കുന്ന ഓരോ ആശയവും കൂടുതൽ വ്യക്തമാക്കാനായി ക്ലാസ്സിൽ പ്രത്യേകമായി പരീ ക്ഷണനിരീക്ഷണങ്ങൾ നിർവ്വഹിക്കുന്നു.	Y	N	Y	N
33.	പലതരത്തിലുള്ള സാമഗ്രികൾ ഉപയോഗിച്ചുള്ള പരീക്ഷണനിരീക്ഷണങ്ങൾ (ലാബ്) ക്ലാസ്സുമുറി യുടെ അകത്തും പുറത്തും വെച്ച് നിർവ്വഹിക്കുന്നു.	Y	N	Y	N
34.	പരീക്ഷണനിരീക്ഷണങ്ങൾ ക്ലാസ്സിൽ നടത്തുന്ന പ്രഭാഷണങ്ങളുമായി (ലക്ചർ) സമാന്തരമായി ക്രമീകരിച്ചിരിക്കുന്നു.	Y	N	Y	N
35.	ഓരോ ആശയത്തിന്റെയും സ്വഭാവം അനുസരിച്ച് വിവിധ രീതികളിലുള്ള അദ്ധ്യാപന രീതികൾ അവ ലംബിക്കപ്പെടുന്നു.	Y	N	Y	N

ക്രമ. നമ്പർ	അദ്ധ്യാപനരീതി	അദ്ധ്യാപകൻ ഉപയോഗിക്കുന്നു		അദ്ധ്യാപകൻ ഉപയോഗിച്ചുകാണാൻ താല്പര്യപ്പെടുന്നു.	
36.	ക്ലാസ്സിൽ വിവരിക്കപ്പെടുന്ന പ്രശ്നങ്ങൾ ഓരോന്നും സന്ദർഭോചിതമാണ്.	Y	N	Y	N
37.	പഠിപ്പിക്കപ്പെടുന്ന ആശയങ്ങൾ ദൃശ്യമാക്കാനായി തക്കതായ ഉപകരണങ്ങൾ ഉപയോഗിച്ചുകൊണ്ടുള്ള വിവിധ പ്രദർശനങ്ങൾ ക്ലാസ്സുമുറിയിൽ നടത്തുന്നു.	Y	N	Y	N
38.	ഊർജ്ജതന്ത്രത്തിലെ പ്രശ്നങ്ങൾ (പ്രോബ്ലംസ്) പരിഹരിക്കുന്നതിനുപയോഗിക്കുന്ന അദ്ധ്യാപന രീതികൾ വളരെ വ്യക്തത തരുന്നതാണ്.	Y	N	Y	N
39.	പ്രശ്നങ്ങൾ (പ്രോബ്ളംസ്) വിവരിക്കുന്നതിലൂടെ ഓരോ പ്രധാനപ്പെട്ട ആശയവും പ്രയോജനപ്രദമായ രീതിയിൽ അവതരിപ്പിക്കപ്പെടുന്നു.	Y	N	Y	N
40.	അശയങ്ങളും അവയോടനുബന്ധിച്ച പ്രശ്നങ്ങളും (പ്രോബ്ളംസ്) വളരെ അർത്ഥവത്തായ രീതിയിൽ രൂപകല്പന ചെയ്തിട്ടുള്ളതാണ്.	Y	N	Y	N
41.	നിത്യജീവിതത്തിലെ വിവിധ സന്ദർഭങ്ങളോട് ബന്ധമുള്ള രീതിയിലുള്ള പ്രശ്നങ്ങൽ (പ്രോബ്ളംസ്) വിവരിക്കുകയും അവ എങ്ങനെ പ്രയോജനപ്പെടുത്താമെന്നു വ്യക്തമാക്കുകയും ചെയ്യുന്നു.	Y	N	Y	N

Appendix B3

UNIVERSITY OF CALICUT
DEPARTMENT OF EDUCATION

QUESTIONNAIRE ON STUDENT ATTITUDE TOWARD PHYSICS

(FINAL-ENGLISH VERSION)

Dr. K. Abdul Gafoor
Professor

Mini Narayanan
Research Scholar

Instructions

The following statements are on aspects of your belief, perception, attitude, and preferences on learning physics. Each statement is provided with two choices, A=Agree, D=Disagree OR Y=Yes, and N=No. Please check your response and indicate what you believe true by circling the right choice against each of the responses.

Name:____

Gender: Male/Female/Others____________________________

Class/Division:___________________________________

School:_______________________________________

Sl. No.	Statements	A	D
	Part A		
1.	Learning Physics would improve my thinking skills	A	D
2.	I am aware of the relevance of learning physics	A	D
3.	Learning Physics would improve my skill in solving real world problems	A	D
4.	Learning Physics would help me perform better in my future endeavors	A	D
5.	I am passionate about understanding Physics concepts	A	D
6.	I think my skills in advanced Mathematics would help understand Physics concepts better	A	D
7.	I think introducing Physics in earlier grade levels would help understand it better	A	D

Sl. No.	Statements	A	D
8.	I love discussing Physics concepts outside my classroom	A	D
9.	All sciences are my favorite, whereas Physics is the least favorite of all of them	A	D
10.	I think I have to improve my reasoning skills to better understand Physics concepts	A	D
11.	I would learn Physics better if the lab activities are done parallel to the lectures	A	D
12.	I would learn Physics better if my teacher uses a variety of teaching tactics	A	D
13.	I think a lab activity done with clear objectives can make a concept thorough	A	D
Physics is my favorite subject. **Because**			
14.	I will be able to know the world around me by learning Physics.	A	D
15.	I notice the application of Physics concepts in my daily activities.	A	D
I hate Physics. **Because**			
16.	Many topics filled with a number of difficult concepts that are crunched together.	A	D
17.	Physics is filled with tough equations that are difficult to memorize.	A	D
18.	Physics is filled with confusing derivations and their mathematical aspects.	A	D
19.	I never get the right answers when solving problems.	A	D
20.	Whenever I learn Physics, I try to hammer many concepts onto my brain without any clear understanding.	A	D
21.	I would never study Physics in my life despite the fact that I receive excellent grades in my physics tests.	A	D

Appendix B4

UNIVERSITY OF CALICUT
DEPARTMENT OF EDUCATION

QUESTIONNAIRE ON STUDENT ATTITUDE TOWARD PHYSICS AND PREFERRED PRACTICES

(FINAL-MALAYALAM VERSION)

Dr. K. Abdul Gafoor
Professor

Mini Narayanan
Research Scholar

നിർദ്ദേശങ്ങൾ

താഴെ കൊടുത്തിരിക്കുന്ന പ്രസ്താവനകൾ ഫിസിക്സ് പഠനവുമായി ബന്ധപ്പെട്ട കാഴ്ചപ്പാടും മനോഭാവവും മുൻഗണനയും ആയി ബന്ധപ്പെട്ടതാണ്. അവയുമായി താങ്കൾക്ക് യോജിക്കുകയോ വിയോജിക്കുകയോ ചെയ്യാം. ഓരോ പ്രസ്താവനയോടും താങ്കൾ യോജിക്കുന്നുവെങ്കിൽ A എന്നും വിയോജിക്കുന്നുവെങ്കിൽ D എന്നും രേഖപ്പെടുത്തുക.

പേര്:...

ആൺകുട്ടി/പെൺകുട്ടി/മറ്റുള്ളവർ...

ക്ലാസ്സ്...ഡിവിഷൻ................................

സ്കൂൾ...

ക്രമ നമ്പർ	പ്രസ്താവനകൾ	A	D
	പാർട്ട് – എ		
1.	ഊർജ്ജതന്ത്രപഠനം എന്റെ ചിന്താശക്തിയെ മെച്ചപ്പെടുത്തും.	A	D
2.	ഊർജ്ജതന്ത്രപഠനത്തിന്റെ പ്രസക്തിയെക്കുറിച്ച് ഞാൻ ബോധവാനാണ്.	A	D
3.	നമ്മുടെ ചുറ്റുമുള്ള പ്രശ്നങ്ങൾക്കു പരിഹാരം കാണുന്നതിനുള്ള എന്റെ കഴിവ് മെച്ചപ്പെടുത്താൻ ഊർജ്ജതന്ത്രപഠനം എന്നെ സഹായിക്കും.	A	D
4.	ഭാവിയിലുള്ള എന്റെ പരിശ്രമങ്ങളെ പൂർവ്വാധികം നല്ല രീതിയിൽ പ്രകടിപ്പിക്കാൻ ഊർജ്ജതന്ത്രപഠനം എന്നെ സഹായിക്കും.	A	D
5.	ഊർജ്ജതന്ത്രത്തിലെ വിവിധ ആശയങ്ങൾ മനസ്സിലാക്കുക എന്നത് എനിക്ക് വളരെയധികം താൽപര്യമുള്ള കാര്യമാണ്.	A	D
6.	ഗണിതശാസ്ത്രത്തിലുള്ള എന്റെ അസാമാന്യ കഴിവ് ഊർജ്ജതന്ത്ര പഠനത്തിന് എന്നെ നിശ്ചയമായും സഹായം ചെയ്യും.	A	D
7.	വളരെ താഴ്ന്ന ക്ലാസ്സുകളിൽ വച്ചുതന്നെ കുട്ടികളെ ഊർജ്ജതന്ത്രം പരിചയപ്പെടുത്തുന്നത് ആ വിഷയം കൂടുതൽ മനസ്സിലാക്കാൻ അവർക്ക് സഹായകമാകുമെന്ന് എനിക്കു തോന്നുന്നു.	A	D

ക്രമ നമ്പർ	പ്രസ്താവനകൾ	A	D
8.	ഊർജ്ജതന്ത്രത്തിലെ ആശയങ്ങളെക്കുറിച്ച് ക്ലാസ്സിനു പുറത്തുള്ള ചർച്ചകളിൽ പങ്കെടുക്കാൻ എനിക്കിഷ്ടമാണ്.	A	D
9.	എല്ലാ ശാസ്ത്രവിഷയങ്ങളോടും എനിക്കു പ്രതിപത്തിയുണ്ടെങ്കിലും ഊർജ്ജതന്ത്രം അവയിൽ എറ്റവും ഇഷ്ടം കുറഞ്ഞതാണ്.	A	D
10.	ഊർജ്ജതന്ത്രത്തിലെ വിവിധ ആശയങ്ങൾ നന്നായി മനസ്സിലാക്കാൻ എന്റെ യുക്തിപരമായ ചിന്താശക്തിയെ മെച്ചപ്പെടുത്തേണ്ടതുണ്ടെന്നു ഞാൻ കരുതുന്നു.	A	D
11.	ക്ലാസ്സുമുറിയിൽ അധ്യാപകൻ നടത്തുന്ന പ്രഭാഷണങ്ങളുടെ (ലക്ചർ) തുടർച്ചയായി അവയുമായി ബന്ധപ്പെട്ട പരീക്ഷണനിരീക്ഷണങ്ങളിൽ (ലാബ്) ഏർപ്പെടുന്നതുവഴി ഊർജ്ജതന്ത്രം കൂടുതലായി മനസ്സിലാക്കുവാൻ എനിക്കു സാധിക്കുമെന്നു ഞാൻ വിചാരിക്കുന്നു.	A	D
12.	വിവിധ രീതികളിലുള്ള അദ്ധ്യാപനരീതികൾ ഉപയോഗിക്കുന്നത് എന്റെ പഠനത്തെ വളരെ അധികം സഹായിക്കും.	A	D
13.	വ്യക്തമായ ലക്ഷ്യബോധത്തോടെയുള്ള ഒരു പരീക്ഷണനീരീക്ഷണം (ലാബ്) നിർവ്വഹിക്കുന്നതിലൂടെ അതിന് അടിസ്ഥാനമായ ഊർജ്ജതന്ത്രത്തിലെ ആശയം കൃത്യമായി മനസ്സിലാക്കാൻ സാധിക്കുമെന്നു ഞാൻ കരുതുന്നു.	A	D
ഊർജ്ജതന്ത്രം എന്റെ ഇഷ്ടവിഷയമാണ്. **അതിനു കാരണം**			
14.	ഊർജ്ജതന്ത്രപഠനത്തിലൂടെ എന്റെ ചുറ്റുമുള്ള പ്രപഞ്ചത്തെ ഞാൻ കൂടുതൽ മനസ്സിലാക്കുന്നു.	A	D
15.	എന്റെ ദൈനംദിന ജീവിതത്തിലെ വിവിധ പ്രവൃത്തികളിൽ ഊർജ്ജതന്ത്രത്തിലെ ആശയങ്ങൾ പ്രയോജനപ്പെടുത്തിയിരിക്കുന്നുവെന്ന് ഞാൻ ശ്രദ്ധിക്കുന്നു.	A	D
ഞാൻ ഊർജ്ജതന്ത്രം വെറുക്കുന്നു **അതിനു കാരണം**			
16.	ക്ലേശകരമായ അനവധി ആശയങ്ങൾ തിരുകി നിറച്ച ഒരു വിഷയമാണ് ഊർജ്ജതന്ത്രം	A	D
17.	ഊർജ്ജതന്ത്രത്തിലെ വിഷമമേറിയ സമവാക്യങ്ങൾ (ഇക്വേഷൻ) മനഃപാഠമാക്കുക നന്നേ പ്രയാസമേറിയതാണ്.	A	D
18.	കുഴപ്പിക്കുന്ന അനവധി അനുമാനങ്ങളും (ഡെറിവേഷൻ) അവയുമായി ബന്ധപ്പെട്ട ഗണിതശാസ്ത്രനിയമങ്ങളും നിറഞ്ഞതാണ് ഊർജ്ജതന്ത്രം.	A	D
19.	ഊർജ്ജതന്ത്രത്തിൽ ഞാൻ പഠിക്കുന്ന പ്രശ്നങ്ങൾക്കൊന്നും തന്നെ ശരിയുത്തരം കാണാൻ എനിക്കു കഴിയുന്നില്ല.	A	D
20.	വ്യക്തമായി മനസ്സിലാക്കാതെ അനവധി ആശയങ്ങൾ തലച്ചോറിലേക്ക് അടിച്ചേല്പ്പിക്കുകയാണ് ഊർജ്ജതന്ത്ര പഠനത്തിലൂടെ ഞാൻ ചെയ്യുന്നത്.	A	D
21.	വളരെ ഉയർന്ന നിലയിലുള്ള മാർക്ക് ലഭിക്കുന്നുവെങ്കിലും ഭാവിയിൽ ഊർജ്ജതന്ത്രം പഠിക്കാൻ ഞാൻ ആഗ്രഹിക്കുന്നില്ല.	A	D

Appendix C1

UNIVERSITY OF CALICUT
DEPARTMENT OF EDUCATION

SCALE OF ATTITUDE TOWARD PHYSICS

(DRAFT-ENGLISH VERSION)

Dr. K. Abdul Gafoor — Professor
Mini Narayanan — Research Scholar

Instructions

The following statements are on aspects of your belief, perception, attitude, and preferences on learning physics. Each statement is provided with five choices, 1=Strongly Disagree, 2=Disagree, 3=Neutral, 4=Agree and 5= Strongly Agree. Please check your response and indicate what you believe true by circling the right choice against each of the responses.

Please indicate how strongly you ***agree or disagree*** with each of the following statements

1 = Strongly Disagree; 2 = Disagree; 3 = Neutral; 4 = Agree; 5 = Strongly Agree

		1	**2**	**3**	**4**	**5**
1	I am passionate about understanding big ideas in physics.					
2	Physics is my favorite subject.					
3	I love discussing main ideas in physics outside my classroom.					
4	I started disliking physics when I started learning it.					
5	Physics is my least favorite of all of science subjects.					
6	I love conducting experiments in physics.					
7	I would learn physics better if we had lab activities related to the lectures.					
8	I would learn big ideas better if my teacher uses different teaching tactics.					
9	Introducing physics in earlier grade levels would help me understand big ideas better.					
10	I need to improve my reasoning skills to better understand physics concepts.					
11	I don’t understand physics concepts from lab activities.					
12	I can utilize my aptitude in mathematics in learning physics.					
13	Physics is filled with confusing derivations and their mathematical aspects.					
14	Many topics filled with a number of difficult ideas that are crunched together.					
15	Physics is full of tough equations that are difficult to memorize.					
16	I never get the right answers when solving problems.					
17	I try to memorize major ideas in physics without any clear understanding.					
18	I would never study physics in my life even though I receive an excellent grade.					
19	I will be able to know the world around me by learning physics.					
20	I notice the application of physics concepts in my daily activities.					
21	Learning physics would help me perform better in my future endeavors.					
22	Learning physics would improve my skill in solving real world problems.					
23	Learning physics would improve my thinking skills.					
24	I am aware of the relevance of learning physics.					

Appendix C2

UNIVERSITY OF CALICUT
DEPARTMENT OF EDUCATION

SCALE OF ATTITUDE TOWARD PHYSICS

(DRAFT - MALAYALAM VERSION)

Dr. K. Abdul Gafoor
Professor

Mini Narayanan
Research Scholar

പ്രിയ വിദ്യാർത്ഥികൾക്ക്,

ഇത് Physics Education Research (PER) ന്റെ ഭാഗമായ ഒരു Survey Questionnaire ആണ്. താങ്കളുടെ പങ്കാളിത്തം ഈ പഠനത്തിന് വളരെ വിലപ്പെട്ടതാണ്.

ഓരോ പ്രസ്താവനയോടുമുള്ള താങ്കളുടെ യോജിപ്പോ വിയോജിപ്പോ 1 മുതൽ 5 വരെയുള്ള നമ്പർ തെരഞ്ഞെടുത്ത്, വ്യക്തമായി വെളിപ്പെടുത്തുക.

1 = ശക്തമായി വിയോജിക്കുന്നു

2 = വിയോജിക്കുന്നു

3 = അഭിപ്രായമില്ല

4 = യോജിക്കുന്നു

5 = ശക്തമായി യോജിക്കുന്നു

തെരഞ്ഞെടുക്കുന്ന നമ്പർ (1, 2, 3, 4, or 5) അനുസരിച്ച് ഓരോ പ്രസ്താവനയുടെയും വലതുഭാഗത്തുള്ള കോളത്തിൽ 'X' എന്നു കുറിക്കുക.

ക്രമ നമ്പർ	പ്രസ്താവനകൾ	1	2	3	4	5
1.	ഊർജ്ജതന്ത്രം എന്റെ ഇഷ്ടവിഷയമാണ്.					
2.	ഊർജ്ജതന്ത്രത്തിലെ പ്രധാന ആശയങ്ങൾ മനസ്സിലാക്കുന്നതിൽ എനിക്ക് ഉത്സാഹമുണ്ട്.					
3.	ഊർജ്ജതന്ത്രത്തിലെ പ്രധാന ആശയങ്ങളെക്കുറിച്ച് ക്ലാസിനു പുറത്തും ചർച്ച ചെയ്യാൻ എനിക്ക് ഇഷ്ടമാണ്.					
4.	പഠിച്ചുതുടങ്ങിയപ്പോൾ എനിക്ക് ഊർജ്ജതന്ത്രത്തിനോട് ഇഷ്ടക്കേട് തുടങ്ങി.					
5.	ശാസ്ത്ര വിഷയങ്ങളിൽ എനിക്ക് ഏറ്റവും ഇഷ്ടക്കുറവ് ഊർജ്ജതന്ത്രത്തിനോട് ആണ്.					
6.	ഊർജ്ജതന്ത്രത്തിലെ പരീക്ഷണങ്ങൾ നിർവഹിക്കാൻ എനിക്ക് ഇഷ്ടമാണ്.					
7.	എന്റെ അധ്യാപകൻ വിവിധ രീതികൾ (ടെക്നോളജി, പ്രൊജക്ട്സ്, ഗ്രൂപ്പ് വർക്ക്, തുടങ്ങിയവ) ഉപയോഗിച്ച് പഠിപ്പിച്ചാൽ പ്രധാന ആശയങ്ങൾ കൂടുതൽ മെച്ചപ്പെട്ട രീതിയിൽ എനിക്ക് മനസ്സിലാക്കാൻ സാധിക്കും.					

ക്രമ നമ്പർ	പ്രസ്താവനകൾ	1	2	3	4	5
8.	ക്ലാസിൽ പഠിപ്പിക്കുന്ന പാഠഭാഗവുമായി ബന്ധപ്പെട്ട ലാബോറട്ടറി പ്രവർത്തനങ്ങൾ അതേ അവസരത്തിൽ നൽകിയാൽ ഊർജ്ജതന്ത്രപഠനം എളുപ്പമാക്കാൻ എനിക്കു സാധിക്കും.					
9.	ചെറിയ ക്ലാസുകളിൽതന്നെ ഊർജ്ജതന്ത്ര ആശയങ്ങൾ പരിചയപ്പെടുത്തുന്നതു പ്രധാന ആശയങ്ങൾ കൂടുതൽ മനസ്സിലാക്കാൻ എന്നെ സഹായിക്കും.					
10.	കണക്കിൽ ഉള്ള എന്റെ അഭിരുചി ഉപയോഗപ്പെടുത്തിക്കൊണ്ട് ഊർജ്ജതന്ത്രം മനസ്സിലാക്കാൻ എനിക്കു കഴിയുന്നു.					
11.	പരിക്ഷണങ്ങൾ നിർവ്വഹിക്കുന്നതിലൂടെ ഊർജ്ജതന്ത്രത്തിലെ പ്രധാന ആശയങ്ങൾ ഞാൻ മനസ്സിലാക്കുന്നില്ല.					
12.	ഊർജ്ജതന്ത്രത്തിലെ ആശയങ്ങൾ കൂടുതൽ നന്നായി മനസ്സിലാക്കാൻ എന്റെ അപഗ്രഥനപാടവം (Reasoning Skills) ഇനിയും മെച്ചപ്പെടുത്തേണ്ടിയിരിക്കുന്നു.					
13.	ഊർജ്ജതന്ത്രം എന്ന വിഷയം കുഴപ്പിക്കുന്ന Mathematical Derivations നിറഞ്ഞതാണ്.					
14.	ഊർജ്ജതന്ത്രത്തിലെ പല ആശയങ്ങളും വിഷമം പിടിച്ചതും ഒന്നിനുമേൽ പലതായി കുത്തിച്ചെലുത്തിയതുമാണ്.					
15.	ഓർമ്മിക്കാൻ പ്രയാസമേറിയ, ബുദ്ധിമുട്ടുള്ള സൂത്രവാക്യങ്ങൾ നിറഞ്ഞതാണ് ഊർജ്ജതന്ത്രം എന്ന വിഷയം					
16.	ഊർജ്ജതന്ത്രത്തിലെ പ്രശ്നങ്ങൾ ചെയ്യുമ്പോൾ പലപ്പോഴും ശരിയുത്തരം എനിക്ക് കിട്ടാറില്ല.					
17.	വ്യക്തമായി മനസ്സിലാക്കാതെ ഊർജ്ജതന്ത്രത്തിലെ പല ആശയങ്ങളും ഞാൻ കാണാതെ പഠിക്കാൻ ശ്രമിക്കുകയാണ് ചെയ്യുന്നത്.					
18.	ഊർജ്ജതന്ത്രം പരീക്ഷയിൽ ഉയർന്ന മാർക്കു നേടിയാലും ഭാവിയിൽ ഊർജ്ജതന്ത്രം പഠിക്കാൻ ഞാൻ ഉദ്ദേശിക്കുന്നില്ല.					
19.	ദൈനംദിന ജീവിതത്തിലെ നിരവധി പ്രശ്നങ്ങൾ പരിഹരിക്കാനുള്ള കഴിവിനെ മെച്ചപ്പെടുത്താൻ ഊർജ്ജതന്ത്ര പഠനം എന്ന സഹായിക്കും.					
20.	ഊർജ്ജതന്ത്ര പഠനം എന്റെ ചിന്താശക്തിയെ മെച്ചപ്പെടുത്തുന്നു.					
21.	ഭാവിയിലെ എന്റെ പല സംരംഭങ്ങളിലും നല്ല പ്രകടനം കാഴ്ചവെക്കാൻ ഊർജ്ജതന്ത്ര പഠനം എന്നെ സഹായിക്കും.					
22.	ഊർജ്ജതന്ത്രം പഠിക്കുന്നതിലൂടെ നമ്മുടെ ചുറ്റുമുള്ള ലോകം മനസ്സിലാക്കാന് എനിക്കു സാധിക്കുന്നു.					
23.	ഊർജ്ജതന്ത്രത്തിന്റെ പ്രസക്തിയെക്കുറിച്ച് ഞാൻ ബോധവാനാണ്.					
24.	ദൈനംദിന ജീവിതത്തിൽ ഊർജ്ജതന്ത്രത്തിലെ ആശയങ്ങളുടെ പ്രയോജനം ഞാൻ ദർശിക്കുന്നു.					

Appendix C3

UNIVERSITY OF CALICUT
DEPARTMENT OF EDUCATION

SCALE OF ATTITUDE TOWARD PHYSICS

(FINAL-ENGLISH VERSION)

Dr. K. Abdul Gafoor
Professor

Mini Narayanan
Research Scholar

Instructions

The following statements are on aspects of your belief, perception, attitude, and preferences on learning physics. Each statement is provided with five choices, 1= Strongly Disagree, 2= Disagree, 3= Neutral, 4= Agree and 5= Strongly Agree. Please check your response and indicate what you believe true by circling the right choice against each of the responses.

Please indicate how strongly you ***agree or disagree*** with each of the following statements

1 = Strongly Disagree; 2 = Disagree; 3 = Neutral; 4 = Agree; 5 = Strongly Agree

		1	**2**	**3**	**4**	**5**
1	I am passionate about understanding big ideas in physics.					
2	Physics is my favorite subject.					
3	I love discussing main ideas in physics outside my classroom.					
4	Physics is my least favorite of all of science subjects.					
5	I love conducting experiments in physics.					
6	I would learn physics better if we had lab activities related to the lectures.					
7	I would learn big ideas better if my teacher uses different teaching tactics.					
8	Introducing physics in earlier grade levels would help me understand big ideas better.					
9	I need to improve my reasoning skills to better understand physics concepts.					
10	I can utilize my aptitude in mathematics in learning physics.					
11	Physics is filled with confusing derivations and their mathematical aspects.					
12	Many topics filled with a number of difficult ideas that are crunched together.					
13	Physics is full of tough equations that are difficult to memorize.					
14	I never get the right answers when solving problems.					
15	I try to memorize major ideas in physics without any clear understanding.					
16	I would never study physics in my life even though I receive an excellent grade.					
17	I will be able to know the world around me by learning physics.					
18	I notice the application of physics concepts in my daily activities.					
19	Learning physics would help me perform better in my future endeavors.					
20	Learning physics would improve my skill in solving real world problems.					
21	Learning physics would improve my thinking skills.					
22	I am aware of the relevance of learning physics.					

Appendix C4

UNIVERSITY OF CALICUT
DEPARTMENT OF EDUCATION

SCALE OF ATTITUDE TOWARD PHYSICS
(FINAL - MALAYALAM VERSION)

Dr. K. Abdul Gafoor
Professor

Mini Narayanan
Research Scholar

പ്രിയ വിദ്യാർത്ഥികൾക്ക്,

ഇത് Physics Education Research (PER) ന്റെ ഭാഗമായ ഒരു Survey Questionnaire ആണ്. താങ്കളുടെ പങ്കാളിത്തം ഈ പഠനത്തിന് വളരെ വിലപ്പെട്ടതാണ്.

ഓരോ പ്രസ്താവനയോടുമുള്ള താങ്കളുടെ യോജിപ്പോ വിയോജിപ്പോ 1 മുതൽ 5 വരെയുള്ള നമ്പർ തെരഞ്ഞെടുത്ത്, വ്യക്തമായി വെളിപ്പെടുത്തുക.

1 = ശക്തമായി വിയോജിക്കുന്നു

2 = വിയോജിക്കുന്നു

3 = അഭിപ്രായമില്ല

4 = യോജിക്കുന്നു

5 = ശക്തമായി യോജിക്കുന്നു

തെരഞ്ഞെടുക്കുന്ന നമ്പർ (1, 2, 3, 4, or 5) അനുസരിച്ച് ഓരോ പ്രസ്താവനയുടെയും വലതുഭാഗത്തുള്ള കോളത്തിൽ 'X' എന്നു കുറിക്കുക.

ക്രമ നമ്പർ	പ്രസ്താവനകൾ	1	2	3	4	5
1.	ഊർജ്ജതന്ത്രം എന്റെ ഇഷ്ടവിഷയമാണ്.					
2.	ഊർജ്ജതന്ത്രത്തിലെ പ്രധാന ആശയങ്ങൾ മനസ്സിലാക്കുന്നതിൽ എനിക്ക് ഉത്സാഹമുണ്ട്.					
3.	ഊർജ്ജതന്ത്രത്തിലെ പ്രധാന ആശയങ്ങളെക്കുറിച്ച് ക്ലാസിനു പുറത്തും ചർച്ച ചെയ്യാൻ എനിക്ക് ഇഷ്ടമാണ്.					
4.	ശാസ്ത്ര വിഷയങ്ങളിൽ എനിക്ക് ഏറ്റവും ഇഷ്ടക്കുറവ് Physics നോട് ആണ്.					
5.	ഊർജ്ജതന്ത്രത്തിലെ പരീക്ഷണങ്ങൾ നിർവഹിക്കാൻ എനിക്ക് ഇഷ്ടമാണ്.					
6.	എന്റെ അധ്യാപകൻ വിവിധ രീതികൾ (ടെക്നോളജി, പ്രൊജക്ട്സ്, ഗ്രൂപ്പ് വർക്ക്, തുടങ്ങിയവ) ഉപയോഗിച്ച് പഠിപ്പിച്ചാൽ പ്രധാന ആശയങ്ങൾ കൂടുതൽ മെച്ചപ്പെട്ട രീതിയിൽ എനിക്ക് മനസ്സിലാക്കാൻ സാധിക്കും.					

ക്രമ നമ്പർ	പ്രസ്താവനകൾ	1	2	3	4	5
7.	ക്ലാസിൽ പഠിപ്പിക്കുന്ന പാഠഭാഗവുമായി ബന്ധപ്പെട്ട ലാബോറട്ടറി പ്രവർത്തനങ്ങൾ അതേ അവസരത്തിൽ നൽകിയാൽ ഊർജ്ജതന്ത്രപഠനം എളുപ്പമാക്കാൻ എനിക്കു സാധിക്കും.					
8.	ചെറിയ ക്ലാസുകളിൽതന്നെ ഊർജ്ജതന്ത്ര ആശയങ്ങൾ പരിചയപ്പെടുത്തുന്നതു പ്രധാന ആശയങ്ങൾ കൂടുതൽ മനസ്സിലാക്കാൻ എന്നെ സഹായിക്കും.					
9.	കണക്കിൽ ഉള്ള എന്റെ അഭിരുചി ഉപയോഗപ്പെടുത്തിക്കൊണ്ട് ഊർജ്ജതന്ത്രം മനസ്സിലാക്കാൻ എനിക്കു കഴിയുന്നു.					
10.	ഊർജ്ജതന്ത്രത്തിലെ ആശയങ്ങൾ കൂടുതൽ നന്നായി മനസ്സിലാക്കാൻ എന്റെ അപഗ്രഥനപാടവം (Reasoning Skills) ഇനിയും മെച്ചപ്പെടുത്തേണ്ടിയിരിക്കുന്നു.					
11.	ഊർജ്ജതന്ത്രം എന്ന വിഷയം കുഴപ്പിക്കുന്ന Mathematical Derivations നിറഞ്ഞതാണ്.					
12.	ഊർജ്ജതന്ത്രത്തിലെ പല ആശയങ്ങളും വിഷമം പിടിച്ചതും ഒന്നിനുമേൽ പലതായി കുത്തിച്ചെലുത്തിയതുമാണ്.					
13.	ഓർമ്മിക്കാൻ പ്രയാസമേറിയ, ബുദ്ധിമുട്ടുള്ള സൂത്രവാക്യങ്ങൾ നിറഞ്ഞതാണ് ഊർജ്ജതന്ത്രം എന്ന വിഷയം					
14.	ഊർജ്ജതന്ത്രത്തിലെ പ്രശ്നങ്ങൾ ചെയ്യുമ്പോൾ പലപ്പോഴും ശരിയുത്തരം എനിക്ക് കിട്ടാറില്ല.					
15.	വ്യക്തമായി മനസ്സിലാക്കാതെ ഊർജ്ജതന്ത്രത്തിലെ പല ആശയങ്ങളും ഞാൻ കാണാതെ പഠിക്കാൻ ശ്രമിക്കുകയാണ് ചെയ്യുന്നത്.					
16.	ഊർജ്ജതന്ത്രം പരീക്ഷയിൽ ഉയർന്ന മാർക്കു നേടിയാലും ഭാവിയിൽ ഊർജ്ജതന്ത്രം പഠിക്കാൻ ഞാൻ ഉദ്ദേശിക്കുന്നില്ല.					
17.	ദൈനംദിന ജീവിതത്തിലെ നിരവധി പ്രശ്നങ്ങൾ പരിഹരിക്കാനുള്ള കഴിവിനെ മെച്ചപ്പെടുത്താൻ ഊർജ്ജതന്ത്ര പഠനം എന്ന സഹായിക്കും.					
18.	ഊർജ്ജതന്ത്ര പഠനം എന്റെ ചിന്താശക്തിയെ മെച്ചപ്പെടുത്തുന്നു.					
19.	ഭാവിയിലെ എന്റെ പല സംരംഭങ്ങളിലും നല്ല പ്രകടനം കാഴ്ചവെക്കാൻ ഊർജ്ജതന്ത്ര പഠനം എന്നെ സഹായിക്കും.					
20.	ഊർജ്ജതന്ത്രം പഠിക്കുന്നതിലൂടെ നമ്മുടെ ചുറ്റുമുള്ള ലോകം മനസ്സിലാക്കാന് എനിക്കു സാധിക്കുന്നു.					
21.	ഊർജ്ജതന്ത്രത്തിന്റെ പ്രസക്തിയെക്കുറിച്ച് ഞാൻ ബോധവാനാണ്.					
22.	ദൈനംദിന ജീവിതത്തിൽ ഊർജ്ജതന്ത്രത്തിലെ ആശയങ്ങളുടെ പ്രയോജനം ഞാൻ ദർശിക്കുന്നു.					

Appendix D

UNIVERSITY OF CALICUT
DEPARTMENT OF EDUCATION

INTERVIEW QUESTIONNAIRE FOR TEACHERS ON PHYSICS INSTRUCTION

Dr. K. Abdul Gafoor
Professor

Mini Narayanan
Research Scholar

1. How long have you been teaching physics?
2. Are you satisfied with your career?
3. How often do you receive in-service training on recent development in physics instruction?
4. What topic/topics seem to be difficult for your students to understand?
5. Are you familiar with the Inquiry-Based approach in teaching physics?
6. Do you specifically use any of the following strategies in your classes?

Strategy	Teacher Response	Justification	
	Y/N/Not aware of	Difficulties upon implementation	Reasons for not implementing
Lecturing			
Lecture with			
Hands-on Learning			
Project-Based Learning			
Problem-Based Learning			

7. Specify any other strategy used in your classrooms with appropriate evidences on the effectiveness of learning outcomes/difficulties experienced (if any). *Check the ones that apply*.

Strategy	**Effective on**	**Difficulties experienced while using**
	a. Student Achievement b. Student Motivation c. Student Attitude d. Remedying Misconceptions e. Time Management f. Other (specify) -----------	Specify a. --------------------------------- b. --------------------------------- c. --------------------------------- d. ---------------------------------

8. What measures do you recommend to enhance students' positive attitude toward physics?

Appendix E1

UNIVERSITY OF CALICUT
DEPARTMENT OF EDUCATION

SCHEME FOR INTEGRATION: INSTRUCTIONAL STRATEGY WISE

Dr. K. Abdul Gafoor
Professor

Mini Narayanan
Research Scholar

TCI (Technology)	1	Introduce major concepts using videos or animations (TP)
SCI (Collaborative Learning)	2	Let students work in groups to realize the underlying concept of a problem (SP)
TCI (Traditional)	3	Provide pre-prepared directions on conducting the experiment (TP)
SCI (Collaborative Learning)	4	Let students work in groups and brainstorm the teacher-made lab procedure (SI)
TCI (Guided Inquiry)	5	Indicate quantities and variables for testing during lab (TP)
TCI (Guided Inquiry)	6	Introduce the project by a challenging problem during in-class discussions (TI)
SCI (Inquiry-based)	7	Let students explore concepts online prior to covering them in class (SP)
TCI (Hands-on Learning)	8	Provide in-class demonstrations to reinforce concepts (TI)
TCI (Cooperative Learning)	9	Let students work on lab in groups with teacher supervision (TI)
SCI (Hands-on Learning)	10	Let students get familiar with major concepts during lab procedures (SP)
SCI (Collaborative Learning)	11	Let students work in groups on designing lab procedure (SP)
SCI (Technology)	12	Let students find resources and related information for projects (SP)
TCI (Cooperative Learning)	13	Introduce and brainstorm the rubric for the group projects (TI)
TCI (Technology)	14	Introduce major concepts using electronic slides or handouts (TP)
TCI (Traditional)	15	Provide explanations and examples orally and in writing (TP)
TCI (Cooperative Learning)	16	Supervise and assist when students work in small groups (TI)
SCI (Collaborative Learning)	17	Let students work in small groups on problems and difficult concepts (SP)
TCI (Guided Inquiry)	18	Provide ample examples during lectures to avoid student misconceptions (TP)
SCI (Guided Inquiry)	19	Facilitate discussions to come up with a problem having real-life application (TI)
TCI (Traditional)	20	Solve textbook problems of various difficulty levels in class (TP)
TCI (Technology)	21	Use web-based resources for problems and graphical analyses (TI)
SCI (Technology)	22	Let students demonstrate problem-solving steps using web resources (SP)
SCI (Hands-on Learning)	23	Provide students opportunity to test the accuracy of the problem (TI)
TCI (Guided Inquiry)	24	Assist students in finding resources and applying information (TI)
TCI (Cooperative Learning)	25	Hold invited talks or watch online presentations with students (TI)
SCI (Collaborative Learning)	26	Let students brainstorm on the rubric for the group projects (SP)
TCI (Traditional)	27	Conduct quizzes and tests in a traditional manner (TP)
TCI (Technology)	28	Use alternative assessment techniques available online (TI)
SCI (Collaborative Learning)	29	Let students prepare lab reports by analyzing obtained results (SP)
TCI (Cooperative Learning)	30	Assist students to analyze results and reach conclusions (TI)
TCI (Guided Inquiry)	31	Introduce and evaluate using the rubric for group projects (TI)
SCI (Guided Inquiry)	32	Make students present their work public before experts in the relative fields (SP)

TP: Teacher-centered in the purest form

SP: Student-centered in the purest form

TI: Teacher-centered as integrated

SI: Student-centered as integrated

Appendix E2

UNIVERSITY OF CALICUT
DEPARTMENT OF EDUCATION

SCHEME FOR INTEGRATION: CLASSROOM PRACTICES WISE

Dr. K. Abdul Gafoor
Professor

Mini Narayanan
Research Scholar

	Classroom Practices
	Lecturing
TCI (Traditional)	Give explanations and examples orally and in writing (Explain)
TCI (Cooperative Learning)	Supervise and assist when students work in small groups (Explain)
TCI (Traditional)	Solve textbook problems of various difficulty levels in class (Elaborate)
TCI (Traditional)	Conduct quizzes and tests in a traditional manner (Evaluate)
	Lecturing with Demonstrations
TCI (Hands-on Learning)	Provide in-class demonstrations to reinforce concepts (Explore)
TCI (Traditional)	Provide explanations and examples orally and in writing (Explain)
TCI (Traditional)	Solve textbook problems of various difficulty levels in class (Elaborate)
SCI (Peer Instruction)	Let students work in small groups on problems and difficult concepts (Explain)
TCI (Traditional)	Conduct quizzes and tests in a traditional manner (Evaluate)
	Hands-on learning-Traditional
TCI (Traditional)	Provide pre-prepared directions on conducting the experiment (Engage)
TCI (Guided Inquiry)	Indicate quantities and variables for testing during lab (Engage)
TCI (Cooperative Learning)	Let students work on lab in groups with teacher supervision (Explore)
TCI (Traditional)	Explain the major concept behind the experiment (Explain)
SCI (Collaborative Learning)	Let students prepare lab reports by analyzing obtained results (Evaluate)
	Hands-on learning-Inquiry-based
SCI (Collaborative Learning)	Let students work in groups and brainstorm the teacher-made lab procedure (Engage)
TCI (Guided Inquiry)	Indicate quantities and variables for testing during lab (Engage)
SCI (Inquiry-based)	Let students explore concepts online prior to covering them in class (Engage)
SCI (Collaborative Learning)	Let students work in groups on designing lab procedure (Explore)
TCI (Cooperative Learning)	Assist students to analyze results and reach conclusions (Evaluate)
	Teaching with Technology
TCI (Technology)	Introduce major concepts using videos or animations (Engage)

TCI (Technology)	Introduce major concepts using electronic slides or handouts (Explain)
TCI (Technology-based)	Use web-based resources for problems and graphical analyses (Elaborate)
TCI (Technology-based)	Use alternative assessment techniques available online (Evaluate)
	Problem-based Learning
SCI (Collaborative Learning)	Let students work in groups to realize the underlying concept of a problem (Engage)
SCI (Hands-on Learning)	Let students get familiar with major concepts during lab procedures (Explore)
SCI (Inquiry-based)	Let students demonstrate problem-solving steps with the help of web resources (Elaborate)
SCI (Hands-on Learning)	Provide students opportunity to test the accuracy of the problem (Elaborate)
TCI (Guided Inquiry)	Provide ample examples during lectures to avoid student misconceptions (Elaborate)
	Project-based Learning
TCI (Guided Inquiry)	Introduce the project by a challenging problem during in-class discussions (Engage)
SCI (Inquiry-based)	Let students find resources and related information for projects (Explore)
SCI (Hands-on Learning)	Let students discuss the major characteristics of the problem within the group (Explain)
SCI (Inquiry-based)	Facilitate discussions to come up with a problem having real-life application (Elaborate)
TCI (Guided Inquiry)	Assist students in finding resources and applying information (Elaborate)
TCI (Cooperative Learning)	Hold invited talks or watch online presentations with students (Elaborate)
SCI (Peer Instruction)	Let students brainstorm on the rubric for the group projects (Elaborate)
TCI (Cooperative Learning)	Introduce and brainstorm the rubric for the group projects (Explore)
SCI (Inquiry-based)	Make students present their work public before experts in the relative fields (Evaluate)
TCI (Guided Inquiry)	Introduce and evaluate using the rubric for group projects (Evaluate)

Appendix E3

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SAMPLE PATTERN OF CLASSROOM PRACTICES WITH MINIMUM, AVERAGE, AND MAXIMUM LEVELS OF INTEGRATION

Dr. K. Abdul Gafoor
Professor

Mini Narayanan
Research Scholar

Engage	Explore	Explain	Elaborate	Evaluate
Provide pre-prepared directions on conducting the experiment		Give explanations and examples orally and in writing	**Solve textbook problems of various difficulty levels in class**	**Conduct quizzes and tests in a traditional manner**
Introduce major concepts using videos or animations		Introduce major concepts using electronic slides or handouts	Use web-based resources for problems and graphical analyses	Use alternative assessment techniques available online
	Provide in-class demonstrations to reinforce concepts			
Indicate quantities and variables for testing during lab	Lead a discussion on major concepts using videos or animations	Provide ample examples during lectures to avoid student misconceptions	Assist students in finding recourses and applying information	Introduce and brainstorm the rubric for the group projects
	Let students work on lab in groups with teacher supervision	Supervise and assist students' work in small groups on problems	Hold help sessions to work on difficult homework problems and concepts	Assist students to analyze results and reach conclusions
Let students work in groups to realize the underlying concept of a problem	Let students brainstorm and reinforce conceptual understanding	Let students work in small groups on problems and difficult concepts	Let students work in small groups on problems and difficult concepts	**Let students prepare lab reports by analyzing obtained results**
	Let students work in groups on designing lab procedure		Let students demonstrate problem-solving steps using appropriate activities	
		Let students discuss the major characteristics of the problem within the group	Provide students opportunity to test the accuracy of the problem	
Introduce the project by a challenging problem during in-class discussions	Let students explore the concepts online prior to covering them in class		Facilitate discussions to come up with a problem having real-life application	Make students present their work public before experts in the relative fields

Appendix E4

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DEPARTMENT OF EDUCATION

PHYSICS CLASSROOM PRACTICES INVENTORY

Dr. K. Abdul Gafoor
Professor

Mini Narayanan
Research Scholar

Instructions

The following statements are on classroom practices that you adopt for teaching physics. Each statement is provided with five choices, Always, Often, Sometimes, Rarely, and Never. Please check your response and indicate the frequency of your classroom practices/instructional tactics that you believe true by checking the right choice against each of the responses.

Sl. No.	Classroom Practices	Always	Often	Sometimes	Rarely	Never
1.	Introduce major concepts using videos or animations					
2.	Let students work in groups to realize the underlying concept of a problem					
3.	Provide pre-prepared directions on conducting the experiment					
4.	Let students work in groups and brainstorm the teacher-made lab procedure					
5.	Indicate quantities and variables for testing during lab					
6.	Introduce the project by a challenging problem during in-class discussions					
7.	Let students explore concepts online prior to covering them in class					
8.	Provide in-class demonstrations to reinforce concepts					
9.	Let students work on lab in groups with teacher supervision					
10.	Let students explore and get familiar major concepts during lab procedures					
11.	Let students work in groups on designing lab procedure					
12.	Let students find resources and related information for projects					
13.	Introduce and brainstorm the rubric for the group projects					

Sl. No.	Classroom Practices	Always	Often	Sometimes	Rarely	Never
14.	Introduce major concepts using electronic slides or handouts					
15.	Provide explanations and examples orally and in writing					
16.	Supervise and assist when students work in small groups					
17.	Let students work in small groups on problems and difficult concepts					
18.	Provide ample examples during lectures to avoid student misconceptions					
19.	Facilitate discussions to come up with a problem having real-life application					
20.	Solve textbook problems of various difficulty levels in class					
21.	Use web-based resources for problems and graphical analyses					
22.	Let students demonstrate problem-solving steps using web resources					
23.	Provide students opportunity to test the accuracy of the problem					
24.	Assist students in finding resources and applying information					
25.	Hold invited talks or watch online presentations with students					
26.	Let students brainstorm on the rubric for the group projects					
27.	Conduct quizzes and tests in a traditional manner					
28.	Use alternative assessment techniques available online					
29.	Let students prepare lab reports by analyzing obtained results					
30.	Assist students to analyze results and reach conclusions					
31.	Introduce and evaluate using the rubric for group projects					
32.	Make students present their work public before experts in the relative fields					

Appendix-F

Summary of the Five Phases in the 5E Instructional Model (Bybee et. al, 2006) with Proposed Activities to Teach the Concept of Vectors

5E Component	Summary and Proposed Activities
Engagement	The teacher is able to access the learners' prior knowledge and direct them to get engaged in a new concept through the use of short activities that promote curiosity and elicit prior knowledge. Activities such as providing a lab experience, conducting a discussion forum, watching a video clip, or completing a short quiz are some examples for this phase to help students make connections between past and present learning experiences. The role of a teacher as an effective facilitator is crucial in this phase. To introduce the concept of vectors, the teacher could begin the treasure hunt activity for the students and refresh students' understanding of directions, angles and SI units measurements, and different types of instruments such as meter stick, yard stick, trundle wheel etc. to measure distance.
Exploration	Exploration experiences provide students with a common base of activities within which current concepts (i.e., misconceptions), processes, and skills are identified and conceptual change is facilitated. This phase is critical since teacher's involvement becomes critical in this phase for eliminating the common misconceptions in physics. Teacher is expected to raise from being a facilitator to an expert to direct the learners from developing incorrect conceptual understanding. The students could begin an investigation by designing and performing suitable lab activities. Students could receive a collaborated activity on finding the straight-line distance between two objects by making a drawing of the situation based on the given directions. They develop understanding the concept of displacement and how to distinguish it from distance travelled. They get opportunity to eliminate misconceptions in measuring angles from given directions, for example, 30 degrees North of West is not the same as 30 degrees West of North.
Explanation	The explanation phase focuses students' attention on a particular aspect of their engagement and exploration experiences and provides chances to demonstrate their conceptual understanding, process skills, or behaviors. Teachers receive occasions to directly introduce a concept, process, or skill. An effective teacher-centered learning atmosphere could eliminate the students' misconceptions and establish proper understanding in this phase. Explanation from the teacher guides students toward a deeper understanding, which is a critical part of this phase. In a physics classroom during this phase, the teacher could introduce the vector notation, vector properties, and different vector operations. With the help of technology, students could receive a variety of models, diagrams and animations of vector operations. Teacher is able to explain and stress the area

5E Component	Summary and Proposed Activities
	of possible misconception. The application of vectors could be introduced in a variety of ways such as introducing real-life situations, using sports videos, projectile motion, and explanation on movement of airplanes and boats in a windy environment. Students discuss different scenarios of the application of vectors through in-class problems and follow-up discussions.
Elaboration	In this phase, teacher's role becomes critical as an excellent facilitator. Student-centered instructional strategies become extremely useful for this phase. Students receive new experiences to develop deeper and broader understanding of the concept and to apply their knowledge in novel situations. Teachers receive opportunities to challenge and extend the learner's conceptual understanding and related skills. In the context of vectors, development of a group project could be an excellent idea. Students in small groups could work on developing trebuchets from scratch. Students could make use of internet, expert's assistance, and other useful resources for the construction. Expectations, major objectives and grading rubrics could be made clear to students prior to introduction of the project idea. Teacher could also make use of this occasion open as a whole school event. The testing of the trebuchets could be done in front of local experts like university professors, engineers, personnel from aircraft designers etc. Students receive directions and ideas on writing their project as a scientific article and how to interpret the results and present them in public.
Evaluation	In the present scenario, the evaluation phase is mostly traditional in nature. Both student-centered and teacher centered classroom practices are used in this phase with the major goal of encouraging students to assess their understanding and abilities. With the help of the established objectives and grading rubrics, teachers could evaluate student progress. In a physics classroom, after the instruction of vector and their properties, teacher could give a traditional examination with many problems of real-life situations, ask students to design and develop a lab activity to measure the range and maximum height of a metal ball using a projectile launcher and present the final result in small groups. Students and teachers could have a discussion session in a cooperative learning environment to evaluate the results after each group presentation.

Appendix G

Parental Permission for Participation in Research

I am conducting a research study to come up with an effective instructional strategy to enhance the attitude toward physics among high school students especially the females by studying the perception, attitude, and learning practices of High School students from South India and USA.
I am asking for your permission to use your child to complete a survey on Perception, Attitude and Expectations on learning physics and a test on Force and Motion to investigate the effectiveness on teaching/learning Physics from your experience. The survey will last for 10-15 minutes in which you will be asked to agree or disagree with 31 different statements in relation with your Physics learning experience. The multiple-choice test on Force and Motion will take about 30-40 minutes in which you will be asked to reflect your prior knowledge on Newtonian Mechanics of force and motion. Both the survey and test will be used as part of data toward my research.

I will keep your child's information strictly confidential. All notes and documents will receive a code number and be kept separate from your signed consent form. The list which has your child's name and code number will be kept in a locked file in the Education Department at the College of Charleston and destroyed when the research is complete. At no time will you be able to be identified in any reports or publications which result from this research.

There are no direct benefits for your participation in this project. However, you could be aware of recent developments in research to enhance the effectiveness of physics education.

PARTICIPATION IN THIS RESEARCH IS VOLUNTARY. You are free to decline to participate in this research study. You may withdraw your participation at any point without penalty. The Charleston County School District is neither sponsoring nor conducting this research. Your decision whether or not to participate in this research study will have no influence on your present or future education.

If you have any further questions about the study, you may contact the researcher (Mini Narayanan) by email at mnarayan@cofc.eduor phone at (843) 856-3814. You may also contact Research Protections & Compliance on the Office of Research and Grants Administration, at 843-953-7421 or email compliance@cofc.edu if you have questions or concerns about research review at the College of Charleston or your rights as a research participant. You will be given a copy of this form to keep.

This research study has been approved by College of Charleston Institutional Review Board for the Protection of Human Research Participants.

I have read this consent form, and I agree to give permission for you to use my child as a participant in completing survey on Perception, Attitude and Expectations on physics learning and test on Force and Motion.

Printed Name of Child ________________________

Printed Name of Parent or Guardian ________________________

Signature of Parent/Guardian ______________________________

Date __________