Research Journal of Social Sciences & Economics Review
Vol. 2, Issue 3, 2021 (July – September)
ISSN 2707-9023 (online), ISSN 2707-9015 (Print)
ISSN 2707-9015 (ISSN-L)
DOI: https://doi.org/10.36902/rjsser-vol2-iss3-2021(158-169)

RJSSER
Research Journal of Social Sciences & Economics Review

Developing Students' Problem Solving Skills through Constructivist Approach in Physics at Secondary Level

* Mateen Iqbal, PhD Scholar (Corresponding Author)
** Mushtaq Ahmad Malik, Assistant Professor
*** Ahmad Bilal Cheema, Assistant Professor

Abstract

To determine the effectiveness of the 7E Eisenkraft teaching paradigm on student performance (i.e. ability to solve problems), this study was carried out at secondary level physics students. Research design was Quasi-experimental. Students at public high and higher secondary schools in the Sargodha area who were in the 10th grade and studying "physics" participated in the study. To choose a representative sample, a multi-stage sampling approach was utilized. Out of 11 female schools and 15 male schools in Sargodha City, two secondary schools were easily picked in the first stage. Two 10th grade classrooms from each school were randomly selected for the second stage. Randomly, two experimental groups and two control groups were formed. In 10th grade, 169 students were in four intact classrooms of physics. Nine weeks was the duration of the experiment. Instrument utilized as pre-test and post-test was Problem Solving Ability Test in Physics (PSATP). Cronbach's Alpha of the scale was 0.71. For analysis of data, independent sample t-test and ANOVA were used. After treatment, result showed that 7E Eisenkraft instructional model had significantly impact on students' performance in Physics subject. It was concluded that, male and female students in the experimental groups performed better than their respective counterparts in the control groups on (PSATP). It is recommended that, training institutions for teachers i.e. Quaid-e-Azam Academic for Educational Development (QAED) should incorporate 7E instructional strategy into their curricula/training, and they should take practical steps to train prospective teachers and enhance their capacity building with an emphasis on ability of problem solving among the students.

Keywords: Constructivist Approach, Problem Solving Skills, Secondary Level Students

Introduction

Science education at secondary level prepare the students to develop all the three domains of bloom taxonomy i.e. cognitive, affective and psychomotor to grasp the natural occurrences in their physical environment in a conceptual way. Science study at secondary level is further divided into its branches i.e. physics, chemistry, biology, geology etc. among them physics is the most near to everyday life especially in the modern age. As physics addresses energy and matter and studies mutual relationship of energy and matter and its properties in the field of mechanics, thermodynamics, wave, light, sound, electricity and nuclear physics. Physics education is considered to be very fundamental in understanding the world around us, it concern both macroscopic and microscopic state of matter (Ince, 2018; Watkins & Mazur, 2013).

The National curriculum for Physics of secondary classes is built upon standards and leaning outcomes. The standards of National curriculum offer high order thinking, deep knowledge and conceptual understanding for the benefit of students' progress and growth along with instructional learning outcomes for knowledge, comprehension, application and scientific skills etc. Hence, the National curriculum for Physics for grade 9th & 10th set standards that can develop problem solving skills and critical thinking (Ministry of Education, 2006).

The aim of secondary school Physics teaching is to allow students to understand the elementary knowledge of Physics essential for future study of contemporary science. Furthermore the main purpose of Physics education to promote conceptual understanding about the modern computer

* Department of Education University of Sargodha, Sargodha, Pakistan Email: syedmateen92@yahoo.com
** Department of Education University of Sargodha, Sargodha, Pakistan Email: mushtaq.ahmad@uos.edu.pk
*** Department of Education University of Sargodha, Sargodha, Pakistan Email: ahmad.bilal@uos.edu.pk

technology and its uses to resolve real life problem. It encourages them to learn experimental abilities, enhance the capacity to think logically and to solve the difficult concept of physics in everyday life with the help of mathematics (Mekonnen, 2014; Reif, Heller, Reif, & Heller, 2013). The study of Physics at secondary level starts with the concepts of rest, motion, linear motion, speed, velocity, uniform velocity, acceleration, force, impulse momentum and torque these ideas or concepts are related to physics. With the help of these concepts one can understand the motion of the things like motion of planets and motion of electrons around nucleus.

Literature Review

Traditional teaching methods are not providing embedded learning of student in science subjects whereas modern teaching methods provide embedded learning in realistic context and focus on logical thinking and meaningful understanding instead of rote memorization (Ihejiamaizu, Ukor, & Neji, 2018; Shaheen & Kayani, 2015). For the holistic growth of our students, effective teaching methods or approaches are designed. However a significant difference still exists in the classrooms between theoretical awareness and practical teaching. So, in educational practices, new teaching approaches must be applied. The comprehensive and appropriate teaching methods in the classroom significantly impact on learning process. In this regard, constructivist teaching approach have significant impact on classroom environment and develop conducive learning environment in science class (Kalamas Hedden et al., 2017; Tondeur, Van Braak, Ertmer, & Ottenbreit-Leftwich, 2017). The constructivist learning approach helps students for comprehending meaning and constructing their own knowledge and give them conceptual understanding in science subjects (Ihejiamaizu et al., 2018; Roblyer & Doering, 2012). However, constructivism school of thought claims that learning is an active process; conceptual and meaningful understanding is developed from prior knowledge and experience through senses and observation of natural phenomena around the world. Constructivism assumes that the role of individual learner is very important in the development of new ideas through prior understanding. However, constructivism put emphasis on the significance of the idea, knowledge, skills and values that raise students' thinking style (Amineh & Asl, 2015; Kiraly, 2014). The approach of constructivist learning is student centered, in which teacher's role is only facilitator, making the students work on themselves and generate new knowledge in the students themselves.

The constructivism approach helps students, to make meaningful their knowledge and give them conceptual understanding in science subjects (Ihejiamaizu et al., 2018; Roblyer & Doering, 2012). The comprehensive and appropriate teaching method in the classroom significantly impact on learning process. Constructivist teaching approach have significant impact on learning environment to generate conducive learning environment in science classes (Kalamas Hedden et al., 2017; Tondeur et al., 2017).

A number of constructivist models were developed and adopted for school use such as the social interaction model, problem-based inquiry model, information construction model, three stage learning approach "Explore, Explain, Evaluate", 4E model "Engage, Explore, Explain, Evaluate", 5E model "Engage, Explore, Explain, Elaborate, Evaluate" and 7E model. This 7E model presented by Eisenkraft (2003) is the extended form of 5E model of constructivist approach with introducing two new components i.e. elicits and extend. The components of 7E model of Eisenkraft (2003) are "Elicit, Engage, Explore, Explain, Elaborate, Evaluate and Extend". This learning model emphasizes logical reason through these seven components of 7E among the students' (Balta & Sarac, 2016; Naade, Alamina, & Okwelle, 2018). Science teachers may implement this model in classroom to develop conducive learning environment and enhances students' performance.

Why 7E is and 5E models

The 5E and 7E models are both good. But, the 7E has a couple of added features that extends the model. First is the Elicit phase which really draws upon the work of David Ausabel's Meaningful Learning Theory (da Silva, 2020). This means that students are viewed as central to any learning process, and the teachers are the facilitators of education. New information can only be meaningfully learned if it is connected to past knowledge. The 'Elicit' phase extends the focus of the learning process to hold a place for the teacher to ascertain what knowledge base the student begins with which can also support the teacher's confrontation of potential misconceptions, the students will encounter as they engage with the learning experience.

The Extend phase of the 7E lesson plan draws students' attention to transfer of knowledge to other situations. This also gives the teacher the opportunity to identify potential misconceptions as the students compare the learning experience they are engaged with to other phenomena they have encountered. The ability to transfer knowledge to new situations allows us to innovate, create and invent. In different countries researches conducted by Kalamas Hedden et al., (2017); Tuwoso, (2016); Wanbugu, Changeiywo, & Ndiritu, (2013) found that the instructional model of 7E constructivist approach has greater impact on increasing success level of students in science subjects because students get actively involved in identifying problem, designing experiment, conduct experiments and communicate with peer and also produces better achievements of students' as compare to traditional teaching methods.

However, 21st century skill i.e. problem solving skills play an important role in science, medical field and business. That's why ability to solve problem must include at secondary level in science subjects to resolve students learning difficulties about scientific phenomena and able them to resolve real-life problems.

Problem Solving Skills

Life is full of difficulties and it is essential for a successful person to have the proper knowledge and reasoning power to deal with these difficulties. The purpose of education is to prepare children for practical life. Therefore, problem solving skills in schools should be encouraged. This method can also be defined as the way in which a person intentionally runs into a problem or complexity where a person uses his or her abilities to find a suitable and satisfactory elucidation to the issue. The aptitude to resolve the issues is like an ongoing process where the teacher asks the children based on their knowledge to discover what they do not know. In this way, assumptions are made to overcome difficulties; guesses are tested so that a satisfactory solution to the problem can be reached (Crawford, 2011; Reddy & Panacharoensawad, 2017)

It is in the nature of human beings that he has been using real life problems to learn by solving them or getting their solutions because of his problem solving ability from the centuries. Knowledge and experience of students is enhanced, which results in human society to progress, in almost all walks of life (Burrow, 2018). Problem solving skills allows learner to boost their questioning, reasoning, and coordination skills (Dolmans, De Grave, Wolfhagen, & Van Der Vleuten, 2005; Khoiriyah & Husamah, 2018; Uden & Beaumont, 2006; Yavuz, Yasemin, & Arslan, 2017). It also enhances their self-efficacy and motivates them to construct knowledge by solving daily life difficulties (Crawford, 2011).

Problem solving ability not only enhances the learning but it also inculcates the sense of cooperation, patience and attitude towards learning among the teacher and students (Rashid, 2011). Whereas, Baker (2011) revealed that the problem solving ability enhances students to become precursors of education in multiple ways with their own knowledge and within their community at large. Beside, problem resolution leads to trust and encourages the learner to take on new and harder tasks. There is an issue when a person has a goal but unable to reach that goal. If the particular situation cannot be changed as desired by action, then thinking should be utilized (Argaw, Haile, Ayalew, & Kuma, 2016; Lou, Liu, Shih, & Tseng, 2011; Reddy & Panacharoensawad, 2017).

Problem is barrier that can be further explained as a gap between the present and desired situation due to lack of information, in the degree (a) the means/operators are ignorant and (b) the objective status is not concrete (Dörner & Funke, 2017; Funke, Fischer, & Holt, 2017; Khoiriyah & Husamah, 2018; Mathew, Malik, & Tawafak, 2019)

Problem solving in human life is inevitable and important to human survival. This is one of 21st century essential skills. Problem solving is the most valuable skill that children in all parts of the world require, both at school and outside of school. Mayer (2006) argued that, when an issue occurs, an objective or objective state has to be reached in a given situation and no predictable or normal solution method is available. The capability of problem solving according to PISA (2018) is explained as "an individual's capacity to engage in cognitive processing to understand and resolve problem situations where a method of solution is not immediately obvious. It includes the willingness to engage with such situations in order to achieve one's potential as a constructive and reflective citizen".

The problematic condition is an unusual situation in such circumstances that does not allow for normal solutions. The willingness to observe is a key component of problem resolution. Observation is the main analytical skill and instrument in the life of an individual in solving an issue (Johnston, 2011).

The five senses are the gate way of knowledge and are recognized to understand the problems. Observation is a key tool to familiar with problem, observations only make it easier to find a solution to a problem).

Observational skills are the basic tools for solving problems in routine life. This is the initial step towards tackling many difficulties. It offers children the opportunity to emphasize, symmetrically and empirically, the techniques of viewing, by improving their skills to consider what they experience in their practical life (Friedlaender & Friedlaender, 2013). Observation is a large practice that not only uses a vision to gather information; it also uses other sensory instruments like hearing, smell, taste and feeling (Simsek & Kabapınar, 2010). Similarly, Johnston and Rudnick (2009) found that child observation by means of their five senses for information, arrangement, combination and classification of objects or events. Child senses are the gate way of knowledge and understanding about the nature of the real life problems.

However, Problem-solving ability is an analytical brain mechanism that investigates the reason for a problem or develops a technique to solve that problem. The brain has the greatest cognitive structures in problems solving such as interpretation, generalization and synthesis, which includes features like the scientific method, logical reasoning, decision-making and reflection. Problem solving means a method requiring various competences such as analyzing, synthesis, reasoning and evaluation to solve routine complicated problems (Ince, 2018; Rahman, 2019; Treffinger, Selby, & Isaksen, 2008; Wang & Chiew, 2010).

Findings of many research studies are that the ability of students to solve problems is connected to the subcomponent of the problem i.e. observation, analysis, synthesis, evaluation and decision making. It was noted that the abilities of students in physics have had an effect on the levels of motivation, self-esteem, attitude and achievement (Abubakar & Danjuma, 2012; Byun & Lee, 2014; Docktor, Strand, Mestre, & Ross, 2015).

Statement of the Problem

In science subjects, to enhance conceptual and meaningful understanding and development of attitude towards science, National curriculum (2006) implemented paradigm shift from behaviourism to constructivism in Pakistan (Ministry of Education, 2006). Traditional teaching methods are not effective for conceptual understanding in science subjects. The modern teaching methods i.e. social interaction model, problem-based inquiry model, information construction model, has significant influence on conceptual understanding of science students. Constructivist approach provides critical thinking and meaningful understanding in science subjects. Eisenkraft (2003) introduced 7E model of Constructivist approach which is more comprehensive and appropriate to develop meaningful and conceptual understanding learning in students' of science subjects at secondary level. So, that study is opted to develop problem solving skills among secondary level students through constructivist approach.

Objective of the Study

The objective was to find out the effects of 7E instructional model of constructivist approach on the problem solving skills of secondary school students' in the subject of physics.

Delimitation of the study

In one research it is not possible or beneficial to opt more than two teaching-learning methods. This research is therefore restricted to examining two methods of teaching, namely 7E Model of constructivist approach and Traditional teaching methods (TTM). The following delimitations were made for this study:

1. This study was delimited to 10th class Physics students studying in secondary schools of District Sargodha.
2. The content utilized in this study was six (06) out of nine (09) chapters from text-book of Physics-X published by Punjab Curriculum Text Board, Lahore.

Research Hypotheses

Following were the hypotheses of study:

H_{01}: There is no significant difference between the mean gain scores of students of both the control and experimental groups on problem solving ability test in physics.

H_{02}: There is no significant difference between the mean gain scores of students within the experimental groups on problem solving ability test in physics.

Research Design

Due to administrative problems in schools, equivalent groups were not possible so, Qausi experimental research was opted for the study. There have been two independent variables, i.e. teaching strategy and gender, each of which has two levels. So, 2x2 factorial design has been utilized, to discourse all potential combinations of the two independent variables in the selected levels (Cheema & Mirza, 2013).

Population

The medium of instruction of science subjects in all the public schools of the Punjab, Pakistan', was Urdu and English mixed explanation. Two schools i.e. Government Boys' Comprehensive High School, Sargodha and Government Girls' Higher Secondary School Hyderabad Town, Sargodha were included in the population on the basis of school Principal's support and collaboration. The schools of Sargodha were also completely representative of the other schools, because its students' had same socio-economic and residential status as public schools and obtained scores of students' from these schools can be generalized to other students of public schools of District Sargodha. Further, population details are provided as follows for this study.

i. **Target Population**: Target population for this study, included all the male and female 10th grade students' studying "physics" in public high and higher secondary schools in Sargodha district.
ii. **Accessible Population:** All 10th grade science students' who study in Government Boys' Comprehensive High School Sargodha and Government Girls' Higher Secondary School Hyderabad Town, Sargodha were the accessible population.

Sampling

Multi stage sampling technique was used in the study. The following are the steps of sample selection;

Stage 1

In the first phase two (2) secondary schools i.e. one female school and one male school, were selected conveniently out of 11 female schools and 15 male schools' in Sargodha City, on the basis of permissions of their principal and the availability of science students. The schools that were involved in the research;

1. Government Boys' Comprehensive High School Sargodha
2. Government Girls Higher Secondary School Hyderabad Town Sargodha

Stage 2

There were four 10th grade classrooms in each selected school, containing 45 students on average. Two sections of 10th class were selected randomly from each school. One section was allocated as a control group and another as an experimental group randomly out of the selected class sections.

Research Instrument

In past, many educational researchers and social scientists have developed many effective and useful instruments for assessment of students' problem solving ability (Adams & Wieman, 2015). But the more focused test concerning to the problem solving ability at secondary level physics curriculum is not available. That is why; the contextual problem solving tests for physics have been prepared covering the subject selected from Physics Textbook (2020) of 10th grade issued by the Punjab Textbook Board.

Test of ability to solve problems in physics consisted of twenty (20) question / contextual problems relevant to textbook concepts, and daily life, representing natural science phenomena based related situations that they met the connection between content and circumstances of real life, as recommended by PISA, (2018), on the basis of a table of specification. All questions had a stem with four responses, first portion is of MCQ and second portion of test indicates selected the best or right answer using the scientific idea and write down reason behind this scientific concept. At the end of each item, the appropriate space was provided for description of reasoning by the students about the chosen correct response. A rubric was also established for evaluation consistency in measuring reasoning answers. This test was bilingual (English with Urdu Translation). It was discussed by five (5) peers having M.Sc. (Physics) or higher along with B.Ed. or higher professional degree, (Thirteen (13) experts including 7 local and 6 international) for accuracy of content and vocabulary to check the concept, relevancy with topics and translation that Urdu and English phrases and face and content validity of instrument and also share their expertise on rubrics. Afterwards, a pilot study was conducted for establishing coefficient of reliability and item analysis of instrument. The scores of the tests were analyzed by the discrimination index and item difficulty according to range of p-value (difficulty level) for item from 30% - 70% or 0.3-0.7 and from 0.31 to 0.77 for item difficulty; ranges were recommended by Bai and Ola (2017). The calculated Alpha value for Problem solving Ability Test in Physics (PSATP) was 0.71.

Procedure of the experiment

After formulation of groups, pre-test was administered to students of experimental group and also to the students of control groups. The test was marked and score were kept confidential so that students may not feel any complex or competition among themselves. On the basis of pre-test scores, students were divided into high, average and low achiever students in both the experimental and control groups. Experiment was carried out for a period of five months which was helpful to minimize novelty effect. The experimental group was taught through 7E learning model of constructivist approach in the subject of Physics by the researcher himself. Similarly, researcher trained the female teacher whose academic qualification was M.Sc. (Physics- Gold Medalist) and professional qualification B.Ed. and experience (10 year teaching). So, the female teacher taught experimental group students through 7E learning model of constructivist approach in the subject of physics at Government Girls higher secondary school Hyderabad town, Sargodha. Control group was taught through traditional methods by a teacher who was equal to researcher in academic qualification (M.Sc. and B.Ed.). Similarly, girls control group was taught through traditional method by a teacher who was equal to trained female teacher in academic qualification M.Sc., B.Ed. At the end of the experiment, the post tests were administered to both the control and experimental groups to assess the domain specific (contextual) problem solving ability. For experimental group, lesson plans were developed according to 7E model of constructivist approach for each unit and were also discussed with five experts having Physics Education background. At the end of the experiment, the post test, problem solving ability, was administered to both the control and experimental groups.

Analysis of Data and Findings

After scoring the tests, the gain scores on problem solving ability test (subtracting pre-test score form post-test scores) in physics were analyzed by applying t-test and one way ANOVA.

Table 1

Overall comparison of mean gain scores in test of problem solving

Groups	N	Means	SD	t	df	p-value	Effect Size
Experimental	87	18.60	4.04	16.57	167	0.001	1.27
Control	82	8.00	4.30				

Table 1 indicates that the difference appeared in mean gain scores in the test of physics about ability to solve problems between students included in control groups and experimental groups was significant, as revealed by t (167) = 16.57, df =167 & p-value equal to 0.00 and the hypothesis of no difference H_{01} was not accepted. Hence, it is found that, greater mean score (M=18.60 & SD=4.04) with larger effect size Cohen‘s d=1.27> 0.8 exhibits that, students of experimental groups treated with 7E instructional model obtained better scores in problem solving ability test in physics as compared to students of control groups (M=8.00 & SD= 4.30) taught through routine teaching methods.

Table 2

Gender wise Comparison of means gain scores in test of problem solving

Groups	N	Mean	SD	t	df	p-value	Effect Size
Experimental	46	10.21	1.80	8.07	84	0.000	1.43
Control	40	6.12	2.84				

Table 2 indicates that the difference found in mean gain scores on the test of physics about ability to solve problems between male students' placed in control and experimental groups was significant, revealed by t (84) = 8.07, df =84 & p-value equal to 0.00 and the hypothesis of no difference. Hence, the greater mean gain score (M=10.21 & SD=3.83) with the larger effect size of Cohen‘s d value=1.43> 0.8 shows that, male students of experimental groups taught through 7E instructional model gained better scores in problem solving ability test in physics as compared to male students of control groups (M=3.60, SD= 1.72) taught through routine teaching methods.

Table 3

Comparing female students' mean gains scores on the problem solving test

Groups	N	Mean	SD	t	df	p-value	Effect Size
Experimental	41	6.70	1.45	4.33	81	0.020	0.82
Control	42	4.97	2.11				

Table 3 depicts that the difference appeared in mean gain scores on the test of physics about ability to solve problems between female students of control and experimental groups was significant, as indicated by t (81) = 4.33, df =81 & p-value equal to 0.02. Hence, the greater mean gain score (M=6.70 & SD=1.45) with the larger effect size of Cohen‘s d value = 0.82 revealed that, female students of experimental groups treated with 7E instructional model gained better scores in physics problem solving ability test as compared to female students of control groups (M=3.60 & SD= 1.72) taught trough routine teaching methods.

Table 4

Comparing high achievers' mean gains scores in the test of problem solving

Groups	N	Mean	SD	T	df	p-value	Effect Size
Experimental	19	8.00	2.62	5.33	35	0.000	1.8
Control	18	3.50	2.50				

Table 4 reflects that the difference found in mean gain scores in the test of physics about ability to solve problems between the high achiever students of experimental groups and students included in control groups was significant, such that t (35) = 5.33, df =35 & p-value equal to 0.000 less than 0.05. Hence, the greater mean gain score (M = 8.00 & SD =2.62) with the larger effect size of Cohen‘s d value = 1.8 > 0.8 indicates that high achiever students of experimental groups treated with 7E instructional model obtained better scores in physics problem solving ability test as compared to high achievers placed in control groups taught through routine teaching methods (M=3.50 & SD=2.50).

Table 5

Comparing average achievers' mean gains scores in the test of problem solving ability

Groups	N	Mean	SD	t	df	p-value	Effect Size
Experimental	27	7.14	1.48	1.90	51	0.000	1.39
Control	26	4.84	1.91				

Table 5 reflects that the difference appeared in mean gain scores in the test of physics about ability to solve problems between the average achiever students of experimental groups and control groups was significant, as indicated by t (51) = 1.90, df =51 & p-value equal to 0.00. Hence, the greater mean gain score (M = 7.14 & SD =1.48) with the larger effect size of Cohen‘s d value = 1.39 > 0.8 shows that average achiever students of experimental groups treated with 7E instructional model gained better scores in problem solving ability test in physics as compared to average achiever students of control groups taught through routine teaching methods (M =4.84 & SD=1.91)

Table 6

Comparing low achievers' mean gains scores in the test of problem solving ability

Groups	N	Mean	SD	t	df	p-value	Effect Size
Experimental	41	9.75	2.22	5.71	77	0.000	1.33
Control	38	6.97	2.09				

Table 6 reflects that the difference appeared in mean gain scores in the test of physics about ability to solve problems between low achiever students of experimental groups and control groups was significant, such that t (77) = 5.71, df =77 & p-value equal to 0.00. Hence, the greater mean gain score (M = 9.75 & SD =2.22) with the larger effect size of Cohen‘s d value = 1.33 > 0.8 shows that low achiever students of experimental groups treated with 7E instructional model obtained greater scores as compared to low achiever students of control groups taught through routine teaching methods (M =6.97 & SD=2.09).

Table 7

ANOVA results for achievement levels (i.e. low, average and high) within experimental groups

Source	SS	df	MS	F	Sig.	Effect Size Eta squared (η^2)
Between Groups	342.889	2	171.44	76.875*	0.000	0.64
Within Group	189.611	84	2.231			
Total	532.500	86				0.40

Table 7 shows the results that difference found in mean gain scores in the test of physics about ability to solve problems between the students having various levels of achievement (i.e. low, average and high) within experimental groups was significant as showed by F = 76.875, p = 0.000 less than 0.05 with moderate effect size η^2= 0.40 and 0.64.

Post hoc test (LSD) was applied for the exploration of further differences within experimental groups. Only the significant results are presented in the table below.

Table 8

Post hoc (LSD) Test

Achievement level (I)	Achievement level (J)	Mean Difference (I-J)	Std. Error	Sig.
High Achiever	Average Achiever	4.36	0.44	.000*
	Low Achiever	5.01	0.41	.000*
Average Achiever	Low Achiever	2.64	0.36	.000*

This table 8 reveals that positive mean difference (4.36) with p-value 0.000 < 0.05 indicates that high achiever students performed better than average achievers with experimental groups. Similarly positive mean difference (5.01) with p-value 0.000<0.05 depicts that high achiever students also performed better than low achievers. Likewise, positive mean difference (2.64) with p-value 0.000 than 0.05, exhibits that performance of average achievers is also significantly better as compare to students of low achievers within experimental groups.

Achievement levels wise analysis between experimental and control groups students' scores through two way ANOVA is presented in table below:

Gender wise analysis of problem solving test scores within experimental group

Now the gender wise analysis of experimental group students' is being presented as follows.

H_{02}: There is no significant difference between the mean gain scores of students of experimental groups on problem solving ability test in physics

Table 9

Gender wise Comparison of mean gain problem solving scores within experimental groups

Gender	N	Mean	SD	t	df	p-value	Effect Size
Female	40	6.65	1.42	10.00	85	0.000	1.13
Male	47	10.10	1.71				

Table 9 indicates that the difference appeared in mean gain scores in the test of physics about ability to solve problems between the female and male students within experimental groups was significant, such that t (85) = 10.00, df =85 & p-value equal to 0.00 and the hypothesis of no difference H_{02} was not accepted. Hence, the greater mean gain score (M=10.10 & SD=1.71) with the larger effect size of Cohen‘s d value= 1.01 greater than 0.8 shows that male students had gained better scores in physics problem solving test than the female students (M=6.65 & SD= 1.42) within experimental groups treated with 7E instructional model.

Table 10

Comparing female and male high achievers' mean gains scores in the problem solving test

Gender	N	Mean	SD	t	df	p-value	Effect Size
Male	13	9.69	1.03	6.02	18	0.000	1.92
Female	07	5.00	1.41				

Table 10 reveals that the difference appeared in the mean gain scores in the test of physics about ability to solve problems between the high achiever female and male students within experimental groups was significant, as reflected by t (18) = 6.029, df =18 & p-value 0.000 less than 0.05. Hence, the greater mean gain score (M=9.69 & SD=1.03) with the larger effect size of Cohen‘s d value = 1.92 > 0.8 exhibits that high achiever male students obtained greater scores than the high achiever female students (M=5.00 & SD= 1.41) within experimental groups treated with 7E instructional model.

Table 11

Comparing female and male average achievers' mean gains scores in test of problem solving

Gender	N	Mean	SD	t	df	p-value	Effect Size
Female	16	6.47	0.94	3.80	24	0.000	1.37
Male	10	8.30	1.56				

*p<0.05

Table 11 depicts that the difference noted in the mean gain scores in the test of physics about ability to solve problems between average achiever female and male students of experimental groups was significant, such that t (24) = 3.80, df =24 & p-value 0.00 less than 0.05. Hence, the greater mean gain score (M=6.47 & SD=0.94) with the larger effect size of Cohen's d value= 1.37 > 0.8 indicates that average achiever female students obtained better scores than the average achiever male students (M=8.30 & SD= 1.56) within experimental groups treated with 7E instructional model.

Table 12

Comparing female and male low achievers' mean gains scores in test of problem solving

Gender	N	Mean	SD	t	df	p-value	Effect Size
Male	24	11.25	1.42	8.58	39	0.000	1.39
Female	17	7.64	1.16				

*p<0.05

Table 12 depicts that the difference appeared in the mean gain scores in the test of physics about ability to solve problems, between low achiever female and male students within the experimental groups was significant, as indicated by t (39) = 8.58, df =39 & p-value 0.000 less than 0.05. Hence, the greater mean gain score (M=11.25 & SD=1.42) with the larger effect size of Cohen's d value= 1.39 > 0.8 shows that low achiever male students gained greater scores than the low achiever female students (M=7.64 & SD= 1.16) within experimental groups treated with 7E instructional model.

Conclusion and Discussion

Teaching learning through 7E instructional model of constructivist approach was more effective than tradition teaching methods to enhance problem solving skills of 10^{th} grade male and female students in physics. It was concluded that the performance of male and female students in problem solving ability test in physics of experimental group was better than their respective counterpart male and female students of control group. Furthermore, the performance of low average and high achiever of students belong to experimental groups in test of physics about think critically was better than the high, low and average achiever students placed in control groups. Moreover, it was also the conclusion that, within experimental group the problem solving ability test scores of male students was better than female students' taught through 7E instructional model. However, conclusion of the study is the enhanced performance on problem solving ability test in physics through 7E model. This finding was also supported by Primanda, Distrik, and Abdurrahman (2019) they found that experimental group students taught through 7E learning cyclic model showed greater scores in "problem solving ability test based on real-life phenomena of physics" as compared to control group students taught through traditional teaching methods. However, 7E Eisenkraft learning cyclic model of constructivist approach, is a student centered pedagogy helps them to understand natural phenomena of physics and enhances students' problem-solving abilities at secondary level. The finding of Ahmad (2011) revealed that, the high achievers of 8^{th} grade students belong to experimental groups who were treated with problem solving teaching strategy performed better on a problem solving ability test in science than the high achievers in the control group who were taught using traditional methods. It is recommended that curriculum developer my incorporate this teaching approach in the curriculum guidelines for construction of intended learning outcomes. Furthermore, the in-service teachers' may incorporate this approach in their teaching learning process for better personality development of the students. It is recommended that in-services teacher training department e.g. Quaid Academy for Educational Development, Lahore, Punjab may develop especial training session, refresher courses or workshops for teachers' not only introduce this approach but also include in routine teaching.

References

Abubakar, S., & Danjuma, I. (2012). Effects Of Explicit Problem-Solving Strategy On StudentsAchievement And Retention In Senior Secondary School Physics. *ATBU Journal of Science, Technology and Education, 1*(1), 123-128. Retrieved from http://www.atbuftejoste.com/index.php/joste/article/viewFile/80/pdf_64

Adams, W. K., & Wieman, C. E. (2015). Analyzing the many skills involved in solving complex physics problems. *American Journal of Physics, 83*(5), 459-467. Retrieved from http://umdberg.pbworks.com/w/file/fetch/96987336/AJP-2015-Adams%26Weiman.pdf

Ahmad, M. (2011). Effect of problem solving teaching strategy on the performance of 8th grade students. *Unpublished doctoral dissertation). Institute of Education and Research, University of the Punjab, Lahore*.

Amineh, R. J., & Asl, H. D. (2015). Review of constructivism and social constructivism. *Journal of Social Sciences, Literature and Languages, 1*(1), 9-16. Retrieved from https://www.academia.edu/31113252/Review_of_Constructivism_and_Social_Constructivism

Argaw, A. S., Haile, B. B., Ayalew, B. T., & Kuma, S. G. (2016). The effect of problem based learning (PBL) instruction on students' motivation and problem solving skills of physics. *Eurasia Journal of Mathematics, Science and Technology Education, 13*(3), 857-871. DOI 10.12973/eurasia.2017.00647a

Bai, X., & Ola, A. (2017). A tool for performing item analysis to enhance teaching and learning experiences. *Issues in Information Systems, 18*(1).Retrieved from https://iacis.org/iis/2017/1_iis_2017_128-136.pdf

Baker, A. R. L. (2011). A look at problem-based learning in high school classrooms to promote student activism. *Journal of Language and Literacy Education, 7*(2), 105-110. Retrieved from https://files.eric.ed.gov/fulltext/EJ1097065.pdf

Balta, N., & Sarac, H. (2016). The Effect of 7E Learning Cycle on Learning in Science Teaching: A Meta-Analysis Study. *European Journal of Educational Research, 5*(2), 61-72.Retrieved from https://files.eric.ed.gov/fulltext/EJ1099652.pdf

Burrow, A. K. (2018). Teaching introductory ecology with problem-based learning. *The Bulletin of the Ecological Society of America, 99*(1), 137-150. Retrieved from https://esajournals.onlinelibrary.wiley.com/doi/pdfdirect/10.1002/bes2.1364

Byun, T., & Lee, G. (2014). Why students still can't solve physics problems after solving over 2000 problems. *American Journal of Physics, 82*(9), 906-913. DOI:10.1119/1.4881606

Cheema, A. B., & Mirza, M. S. (2013). Effect of Concept Mapping On Students' Academic Achievement. *Journal of Research & Reflections in Education (JRRE), 7*(2). Retrieved from https://www.informationtamers.com/PDF/Effect_of_Concept_Mapping_On_Students%E2%80%99_Academic_Achievement.pdf

Crawford, T. R. (2011). Using problem-based learning in web-based components of nurse education. *Nurse education in practice, 11*(2), 124-130. Doi: 10.1016/j.nepr.2010.10.010.

da Silva, J. B. (2020). David Ausubel's Theory of Meaningful Learning: an analysis of the necessary conditions. *Research, Society and Development, 9*(4), 3. https://orcid.org/0000-0003-3556-9881

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.Retrieved from https://journals.aps.org/prper/pdf/10.1103/PhysRevSTPER.11.020106

Dolmans, D. H., De Grave, W., Wolfhagen, I. H., & Van Der Vleuten, C. P. (2005). Problem-based learning: Future challenges for educational practice and research. *Medical education, 39*(7), 732-741. Retrieved from http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.579.7449&rep=rep1&type=pdf

Dörner, D., & Funke, J. (2017). Complex problem solving: what it is and what it is not. *Frontiers in psychology, 8*, 1153. https://doi.org/10.3389/fpsyg.2017.01153

Eisenkraft, A. (2003). Expanding the 5E model. *SCIENCE TEACHER-WASHINGTON-, 70*(6), 56-59. Retrieved from http://aae.lewiscenter.org/documents/AAE/Science/NGSS/eisenkrafttst.pdf

Friedlaender, G. E., & Friedlaender, L. K. (2013). Art in science: enhancing observational skills. *Clinical Orthopaedics and Related Research®*, *471*(7), 2065-2067. doi: 10.1007/s11999-013-3000-0

Funke, J., Fischer, A., & Holt, D. V. (2017). When less is less: solving multiple simple problems is not complex problem solving—A comment on Greiff et al.(2015). *Journal of Intelligence*, *5*(1), 5. Doi:10.3390/jintelligence5010005

Ihejiamaizu, C. C., Ukor, D. D., & Neji, H. A. (2018). Utilization of 5Es' constructivist approach for enhancing the teaching of difficult concepts in Biology. *Global Journal of Educational Research*, *17*(1), 55-60. DOI: https://dx.doi.org/10.4314/gjedr.v17i1.8

Ince, E. (2018). An Overview of Problem Solving Studies in Physics Education. *Journal of Education and Learning*, *7*(4), 191-200. Retrieved from https://files.eric.ed.gov/fulltext/EJ1179603.pdf

Johnston, P. H. (2011). Response to intervention in literacy: Problems and possibilities. *The Elementary School Journal*, *111*(4), 511-534. DOI:10.1086/659030

Johnston, T. S., & Rudnick, D. L. (2009). Observations of the transition layer. *Journal of physical oceanography*, *39*(3), 780-797.

Kalamas Hedden, M., Worthy, R., Akins, E., Slinger-Friedman, V., & Paul, R. (2017). Teaching sustainability using an active learning constructivist approach: Discipline-specific case studies in higher education. *Sustainability*, *9*(8), 1320. doi:10.3390/su9081320

Khoiriyah, A. J., & Husamah, H. (2018). Problem-based learning: Creative thinking skills, problem-solving skills, and learning outcome of seventh grade students. *JPBI (Jurnal Pendidikan Biologi Indonesia)*, *4*(2), 151-160. http://ejournal.umm.ac.id/index.php/jpbi

Lou, S. J., Liu, Y. H., Shih, R. C., & Tseng, K. H. (2011). The senior high school students' learning behavioral model of STEM in PBL. *International Journal of Technology and Design Education*, *21*(2), 161-183. Retrieved from https://www.learntechlib.org/p/64615/.

Mathew, R., Malik, S. I., & Tawafak, R. M. (2019). Teaching Problem Solving Skills using an Educational Game in a Computer Programming Course. *Informatics in education*, *18*(2), 359-373. Retrieved from https://files.eric.ed.gov/fulltext/EJ1233506.pdf

Mayer, R. E. (2006). The role of domain knowledge in creative problem solving. *Creativity and reason in cognitive development*, 145-158. Retrieved from http://perpus.univpancasila.ac.id/repository/EBUPT190078.pdf#page=165

Mekonnen, S. (2014). Problems challenging the academic performance of physics students in higher governmental institutions in the case of Arbaminch, Wolayita Sodo, Hawassa and Dilla Universities. *Natural science*, *2014*. DOI:10.4236/ns.2014.65037

Naade, N., Alamina, J., & Okwelle, P. (2018). Effect of 7E's's constructivist approach on students' achievement in electromagnetic induction topic in senior secondary school in Nigeria. *Journal of education, society and behavioural science*, 1-9. DOI: 10.9734/JESBS/2018/39997

OECD. (2019). *PISA 2018 assessment and analytical framework*: OECD publishing.Retrieved from https://www.oecd-ilibrary.org/docserver/b25efab8-en.pdf?expires=1629867358&id=id&accname=guest&checksum=662C004C0C7060978FD3A956FE2BEC77

Primanda, A., Distrik, I. W., & Abdurrahman, A. (2019). The Impact of 7E Learning Cycle-Based Worksheets Toward Students Conceptual Understanding and Problem Solving Ability on Newton's Law of Motion. *Journal of Science Education*, *2*(19), 95-106.Retrieved from http://repository.lppm.unila.ac.id/11181/1/13.%20%20V19-2018-2-6%20%281%29.pdf

Rahman, M. (2019). 21st century skill'problem solving': Defining the concept. *Asian Journal of Interdisciplinary Research*, *2*(1), 64-74. DOI: http:doi.org/10.34256/ajir1917

Rashid, R. A. (2011). A Perspective Evaluation of Problem-Based Learning in ESL Classroom in the Malaysian Higher School Certificate Program. *Journal on English Language Teaching*, *1*(4), 25-32. Retrieved from https://files.eric.ed.gov/fulltext/EJ1071039.pdf

Reddy, M., & Panacharoensawad, B. (2017). Students Problem-Solving Difficulties and Implications in Physics: An Empirical Study on Influencing Factors. *Journal of Education and Practice*, *8*(14), 59-62. Retrieved from https://files.eric.ed.gov/fulltext/EJ1143924.pdf

Reif, F., Heller, J., Reif, F., & Heller, J. (2013). Knowledge Structure and Problem Solving in Physics Knowledge Structure and Problem Solving in Physics: April. https://doi.org/10.1080/00461528209529248

Roblyer, M., & Doering, A. (2012). Intergrating instructional technology into teaching: Boston, MA: Pearson.

Simsek, P., & Kabapınar, F. (2010). The effects of inquiry-based learning on elementary students' conceptual understanding of matter, scientific process skills and science attitudes. *Procedia-Social and Behavioral Sciences*, *2*(2), 1190-1194. doi:10.1016/j.sbspro.2010.03.170

Tondeur, J., Van Braak, J., Ertmer, P. A., & Ottenbreit-Leftwich, A. (2017). Understanding the relationship between teachers' pedagogical beliefs and technology use in education: a systematic review of qualitative evidence. *Educational technology research and development, 65*(3), 555-575. Retrieved from https://www.academia.edu/28595855/Understanding_the_relationship_between_teachers_pedagogical_beliefs_and_technology_use_in_education_a_systematic_review_of_qualitative_evidence

Treffinger, D. J., Selby, E. C., & Isaksen, S. G. (2008). Understanding individual problem-solving style: A key to learning and applying creative problem solving. *Learning and Individual Differences, 18*(4), 390-401. Retrieved from http://www.creativelearning.com/~clearning/images/freePDFs/UnderIndProbSolvStyle.pdf

Tuwoso. (2016). *The implementation of constructivism approach for physics learning in vocational high school.* Paper presented at the AIP Conference Proceedings.Retrieved from https://aip.scitation.org/doi/pdf/10.1063/1.4965791

Uden, L., & Beaumont, C. (2006). Why problem-based learning. In *Technology and problem-based learning* (pp. 44-64). IGI Global.

Wanbugu, P., Changeiywo, J., & Ndiritu, F. (2013). Investigations of experimental cooperative Concept mapping instructional approach on secondary school girls' achievement in physics in Nyeri county, Kenya. *Journal of Education and practice*, *4*(6), 120-130. Retrieved from https://www.iiste.org/Journals/index.php/JEP/article/view/4823/4901

Wang, Y., & Chiew, V. (2010). On the cognitive process of human problem solving. *Cognitive systems research, 11*(1), 81-92. doi:10.1016/j.cogsys.2008.08.003

Watkins, J., & Mazur, E. (2013). Retaining students in science, technology, engineering, and mathematics (STEM) majors. *Journal of College Science Teaching, 42*(5), 36-41.Retrieved from https://mazur.harvard.edu/files/mazur/files/rep_685.pdf

Yavuz, G., Yasemin, D., & Arslan, Ç. (2017). Elementary School Students Perception Levels of Problem Solving Skills. *Universal Journal of Educational Research, 5*(11), 1896-1901. Retrieved from https://files.eric.ed.gov/fulltext/EJ1159726.pdf