Impact of Inquiry-Based Learning Using the 5E Model on Teachers' Practices and Learners' Achievement in Force and Motion in Secondary Schools of Jinja District, Uganda

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Abstract: This study aimed to assess the impact of Inquiry-Based Learning using the 5E model on teacher's practices and students' achievement in Force and Motion in Secondary Schools in Jinja District. The study employed a quantitative research method and a pretest-posttest non-equivalent quasi-experimental research design. The study sample was one hundred forty-one students and teachers who were sampled through simple random sampling procedures. Four teachers were trained in implementing the IBL in the classroom and they taught the experimental classes while two teachers were not trained and they taught the control classes with the traditional teaching method. Reformed Teaching Observation Protocol (RTOP) was used to collect observation data while Force and Motion Conceptual Evaluation was used to test students' performance and conceptual understanding of mechanics-related topics. Data from student achievement tests were analysed under SPSS using the independent samples t-test while data from classroom observation was analysed by the MS Excel 2016. The study concludes that IBL has the potential to improve teachers' classroom practices as well as students' achievement in physics, especially if the teachers are given training on IBL. The study recommends that additional support in form of training be given to teachers to help them adapt to IBL. Also, teacher education programs ought to provide IBL instruction and training to educators.

Keywords: Inquiry-Based Learning; 5E model; RTOP; achievement; Physics Education; Instructional Model.

Introduction

Physics is one of key subjects that play role in the field of science and technology. However, many students consider learning physics a difficult pursuit, causing some to develop negative attitude towards the subject. Studies have revealed that students are still faced with learning difficulties in basic concepts such as force and motion, among others that set a

basis for the development of physics knowledge (Bayraktar, 2009; Tural, Akdeniz, Alev 2010; Atasoy & Akdeniz, 2011). Such learning difficulties are mainly due to the abstract nature of the concepts (Atasoy & Akdeniz, 2011) and inadequate methodology to teach physics (Wilson, 2020).

Over time, various attempts have been made to find out the best way of teaching physics (Hu, Gao & Liu, 2017) but physics is still considered the most unpopular and is known to be a boring subject compared to chemistry and biology (Veloo, Nor & Khalid, 2015). Similar efforts through the ministry of education and sports, the government of Uganda has taken action to ensure that secondary school students perform better in science and mathematics (Kirya, Mashood & Yadav, 2021). These include investing resources and pressing science teachers to attend continuous professional development workshops such as SESEMAT so as to improve their classroom practices which are envisaged to improve students' achievement in science and mathematics (Manyiraho, Atibuni, Olema, & Wamakote, 2020). There has been a slight improvement in students' achievement (Akwei, 2017; On & Candidates, 2017; Candidature, 2020). However, there are several complicated and multifarious causes that have slowed down the advancement of science students to the Advanced high school level. These include gender differences in enrolment, trends in O- to A-level advancement, teacher perceptions of girls' physics abilities (or lack thereof), school locations, and school types. A public outcry in the nation has been raised against the low quality of science education because of the reasons as well as the shortage of qualified physics teachers, the scarcity of scientific equipment, and the ineffective pedagogical methods utilized by science teachers. As a result, there are few students who take physics at the advanced level or higher levels (Talemwa & Opae papa, 2014).

The inquiry Based Learning (IBL) approach has been recommended as one of the best approaches for learning (Rutten, van der Veen & van Joolingen, 2015; Hu, Gao & Liu, 2017). The IBL approach is premised on the constructivism theory which holds that learning is an active process in which learners construct new ideas or concepts based on previous experiences and knowledge. IBL approach has several models of teaching including the Herbart instruction model that is geared towards giving an understanding of how people learn. In this model, Herbart emphasized that teaching must happen in four logical steps: preparation, presentation, generalization and application. In preparation, the teacher draws the students' attention to earlier experiences. In presentation, the instructor links newly introduced experiences to earlier ones. In generalisation, the teacher develops concepts and clarifies ideas, and finally, in application, the teacher gives the pupils opportunities to apply concepts in novel circumstances in order to demonstrate their grasp.

John Dewey's instruction model is another approach which was rooted in experience and reflective thinking, emphasizing that the teaching of science concepts should not only emphasize the hands-on activities (practical work) but also the mind (Dewey, 1938).

Although several models have been designed to guide the scientific inquiry, the 5E model, which started its historical development with the question of how people learn, has become an exemplary model for educational institutions, especially in science education (Bybee, 2009). The 5E instructional model is an inquiry-based learning model that is based upon cognitive psychology, constructivist-learning theory and best practices in science teaching (Bybee et al., 2006). The model can be used to design a science lesson in a cyclic manner that involves five cognitive stages of learning: engage, explore, explain, elaborate and evaluate(Malik, Dirgantara, & Agung, 2018). Engagement is geared towards arousing the learners' interest. Here, teachers have to think creatively about how they can surprise the learners with scientific imagination and reasoning so as to draw them towards the instruction task. Teachers can use techniques like brainstorming on an initial question. Exploration stage incorporates active exploration which promotes a mental focus on the concept and provides the students with a common, concrete learning experience. This phase challenges students to apply all the skills including observing, questioning and investigating to understand the subject under study and gives students "hands-on" experiences before any formal explanation of the concept is explained by the teacher. Explanation stage fosters the cognitive development as students use the mind to make sense of their findings during the exploration stage. The phase enables students to describe their understanding and pose questions about the concepts they have been exploring. Elaboration stage focuses on applying the knowledge acquired to everyday life experience.

Evaluation stage encourages assessment of learners' understanding using both formative and summative assessments.

This study sought to establish the impact of planning and delivery of IBL physics lessons using the 5Es model on teachers' practices and students' achievement in force and motion by answering the following research questions:

1. What was the initial teachers' level of knowledge and practice in terms of application of IBL physics lesson planning and delivery using the 5E instruction model?
2. What is the impact of applying the 5E model lesson plan and delivery on teachers' practices and students' achievement in Jinja Secondary Schools?
3. Is there a significant difference in students' achievement between the control and the experimental group before and after the treatment?

Methodology

Research Design

The study employed the quantitative research method and a pretest-posttest non-equivalent quasi-experimental research design. The design was used in the study as the researcher sought to establish if a change in the independent variable (IBL teaching approach) would cause a subsequent change in the dependent variable (teachers' practices and students' achievement).

Population and Sampling

There are 32 secondary schools in Jinja District, ten public and twenty-two private schools. Out of these, six schools were selected to participate in the study. These schools were selected using simple random sampling since all the schools were marked with persistent high physics failure rates and so each school had a chance of being selected. The six sampled schools consisted of a total population of 230 students in their senior three. The sample size was considered large enough for statistical purposes which in most cases require a minimum size of thirty or more participants. Using the Morgan and Krejcie statistical technique, a sample size of 141 participants was drawn from this population, including 6 teachers and 135 students.

Instruments

The study used two kinds of data collection instruments: the achievement test and the observation guide. These tools were used because they would enable the researchers to obtain both students' and teachers' outcomes. Creswell and Plano Clark (2011) contend that integrating more than one type of participants in a single study improves results as the limitations of one type of data are balanced by the strength of another.

The Achievement Test

This instrument was a multiple-choice test in two parts; the pre-test, which was given before the intervention and the post-test, which was given after the intervention. The pre-test and post-test instruments consisted of 10 items each, derived from 47 items of the Force and Motion Conceptual Evaluation (FMCE) test, a standard test developed by a team of experts known as Ron Thornton and David Sokoloff (Thornton & Sokoloff, 1998). The 10 items of each test were selected purposively to ensure that the questions covered similar content and that the corresponding questions in both tests had similar items.

Observation Guide

The observation guide was a Reformed Teaching Observation Protocol (RTOP) developed by Piburn et al. (2000). This guide was first used on both control and experimental teachers to conduct a pre-assessment of initial teachers' level of knowledge and practice in terms of application of IBL physics lesson planning and delivery using the 5E instruction model. The training was given to four teachers from the experimental schools after which an intervention was made and teachers in the experimental schools were observed again to find out the impact of inquiry-based learning using the 5E model in teaching force and motion on teachers' practices in Jinja Secondary Schools. To manage the control and experimental groups during the intervention, the researchers ensured that there was no interaction between both the teachers and students of the control and experimental groups since the control group teachers were not trained in the 5E model.

Validity and Reliability

For validity and reliability of the research instruments, the study used both achievement test and observation protocol adopted from standard instruments whose validity and reliability measures had been tested and proven for data collection. Further still, the content validity of the 10 items of pre and post-test was ensured by seeking opinion of experts together with the team of lecturers from the physics department at the ACEITLMS-University

of Rwanda. The reliability of the achievement test was further obtained using two tests of equal difficulty and similar format. These were administered to a different but related sample before the actual study was undertaken with different schools and a reliability coefficient of 0.71 was obtained. Likewise, for interrater reliability for the RTOP, one trial classroom (from pilot school) between a researcher and an assistant across all 25 RTOP statements was conducted before real-time classroom observation. Basing on the scores that each observer had given for each RTOP statement, the interrater reliability was computed using Kappa statistics; Cohen's Kappa = (AO − AC) / (1 − AC) where OA is the rate of agreement between observers, and AC is the rate of the inter-observer agreement occurred due to chance. The interrater reliability was found to be 0.79 and according to Cohen (1988), the value above 0.7 is considered reliable.

Ethical Considerations

As part of ethical considerations, the research document was sent to the research and innovation unit at the University of Rwanda-College of Education (URCE) for ethical evaluation after which an ethical research clearance was given and used to ask permission from Jinja District. Permission to access schools was requested from the district. A consent form was then given to participants requesting them to participate in the study. Anonymity and confidentiality were also considered.

Statistical Treatment of Data

Data from students' achievement tests was analysed through SPSS using the independent samples t-test while data from classroom observation was analysed through the MS Excel and scale of mean score interpretation was as follows: 0-0.49 = Never occurred 0.50-1.49 = below Standard 1.50-2.49= Progressing Toward Standard 2.50-3.49 = Meets Standard and 3.50- 4.00 = Exceeds Standard.

Results and Discussion

This section presents the results in respect to the research questions that guided the study.

Research Question 1: What was the initial teachers' level of knowledge and practice in terms of application of IBL physics lesson planning and delivery using the 5E instruction model?
The RTOP lesson observation protocol was used to observe six physics lessons in participating secondary schools and results are shown in table 1. Results from table 1 show that the teachers' initial

knowledge of the application of IBL physics lesson planning and delivery was below standard. This was based on the average score of 1.35 out of 4. The teachers' highest score was 3.00 and this was obtained from the section of classroom culture; teacher-student relationship. Teachers encouraged active participation of their learners. They demonstrated knowledge that is progressing towards standards in the content especially propositional knowledge (statement 6, 8 and 9). However, teachers' practices as observed in aspects of lesson design and implementation, procedural knowledge and classroom culture including communicative interventions and student/teacher relationships were inadequately demonstrated.

In the initial observations, teachers showed poor performance in mainly the engage and exploration stage (statements 1, 3, 5, 18 and 19). In engagement stage, teachers demonstrated insufficient knowledge as they restricted the lesson introduction to merely recall of knowledge from previous lesson covered other than integrating it with engaging activity or questions that can excite learners. Proceeding to the exploration stage, it was commonly observed that the teacher would carry out a formal presentation before exploration. A case in point was a teacher who performed a demonstration on the motion of a body thrown vertically upwards, throwing a piece of chalk in the air. Teachers asked the related questions after demonstration, thus limiting learners' capacity to explore phenomena. Similarly, findings revealed that teachers demonstrated weaknesses in guiding learners into meaningful exploration. Some teachers who used videos to guide the exploration gave subsequent questions at the end of the video instead of before (Ndihokubwayo, Uwamahoro & Ndayambaje, 2020).

The explanation stage was exceptionally difficult for the teachers to have students' feedback from the group discussions. Besides, there were no questions raised by learners. Most of the questions originated from the teachers and learners' role was to answer. The classroom was purely dominated by teacher talk. In the elaborate phase, teachers were expected to ask questions that lead students to extend knowledge to address new but related situations.

Themes	Subthemes	#	RTOP statements	Mean score
Lesson design and implementation		1	The instructional strategies and activities respected students' prior knowledge and the preconceptions	1.83
		2	The lesson was designed to engage students as members of a learning community	1.83
		3	In this lesson, student exploration preceded the formal presentation	0.50
		4	This lesson encouraged students to seek and value alternative modes of investigation or problem-solving	1.17
		5	The focus and direction of the lesson was often determined by ideas originating with students	0.67
Content	Propositional knowledge	6	The lesson involved fundamental concepts of the subject	2.17
		7	The lesson promoted strongly coherent conceptual understanding	1.00
		8	The teacher had a solid grasp of the subject matter content inherent in the lesson	2.67
		9	Elements of abstraction (i.e., symbolic representations, theory-building) were encouraged	2.33
		10	Connections with other content disciplines and/or real-world phenomena were explored and valued	0.83
	Procedural Knowledge	11	Students used a variety of means (models, drawings, graphs, concrete materials, manipulative, etc.) to represent phenomena	1.00
		12	Students made predictions, estimations and/or hypotheses and devised means for testing them	0.67
		13	Students were actively engaged in a thought-provoking activity that often involved critical assessment	1.83
		14	Students were reflective about their learning	1.83
		15	Intellectual rigor, constructive criticism, and the challenging of ideas were valued	0.83
Classroom culture	Communicative interactions	16	Students were involved in the communication of their ideas to others using a variety of means and media	0.67
		17	The teacher's questions triggered divergent modes of thinking	1.83
		18	There was a high proportion of student talk, and a significant amount of it occurred	0.67
		19	Student questions and comments often determined the focus and direction of classroom discourse	0.67
		20	There was a climate of respect for what others had to say	1.33
	Student/Teacher Relationships	21	Active participation of students was encouraged and valued	3.00
		22	Students were encouraged to generate conjectures, alternative solution strategies, and ways of interpreting evidence	0.83
		23	In general, the teacher was patient with students	1.83
		24	The teacher acted as a resource person, working to support and enhance student investigations	0.83
		25	The metaphor "teacher as a listener" was very characteristic of this classroom	0.83
			Overall scores	**1.35**

Table 2: Teachers' Observation Scores across each of the 25 RTOP Statements after Intervention

Themes	Subthemes	#	RTOP statements	Non-trained teachers Mean/4	%
Lesson design and implementation		1	The instructional strategies and activities respected students' prior knowledge and the preconceptions	1.5	37.5
		2	The lesson was designed to engage students as members of a learning community	1.5	37.5
		3	In this lesson, student exploration preceded the formal presentation	0	0
		4	This lesson encouraged students to seek and value alternative modes of investigation	1.5	37.5
		5	The focus and direction of the lesson was often determined by ideas originating with students	1	25
Content	Propositional knowledge	6	The lesson involved fundamental concepts of the subject	2	50
		7	The lesson promoted strongly coherent conceptual understanding	1	25
		8	The teacher had a solid grasp of the subject matter content inherent in the lesson	3	75
		9	Elements of abstraction (i.e., symbolic representations, theory-building) were encouraged when it was important to do so	2	50
		10	Connections with other content disciplines and/or real-world phenomena were explored and valued	0.5	12.5
	Procedural Knowledge	11	Students used a variety of means (models, drawings, graphs, concrete materials, manipulative, etc.) to represent phenomena	1.5	37.5
		12	Students made predictions, estimations and/or hypotheses and devised means for testing them	0.5	12.5
		13	Students were actively engaged in a thought-provoking activity that often involved critical assessment	2.5	62.5
		14	Students were reflective about their learning	1.5	37.5
		15	Intellectual rigor, constructive criticism, and the challenging of ideas were valued	1.5	37.5
Classroom culture	Communicative Interactions	16	Students were involved in communication of ideas to others using a variety of means and media	0.5	12.5
		17	The teacher's questions triggered divergent modes of thinking	1.5	37.5
		18	There was a high proportion of student talk, and a significant amount of it occurred among them	1	25
		19	Student questions and comments often determined the focus and direction of classroom discourse	0.5	12.5
		20	There was a climate of respect for what others had to say	1.5	37.5
	Student/Teacher Relationships	21	Active participation of students was encouraged and valued	3.5	87.5
		22	Students were encouraged to generate conjectures, alternative solution strategies, and interpretation	1.5	37.5
		23	In general, the teacher was patient with students	1.5	37.5
		24	The teacher acted as a resource person, working to support and enhance student investigations	0.5	12.5
		25	The metaphor "teacher as a listener" was very characteristic of this classroom	1.5	37.5
			Overall scores	**1.4**	**35**

Table 3: Teachers' Observation Scores across each of the 25 RTOP Statements after Intervention

Themes	Subthemes	#	RTOP statements	Trained teachers Mean/4	%
Lesson design and implementation		1	The instructional strategies and activities respected students' prior knowledge	2.5	62.5
		2	The lesson was designed to engage students as members of a learning community	2.5	62.5
		3	In this lesson, student exploration preceded the formal presentation	2.75	68.75
		4	This lesson encouraged students to seek and value alternative modes of investigation	3.25	81.25
		5	The focus and direction of the lesson was often determined by ideas originating with students	2.75	68.75
Content	Propositional knowledge	6	The lesson involved fundamental concepts of the subject	2.75	68.75
		7	The lesson promoted strongly coherent conceptual understanding	3	75
		8	The teacher had a solid grasp of the subject matter content inherent in the lesson	3	75
		9	Elements of abstraction (i.e., symbolic representations, theory-building) were encouraged	2.75	68.75
		10	Connections with other content disciplines and/or real-world phenomena were explored and valued	3.25	81.25
	Procedural Knowledge	11	Students used a variety of means (models, drawings, graphs, concrete materials, manipulative, etc.) to represent phenomena	3	75
		12	Students made predictions, estimations and/or hypotheses and devised means for testing them	2.75	68.75
		13	Students were actively engaged in a thought-provoking activity that involved critical assessment	2.75	68.75
		14	Students were reflective about their learning	3	75
		15	Intellectual rigor, constructive criticism, and the challenging of ideas were valued	3.25	81.25
Classroom culture	Communicative Interactions	16	Students were involved in the communication of their ideas to others using a variety of means	3.25	81.25
		17	The teacher's questions triggered divergent modes of thinking	3.5	87.5
		18	There was a high proportion of student talk, and a significant amount of it occurred among students	3.25	81.25
		19	Student questions and comments often determined the focus and direction of classroom discourse	3	75
		20	There was a climate of respect for what others had to say	3.5	87.5
	Student/Teacher Relationships	21	Active participation of students was encouraged and valued	3.5	87.5
		22	Students were encouraged to generate conjectures, alternative solution strategies, and ways of interpreting evidence	3.5	87.5
		23	In general, the teacher was patient with students	3	75
		24	The teacher acted as a resource person, working to support and enhance student investigations	2.75	68.75
		25	The metaphor "teacher as a listener" was very characteristic of this classroom	3.25	81.25
			Overall scores	3.03	75.75

In contrast, the average score for the teachers in terms of connecting content with other real-world phenomena (statement 10) was 0.83 which showed that the activity was significantly below standard. While most teachers could give an exercise in a way to evaluate their lesson, only a handful of the teachers could provide prompt feedback to the learners. Worse still, the results were poor with majority of students below average. Similar studies have revealed teachers' weakness in application of IBL. Ndihokubwayo, Uwamahoro and Ndayambaje (2020) revealed that teachers had weaknesses in the exploration stage (statement 3), explanation (5, 18 and 19) and elaboration (10). Mukandayisenga, Opanga and Nsengimana (2021) argued that although IBL had a potential to improve students' learning, teachers portrayed inability to use inquiry in teaching practice.

Research Question 2: What is the impact of applying the 5E model lesson plan and delivery on teachers' practices and students' achievement in Jinja Secondary Schools?

Teaching practices documented by the Reformed Teaching Observation Protocol (RTOP) were collected and analysed between trained and non-trained teachers on inquiry-based learning (IBL) approach during the implementation of teaching intervention. During the intervention, the researchers ensured that there was no interaction between both the teachers and students of the control and experimental groups such that the results would be free from bias. The overall mean scores for non-trained and trained teachers were 1.4 and 3.03 out of 4, respectively as shown in table 2 and table 3.

Table 3 results showed improved teacher practices for trained teachers as the trained teachers scored 3.5 out of 4 on four statements (statement -17, 20, 21, and 22). These statements are related to classroom culture, especially statement-17 and 20, belonging to communicative interactions while others belong to student/teacher relationships. The lowest score was 2.5 out of 4, which showed that classroom practices exhibited by the trained teachers met standard even in statement-1 [The instructional strategies and activities respected students' prior knowledge and the preconceptions inherent therein] and statement-2 [The lesson was designed to engage students as members of a learning community], related to lesson design and implementation where they scored least.

On the other hand, teachers in the traditional classes generally showed poor activities. Although the highest statement-21 [Active participation of students was encouraged and valued] was scored at 3.5 out of 4 as in experimental class, teachers in the traditional class demonstrated high weakness in exploration stage (statement-3, In this lesson, student exploration preceded the formal presentation) where it was characteristic of all teachers observed to make presentations before asking students to carry out their own exploration through investigations and experimentations which consequently denied students opportunity to make predictions, estimations and/or hypotheses (statement-12) and means for testing them.

Trained teachers scored high in classroom culture because IBL allows teachers to conduct a conducive classroom. For instance, in statement-17, teachers' questions triggered divergent modes of thinking as IBL enhances such questioning in nature. Etemadzadeh, Seifi & Far (2013) attempted to investigate whether asking questions prior to writing would improve the quality of Malaysian secondary students' writing. Findings from the T-test showed that participants who received two weeks of treatment demonstrated 17% improvement in their writing skills. Thus, the authors realized that the questioning technique effectively provokes students to write.

Teachers were able to create a climate of respect for what others had to say (statement-20). Due to the procedures of IBL, students systematically present their findings, making them listen to others' work. This attention is needed in a class to capture mutual understanding and call students' attention. Teachers identified findings from an integral part of facilitating reasonable discussions (Lim & Ismail, 2020) as promotors of learning discussion and were found to tend to ask follow-up questions that increased and sustained students' participation in classroom discussions. Therefore, the active participation of students was encouraged and valued (statement-21) by the experimental group teachers due to training on IBL. Active learning was dedicated to physics classrooms in Rwanda (Ndihokubwayo, Uwamahoro & Ndayambaje, 2022). The authors found that teachers engaged their students in physics activities and interact through group work and questioning. Such engagement encouraged students to generate conjectures, alternative solution strategies and ways of interpreting evidence (statement-22). For instance,

during class where teachers were trained, students were involved in analyzing situations such as velocity and acceleration-time graphs, interpreting them, and had room to provide various ideas. This is a crucial learning input that every teacher should engage in students.

Similar studies were done by several researchers and documented classroom practices using RTOP. Ndihokubwayo, Uwamahoro & Ndayambaje (2020) found a considerable presence of reformed teaching (>50%) in optic lessons. The study revealed a 61% level of learner-centred across grouped RTOP statements and 53% scores indicating reformed teaching of optics among Rwandan physics classrooms. Sawada et al. (2002) measured reform practices in Science and Mathematics classrooms in the US and found that student learning is significantly enhanced when teaching is highly reformed. The study also found a relationship between reformed teaching and student achievement. The development of RTOP produced a valuable tool for reflecting upon and improving physics teaching. Macisaac and Falconer (2002) used it to assess students' conceptual learning and teachers' RTOP scores were found to strongly correlate with their students' conceptual gains in introductory science and physics courses.

Findings of this study indicated that the training of teachers greatly improved the performance in IBL and this is supported by the findings of Duran and Duran (2004) which indicated that training of teachers may help them appreciate and use the 5E's instruction model. The 5E's model guided teachers in preparing lessons in such a way that would elicit the desired skill sets and attitude among learners. The learners were driven into autonomous learning as they demonstrated willingness to participate in classroom activities. These findings support Cairns (2019) who presented that in IBL, learners are responsible for generation of knowledge as opposed to consuming it.

Research question 3: Is there a significant difference in students' achievement between the control and the experimental group before and after the treatment?

The researchers administered a pre-and post-test to check for students' achievement in both the control and the experimental groups. The results of the pre-test for the control group and the experimental group are reflected in tables 4 and 5.

Table 4: Descriptive statistics pre-test performance (Std.: standard, N: sample size)

	Group	N	Mean	Std. Deviation	Std. Error Mean
Students' pre-test score	control	71	27.75	11.109	1.318
	experimental	64	28.75	12.280	1.535

Table 5: Independent samples t-test for pre-test scores

Pre-test	Levene's Test for Equality of Variances		t-test for Equality of Means						
	F	Sig.	T	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper
Equal variances assumed	.175	.676	-.499	133	.62	-1.00352	2.012954	-4.98507	2.97802
Equal variances not assumed			-.496	127.696	.62	-1.00352	2.01295	-5.00741	3.00037

Table 4 shows the mean score foe the control group to be 27.75 and for the experimental group to be 28.75. Table 5 shows the Sig of .62 which is greater than the critical value, meaning there was no significant difference in performance between the control and the experimental groups. This implies that students in both groups were comparable before the intervention in terms of their achievement in force and motion concepts.

In the experimental group, four teachers were given training on how to apply the 5E model to the teaching of force and motion. The control group

used conventional teaching methods, in contrast. After teaching the concepts of force and motion, the researchers conducted an intervention to assess the outcomes of the inquiry-based learning using the 5E model. According to Table 6, the experimental group's mean score was 70.0, compared to the control group's mean score of 40.99. A substantial performance difference between the control and the experimental groups is shown by the Sig of.00 in Table 7, which is lesser than the critical value. The experimental group that received treatment had a higher mean score than the control group, which received instruction via the conventional method.

Table 6: Descriptive statistics post-test performance (Std.: standard, N: sample size)

	Group	N	Mean	Std. Deviation	Std. Error Mean
Students' post-test	Control	71	40.99	15.414	1.829
scores	experimental	64	70.00	17.638	2.205

Table 7: Independent samples t-test for post test scores

Post-test	Levene's Test for Equality of Variances		t-test for Equality of Means					95% Confidence Interval of the Difference	
	F	Sig.	T	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Equal variances assumed	3.53	0.06	-10.20	133	.000	-29.01	2.85	-34.64	-23.39
Equal variances not assumed			-10.13	125.90	.000	-29.01	2.877	-34.68	-23.34

This difference has been supported by Bybee et al. (2006) who asserted that by using the 5E model, students are able to change their initial concepts by self-reflecting and collaborating with others, thereby improving their performance. Malik, Dirgantara & Agung (2018) implemented the 5E learning cycle model-based inquiry to improve students' learning achievements on the static fluid in Indonesian senior high schools and results showed an improvement in the test score of students after being taught using the 5Emodel. These results provide evidence for the effectiveness of the 5E model to improve teachers' practices which in turn improve the students' learning achievement.

Conclusions and Recommendations

The study concludes that the 5E IBL Model improved students' understanding of force and motion concepts. This was proved by a higher mean score in the experimental group which was taught using the 5E IBL Model as compared to the control group to which traditional methods were used. Therefore, the 5E IBL Model is more effective than the traditional approach in terms of raising secondary students' competence in physics, particularly the notions of force and motion. The study recommends that additional support in form of training be given to teachers to help them adapt to IBL. Also, teacher education programs ought to provide IBL instruction and training to educators.

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