Effect of instructional interventions on students learning gains: An experimental research

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Abstract
This paper describes the method of instruction used in teaching and learning of mechanics and the gain in students' understanding of the basic concepts of Mechanics. The research was conducted on the first year students who were registered for the course Mechanics. The Pretest–Posttest control group design was used in this research. The control group was taught by teacher lecture and tutorial classes where the instructor solves quantitative problems and students copy the solutions. The two test groups, Test group T_1 and Test group T_2 were exposed to question - answer approach with group discussion and feedback in the form of interactive lecture. The Test group T_2 had additional treatment: self reflection where students reflected their learning every week by writing structured reflective journals. To assess the effectiveness of the mode of instruction used, and the quality of student's engagement in learning mechanics, I used the Mechanics Baseline Test (MBT) as instruments of data collection. The result of the research indicated that students exposed to the question – answer approach with group discussion as a teaching intervention performed better than students taught by teacher lecture on MBT. The Cohen effect size also showed that students who reflected on their own learning and knowledge by organizing their ideas had better understanding of the basic concepts of Newton's laws of motion.

Keywords: Instructional interventions, Learning gains, self-reflection.

Resumen
Este artículo describe el método de instrucción usado en la enseñanza y aprendizaje de la mecánica y el incremento de comprensión en los estudiantes de los conceptos básicos de la Mecánica. La investigación se llevó a cabo en los estudiantes de primer año quienes fueron registrados para los concursos de Mecánica. El grupo de control diseñado Pretest-Posttest fue utilizado en esta investigación. El grupo de control fue impartido por profesores lectura y clases de tutorías donde el instructor resuelve problemas cuantitativos y los estudiantes copian las soluciones. Los dos grupos de prueba, Prueba de grupo T_1 y prueba de grupo T_2 donde se expuso a la pregunta – respuesta con el método de discusión en grupo y retroalimentación en la forma de lectura interactiva. La Prueba de grupo T_2 tuvo el tratamiento adicional: Auto reflexión, donde los estudiantes reflejaron su aprendizaje cada semana escribiendo sus reflexiones estructurales darias. Para evaluar la eficacia del método de instrucción utilizado, y la calidad de participación de los estudiantes en el aprendizaje de la mecánica, he utilizado la Prueba de Base Mecánica (MBT) como instrumento de recolección de datos. El resultado de la investigación indicó que los estudiantes expuestos a la pregunta – respuesta con el método de discusión en grupo como una intervención de enseñanza se realizó mejor que los estudiantes enseñados por profesores de lectura en MBT. El tamaño del efecto Cohen también mostró que los estudiantes quienes reflejaron en su propio aprendizaje y el conocimiento mediente la organización de sus ideas tuvieron mejor comprensión de los conceptos básicos de las leyes de Newton de movimiento.

Palabras clave: Intervenciones de enseñanza, Beneficios del aprendizaje, auto-reflexión.

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I. INTRODUCTION

It has long been recognized that the lecture environment often fosters passive learning. For instance, teaching by telling is an ineffective mode of instruction for most students [1], traditional lecture style does not encourage students to actively think or to effectively construct knowledge [2], a good lecturer may present physics in an interesting way, but students do not always know how to learn it appropriately [3]. Cahyadi [4] reports various reasons why the traditional teaching approach fails to promote knowledge construction: the amount of information presented in a lecture is too much for students' working memory to cope with, students are not given enough time to have social interactions which facilitate their learning, misconceptions are often ignored, and this influences the process of understanding new information. The study by Schwartz *et al* [5] suggest that breadth-based learning (aiming for breadth in content coverage) in high school classrooms does not offer students any advantage when they enroll in introductory college science courses.

In a traditional lecture teachers generally behave in a didactic manner, disseminating information to students where curricular activities rely heavily on textbooks and work books of data and manipulative materials. However, teachers should generally behave in an interactive manner and they should seek the students' point of view. In Ethiopian the common characteristic of physics teachers in teaching undergraduate physics, is transmitting the logical structures of their knowledge through lecture as per the structure of the textbooks and curriculum material given to them and directing students in practical classes towards discovering the predetermined universal truths expressed in the form of law, principles, rules and algorithms. The teaching of physics is dominated by lectures resulting passivity in students compromising acquisition of process and inquiry skills [6]. However, the use of lecture time to present derivations and solution to mathematical physics problems has been observed to be ineffective in promoting students learning of physics [7]. The average normalized gain in students Mechanics Baseline Test after instruction by lecture was 0.10 (Ibid). This low average normalized gain suggests that the traditional lecture is hardly promising in enhancing conceptual understanding in mechanics. Research findings strongly support this idea. For example, Arons [8] and Hestenes [9] recognized that conventional homework problems, test questions and most end-of-chapter exercises in textbooks put emphasis on calculation and numerical results without probing into conceptual understanding. Kim and Pak [10] also reported that solving a great number of textbook problems proved to be no aid in performing well on the mechanics concept test.

All the above discussions show that physics instruction by teacher lecture tends to be ineffective in helping students develop a real understanding of physics. In my university's context which may also likely in all Ethiopian Universities, we typically use lecture time to present derivations, to show examples on how to solve quantitative problems and for presenting the solution to quantitative physics problems. However, these are observed to be ineffective in promoting students learning of physics. The evidence to my argument is the fact that most of our undergraduate students fail to solve similar problems that appear in exams and hence subjected to delay and retake the course or dismissal from the program. More than this, our emphasis on quantitative presentation leads our students to rote learning of formulae at the expense of students' conceptual understanding. Scholars, for instance,[11a, 11b, 12, 13], have carefully documented college physics students' understanding of a variety of topics, and have concluded that traditionally taught courses do little to improve students' understanding of the central concepts of physics, even if they learn problem-solving algorithms.

Lectures become more useful when students are forced to become active participants in the lecture [14]. Research reports indicate that learning in groups creates an environment of active involvement and exploratory learning [15]; results in cognitive conflicts, exposes inadequate reasoning, creates disequilibrium and higher quality understanding will emerge [16]; increase the development of social learning, and the growth of inter-personal skills, including reasoning, problem solving, and leadership [17]; exposes students to diverse learning styles promoting a better appreciation of complex concepts and social dynamics [18]; results in higher cognitive achievement, more positive attitude, greater self-esteem, more engagement on tasks, increased motivation and enjoyment [19], positively related with student achievement [20, 21], and higher level of thinking [22]. An effective learning in science is interactive, involving the learner in constructing ideas as a result of experiences [23, 24]. In the discussion method students indulge in argumentation over a topic [25]; this encourages the participants to direct their thinking process towards the solution of a problem. However, in applying discussion teachers should check for the participation of each learner in the discussion as the whole essence of discussion is thinking together with shared meanings.

In his study of the impact of role change in teaching and learning physics on students, Getinet [26] has changed his teaching practice from traditional lecture format to a more student centered process that utilized group activities. He reports that group learning provides an opportunity for him to observe students working through problems, explaining their reasoning, discussing their ideas with their peers, and intervenes when students encounter difficulties. In his study using the standardized test scores of more than 6,000 students in the subject of mechanics, Hake [13] showed that the approach of interactive engagement is twice as effective as the traditional lecture approach. According to Thornton and Sokoloff [27], active learning strategies supported by the use of microcomputer-based tools significantly improved conceptual learning. Lawrenz *et al* [28] suggest that students exposed to the Active Physics curriculum scored higher on the achievement test than students who did little use of the Active Physics curriculum. Very recent researches in Ethiopian context show that student-centered instruction significantly contributes to students graphical interpretation skills, understandings of kinematics concepts and elimination of misconceptions than traditional instruction [29], and activity based group learning has positive effects on students' cognitive learning and their feelings of their learning [26]. Kalu and Ali [30] suggested that teachers affect student learning and attitudes through the curriculum and quality of instruction. These all suggest that teachers should provide an opportunity and an environment of active and involved learning by preparing tasks or activities particularly conceptual questions that require students discuss with their peers, develop higher level of thinking and problem solving skills.

Assessment tasks that instructors use in the course send messages to the students about what they should focus on, and provide feedback whether their efforts were successful or not. In the lecture method that prevails in Ethiopian context of physics instruction, student's grades are totally based on exams which focus on quantitative problems. This method of assessment leads students to focus on rote learning of formula and how to apply equations to problem solving. Moreover, student assessment in Ethiopian Higher Education is dominated by norm referencing, insufficiently robust to assure compatibility of grading standards between cohorts of students, and is not sufficiently transparent to ensure that students are graded fairly and consistently [31]. However, research findings indicate that assessment influence the effort students put into learning and the quality of their engagement with the learning tasks. For instance, classroom assessment with feedback is fundamental to learning and teaching activities [32]; empowers students as self-regulated learners [33]; can lead learners towards successful achievement in summative assessment contexts [34]. Assessment must be considered in examining the effects of problem-based learning [35].

The teachings of science lag far behind the development of the philosophy of science indicating a need of improving teaching of science [36]. Research findings indicate that students sense and interpret new information based on existing structures (like past experiences, stored knowledge and motivation). In mechanics; basic concepts are close to the students' daily life experiences of motion and forces, the alternative conceptions students held from their life experience interferes with the learning and understanding of physics concepts [37, 38]. Capon and Kuhn [39] reports that problem-based learning produces benefit if new information is integrated with existing knowledge structures activated by the problem-based experience. As antidote to problems like this, scholars place emphasis on conceptual learning science education [40]. However, in Ethiopia, the hydraulic model of learning and teaching which emphasizes transmission of knowledge, bunches of facts from teacher to "empty headed" students, like pouring water from a jug to empty glass, lead students to rote learning of formula compromising understanding of concepts. There are local researches that criticize the teaching of physics in Ethiopian schools and universities. For example, the use of lecture method to provide students bunches of facts, principles, laws, and derivation of mathematical expressions has little benefit to students' conceptual understanding [7]. Getinet [41] also reports that due to the constraints (such as teachers emphasize on the mathematics of the physics, lack of apparent relevance of the contents to students life experience, absence of practical classes, student's poor language proficiency to understand the plasma television instruction, teacher's low input to student learning, etc) at preparatory school level, majority of students in Ethiopia are not in a position to cope up with physics courses in Universities upon their admission to higher institutions and thus vulnerable to dismissal in their first Year University experience.

Students need to learn to formulate and solve complex problems, design investigations and work collaboratively. To carry out these activities students need to learn how to reflect on the reasoning process, ask questions, self-asses and communicate effectively. By changing assessment tasks we can shift the attention of our students to what we consider important. According to Black and William [42] the learning gains from systematic attention to formative assessment including feedback for the students is larger than gains found for most other educational interventions. Group discussion and journal writing (weekly reports) are techniques among others in which students can learn how to reflect on the reasoning process, ask questions, self-asses and communicate effectively. In their weekly report students can reflect their own learning by answering questions such as: What did I learn this week? How did I learn it? What questions remain unclear? This is important because it provides students an opportunity to reflect on their own learning including their difficulties. This in turn provides instructors an opportunity to learn about their students' conceptual difficulties, students' understanding of their own learning. This type of reflective learning and teaching can promote conceptual understanding. However, to the best of my knowledge no research was conducted in our universities context on the effect of group discussion and self reflection on student's understanding of the basic concepts of mechanics.

II. THE PROBLEM

One of the main aims of teaching physics is to facilitate students understanding of the basic concepts that would help to solve real life problems. The effectiveness of student's engagement in learning can be examined in terms students' conceptual understanding as judged by their result on conceptual tests. These days students placed to Physics Education Department, trainees for the profession teaching high school physics are those who failed by competition, because of their low result in university entrance examination, to join other departments; they have been placed without their interest and choice [43]. Getinet's study reveal that students placed to Physics Education Department have poor ability in school mathematics, poor background in physics, and unable to understand the concepts of physics, and their performance in exam was very poor, and hence subjected to delay and/or dismissal. Other recent studies also report similar results indicating the persistent and deep-rooted problems in the quality of students learning of physics at pre-university level. For example, the quality of science education in Ethiopia has been seriously compromised and there has been a decline of the competence of applicants in physics [44]; the rate of enrolment in physics is the lowest and students having the lowest mean score in Ethiopian National Higher Education Enterance Examination were assigned to the physics undergraduate programs [45]. It is feasible to raise questions like: How these students will be a high school physics teacher? What will be the fate of future students who will be trained physics with the would be uninterested academically weak (or less able) physics student teachers?

On the other hand, undergraduate physics instructors in physics education departments of in our university, which is also likely to all physics education departments in other universities of Ethiopia, including myself have been attaching student's failure to their poor background and placement of students to the department without their interest. Potgieter *et al* [46] suggest that lecturers of physics be well informed about the baseline knowledge and understanding of students upon entry to tertiary education to ensure a smooth transition between secondary and tertiary education. Notwithstanding this, in Ethiopian context no instructor considers whether the method he/she approached in teaching physics has an effect (positive or negative) in students learning of physics. No instructor is questioning whether his/her instructional practices appealing to the majority of students or not. The use of lecture method had little benefit to students' conceptual understanding; the gain in students' understanding of the basic concepts of Newtonian mechanics after instruction with lecture method was found to be 0.10 (Std.Dev.0.05). However, understanding the basic concepts of Mechanics is a basis for understanding the subsequent physics courses. Other researchers also claim that secondary and university physics students have difficulties in the understanding of mechanics and lack basic knowledge and this is influencing students understanding of other more complex topics at higher levels of physics [47, 48].

In Ethiopian context, significant difficulties of students in learning physics at preparatory schools were difficulty of the contents of physics, teachers emphasize on the mathematics of the physics, lack of apparent relevance of the contents to students life experience, absence of practical classes, perception of the difficulty of the subject, student's poor language proficiency to understand the plasma television instruction, teacher's low input to student learning, and lack of commitment both on the sides of teachers and students [41]. This has contributed to students' poor background in physics and greatly influenced their performance in their first year physics study. Getinet [43] reports a strong correlation between students' high school physics and their first year GPA. Hazari *et al* [49] also reports that high school physics and affective experiences of students, and mathematics preparation are factors that influence university physics performance. Sadler and Tai [50] suggest that high school physics course has a modestly positive relationship with the grade earned in introductory college physics. These authors emphasize that the variation observed in the performance of students is not simply innate ability but can be explained by the range ineffectiveness of their pre-college preparation.

However, Getinet [26] reports that "… if students get an environment in taking responsibility in their learning and if teachers intentionally include activities/ tasks that potentially encourage social interaction and negotiation, students' quality of learning (including their feeling, thinking and doing) can grow in many folds than when they are exposed to the banking model of teaching. Therefore, looking for instructional interventions that may help students learn and understand the basic concepts of mechanics should be of a primarily concern. The research questions that guided this study are: (1) do students learn the basic concepts of mechanics by question - answer approach with group discussion than lecture method? (2) Does self reflection contribute to students' conceptual understanding of the basic concepts of mechanics? (3) do the interventions used on test groups bring a performance difference on mechanics baseline test?

III. OBJECTIVES AND SIGNIFICANCE OF THE STUDY

The general objective of this study was to investigate the effectiveness of instructional interventions, namely, problem posing (question – answer), group discussion, and self reflection on students' conceptual understanding of mechanics in comparison to the lecture method. The specific objectives of this research were to see if (i) question - answer approach with group discussion helps students learn the basic concepts of mechanics; (ii) self reflection contributes to students' performance on MBT. This research is significant for both teachers and students. The approach may help teachers to diagnose students' difficulties in learning and give remedy on spot. The students can learn self reflection and sharing responsibility to their own learning.

IV. METHODOLOGY

A. Research Design

The Pretest- Posttest control group design was employed in this research. The control group was taught by teacher lecture and tutorial classes where the instructor solves quantitative problems and students copy the solutions. There were two test groups, Test group T_1 and Test group T_2. Students were randomly assigned to the two test groups. The two test groups were exposed to question - answer approach with group discussion and feedback in the form of interactive lecture. The Test group T_2 had additional treatment: self reflection where students reflected their learning every week by writing structured reflective journals.

B. Sample and sample size

This study was conducted on first year students registered for the course Mechanics. The number of students registered for this course was 96. However, only the results of 56 students who sat for both pre-test and post test were included in this research report. There were 18 students in the experimental group T_1, 16 students in the experimental group T_2 and 22 students in the control group. The participants in the test group are those students placed to Physics Education Department without their choice and who failed by competition, because of their low result in university entrance examination to join other departments.

C. Source of data

Student's pretest and posttest results were used as the source of data for this study. In this study, students' conceptual understanding was assessed by the Mechanics Baseline Test (MBT), a concept test designed to assess student understanding of the most basic concepts in Newtonian Mechanics.

D. Limitations and delimitation

This research was delimited to first year students who were registered for the course Mechanics. In this study, I, the researcher, instructed the test groups while the control group was instructed by different teacher, my collogue, who had more teaching experience than the experience I had in teaching. However, prior to the instructional interventions, we prepared the same content in the same sequence. We also used the same reference material. One of the limitations in this research is thus, teachers' competence, that may affect students learning, was not considered. In addition to this, this paper doesn't explore the relation between students' conceptual understanding, as judged by performance on MBT, and student's final grade on the course.

E. Research Procedure

The MBT was administered to both the experimental and the control groups as a pre-test prior to the instructional interventions. The test was distributed to all students that come to the class on the first day of the start of the class of the semester. Students were randomly assigned to the two test groups. Students in both the experimental and the control groups studied the same content in the same sequence. Students in the experimental (test) groups were exposed to question – answer approach with group discussion as a teaching intervention while students in the control group were instructed by teacher lecture through out the semester. In the question – answer approach with group discussion, students were provided conceptual questions on each lesson topic. Students in the test group were allowed to discuss on and prepare answers to the conceptual questions in groups. Then, I gave immediate feedback to student's response in the form of presentation by interactive lecture method. Furthermore, students in the test group T_2 were asked to reflect on their own learning by submitting a weekly report every weekend. In the last week of the semester the MBT was administered to both experimental and control groups at the same time in the same room without announcement. This test was called post-test in this paper. Only the results of those students who sat for both pre-test and post test were analysed and included in this research report. Those students' pre-test results who didn't take the post test and students' post-test results who didn't take the pre-test were annulled.

V. FINDINGS

In this research, the analysis of the class averages such as percentage averages scores of pretest with its standard deviation, percentage averages scores of posttest with its standard deviation, normalized gain <g> with its standard deviation on MBT were performed and presented in Table I. In addition Pearson's Correlation coefficient of individual student's normalized gain and pretest scores, pretest scores and posttests scores, pretest scores and student's absolute gain on MBT were analyzed and presented in Table II. Furthermore, the Cohen Effect size, d was analyzed and presented in Table III. In the calculations the following formula are used:

$$Average\ normalized\ gain, <g> = \frac{<\%posttest> - <\%pretest>}{100 - <\%pretest>}, \quad (1)$$

$$Effect\ size,\ d = \frac{\bar{x} - \bar{y}}{\sigma_{pooled}}, \quad (2)$$

where $\bar{x}$ and $\bar{y}$ are populations means expressed in the row (original measurement) unit, σ_{pooled}, is called, the pooled standard deviation commonly used by Rosnow and Rosenthal [51] and it is the root mean square of the two standard deviations for the x and y-group means [52]. It is the square root of the average of the squared standard deviations given by the equation

$$\sigma_{pooled} = \sqrt{\frac{\sigma_x^2 + \sigma_y^2}{2}}. \quad (3)$$

Here, the x and y are the row (original measurement) scores for the experimental and control groups.

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TABLE I. Pretest, posttest and normalized gain data on MBT.

		Average (standard deviation) %		
Group	N	Pretes (St.Dv.)	Posttest (St.Dv.)	Normalized gain, g (St.Dv.)
CG	22	19.93 (6.35)	28.32 (6.45)	0.10 (0.05)
T_1	18	21.43 (6.22)	30.77 (4.97)	0.12 (0.06)
T_2	16	19.93 (7.46)	31.47 (8.57)	0.14 (0.09)

The analysis of the results of students on Mechanics Baseline Test (MBT) presented in Table I showed that the average pretest scores on MBT were 19.93% (Std. Dev. 6.35%) for the control group, 21.43% (Std. Dev. 6.22%) for the test group T_1, and 19.93% (Std. Dev. 7.46%) for the test group T_2. The sample students average pretest results on MBT were low and there was no as such significant difference in the pretest results of the three groups indicating that the groups were almost uniform. The average scores on the posttest were 28.32% (Std. Dev. 6.45%) for the control group, 30.77% (Std. Dev. 4.97%) for the test group T_1, and 31.47% (Std. Dev. 8.57%) for the test group T_2. The posttest scores were very low indicating that students have deficiencies in the qualitative understanding of the basic concepts of mechanics even after instruction. We see from Table I that the spread of the students result from the mean score was very large for those students in the test group T_2. This indicates that the MBT result of students involved in reflecting their own learning where scattered in a sense that the weekly report might benefited some students than others in conceptual understanding of Newtonian Mechanics.

However, the posttest scores were too low when compared with the report that the threshold score of mechanics test for Newtonian understanding is 60%. Even the average score of those students in the treatment group with self-reflection is about half of the threshold score. These low results clearly show that the sample students have real deficiencies in understanding the basic concepts of the course qualitatively. Peer instruction resulted in a significant increase of students mean score on mechanics when compared with traditional instruction [53]. When compared to reports of score on MBT (*e.g.*, ibid), the result obtained in the current research, Table I, is really disappointing though the cause for this undesirable result needs careful investigation of student's entry behaviour to cope up with the course, student's real engagement in learning physics and the methodology of the course delivery. Any ways this big gap between the reported results and the current research result clearly shows how poor the quality of teaching and learning of the physics course was in Ethiopian universities context.

The average normalized gain of students on MBT were 0.10 (Std. Dev. 0.05) for the control group, 0.12 (Std. Dev. 0.06) for the test group T_1, and 0.14 (Std. Dev. 0.09) for the test group T_2. No report was found from literature on the normalized gain of MBT. However, the calculated average normalized gain of students on MBT were 10%, 12%, and 14% of the maximum possible gain, for the control group, for the test group T_1, and for the test group T_2, respectively. These indicate that students understanding of the basic concepts of Newtonian mechanics even after instruction were poor. However, the results of the treatment group with weekly report was relatively better indicating that if feedback were given to students the weekly report seems promising in enhancing conceptual understanding of students in the course.

TABLE II. Correlation coefficients results.

Group	N	Correlation coefficient between: Pre & post test	Pretest & absolute gain	Pretest & normalized gain
CG	22	0.78	-0.25	-0.12
T_1	18	0.59	-0.33	-0.15
T_2	16	0.64	-0.62	-0.53

The correlation coefficients between the pre test and post test for the control group 0.78 showed that shows a relatively strong degree of relationship between the two results which indicates that their poor academic background might attribute to the low performance even after instruction with lecture. On the other hand, it also shows that teacher lecture method used had little effect in helping students understand the basic concepts of mechanics. There is a relatively large negative correlation between the absolute gain (post-test score - pre-test score) and the pre-test score ($r = -0.62$) for the test group T_2. This negative correlation indicates that test group T_2 has started the classes with relatively smaller pre-test scores tend to have larger absolute gains than the other groups. We also see that there is a negative correlation between the normalized gain and the pre-test score ($r = -0.51$) for the test group T_2. It means that relative to other groups, this test group has larger gain in their learning that might be due to their reflection on their own learning.

TABLE III. Effect size data on MBT.

Between the groups	Effect size, d
T_1 & CG	0.27
T_2 & CG	0.65
T_1 & T_2	0.23

Table III shows the Cohen Effect size, d between the groups on MBT. The Cohen effect size were 0.65 between the control group and the test group T_2, 0.27 between the control group and the test group T_1, and 0.23 between the test groups T_1 and T_2. Cohen [52] defined effect sizes as "small, $d = 0.2$," "medium, $d = 0.5$," and "large, $d = 0.8$". According to this definition, the effect size between the control group and the test group T_2 lies in the medium range; the effect sizes of 0.27 between the test group T_1 and the control group, 0.23 between the test group T_1 and test group T_2 both lie in the small range. The effect size 0.27 between the test group T_1 and the control group CG indicates that the question – answer approach with group discussion as a teaching intervention has contributed positively to students understanding of the basic concepts of mechanics better than teacher lecture. It means that the test group T_1 had a relatively better understanding on the basic concepts of mechanics.

The Cohen effect size of 0.65 between the control group and the test group T_2 indicates that the combined effect of the question – answer approach with group discussion and self reflection have greatly helped students in the test group T_2 to understand the basic concepts of Mechanics. The effect size of 0.23 between the test group T_1 and test group T_2 shows that students involved in reflecting their own learning, students in the test group $T_{2,}$ had better understanding of the basic concepts of Newton's laws of motion and achieved relatively better result on MBT than students in the test group T_1. This indicates that if students are allowed to reflect on their own learning and knowledge by organizing their ideas, they may understand and internalize the basic concepts of mechanics. In general, I may infer from this result that had continuous feedback on self-reflection were given to students, they might have understood more and retained the basic concepts of mechanics, and performed better on MBT.

The result of the current study indicates the positive effect of engaging students in their learning and thus agrees well with local and global research reports reviewed and discussed in the introduction. Research in physics education and other discipline supports the positive effect involving students in their own learning. For example, small-group learning are effective in promoting greater academic achievement, more favorable attitudes toward learning, and increased persistence through courses and programs [54]; active learning courses resulted a gain which is more than two standard deviations above the lecture courses [55]; structured active learning experiences lead to substantial differences in the students' reasoning and self expression skills compared to lecture method [56]; students exposed to peer-led guided inquiry method of instruction consistently outperformed those students exposed to lecture on the course exams and on the final exam [57]; students in challenge-based instruction classes performed significantly better than students in traditional lecture-based instruction classes on the more difficult questions [58]. Hoellwarth *et al*. [59] studied student performance on conceptual understanding and on quantitative problem-solving ability in introductory mechanics in both studio and traditional classroom modes, and found that significantly larger normalized learning gain in conceptual understanding for students in the studio sections than the traditional. Beichner *et al*. [60] report that students centered activities resulted in significantly increased conceptual understanding, improved attitudes, successful problem solving, and higher success rates in calculus-based introductory physics particularly for females and minorities in comparisons to traditional instruction.

VI. CONCLUSION

The result of this research indicated that the instructional interventions used in teaching and learning of the course mechanics had an effect on students learning gains as judged by their performance on MBT. Students exposed to the question – answer approach with group discussion as a teaching intervention performed on MBT than students taught by teacher lecture. The results of this research show clear difference between the test group and control groups in understanding the basic concepts of mechanics. Furthermore, students involved in reflecting their own learning understood the basic concepts of mechanics and relatively scored better results on MBT after instruction than students in the test group T_1 and in the control group. This might indicate us that while reflecting on their own learning, students were able to summarize their knowledge by organizing their ideas and internalize the basic concepts. Had timely feedback given to students' reflection on their own learning as intended initially, a better result might have been obtained. Even though, students with better entry background can easily learn and understand new materials, the results of this research suggest that students with poor background in physics can improve their learning if classroom environment involves them in their own learning. It means that instead of attaching student's failure to their poor entry background and placement of students to physics education department without their interest, we as teachers have to look an opportunity to expose our less able students to a variety of learning experiences and make them share responsibility in their own learning in effect help them learn and understand the basic concepts of mechanics. A classroom environment which encourage active learning of students like group discussion and self reflection as used in the current study potentially enable teachers in monitoring students' understanding, provide an opportunity for students to engage in active learning and boots student' concentration levels.

I sum up my conclusion mentioning what Getinet [26] concludes: "…teaching is a moral enterprise; the best curricula and most perfect syllabus may remain dead. But it can be awaken and put to life by method of instruction which provide basis for students' active involvement in their learning. To this end, we teachers need to include ample instructional opportunities that can broaden the range of student's intellectual experiences, inculcate the habit of analyzing, asking"why?" than simply reiterating textbook materials through transmission mode of instruction which guarantees only content coverage. At the heart of this, there is active learning approach."

REFERENCES

[1] McDermott, C. L., *Oersted medal lecture 2001: Physics education research—the key to students learning*, Am. J. Phys. **69**, 1127–37 (2001).

[2] Mazur, E., *Peer Instruction*, (Prentice Hall, Upper Saddle River, NJ, 1997).

[3] Hestenes, D., *Who needs Physics Education Research?*, Am. J. Phys. **66**, 465-467 (1998).

[4] Cahyadi, V., *Improving Teaching and Learning in Introductory Physics*, (PhD Dissertation, University of Canterbury, New Zealand, 2007).
[5] Schwartz, M. S., Sadler, P. M., Sonnert, G. & Tai, R. H., *Depth Versus Breadth: How Content Coverage in High School Science Courses Relates to Later Success in College Science Coursework*, Science Education **93**, 798-826 (2008).
[6] Esayas, B., *A look at problems of science Education in secondary schools*, (proceedings of the National Work shop on strengthening Educational Research, Addis Ababa University printing Press, AA, 1995).
[7] Getinet, T., *Students understanding of the basic concepts of Newtonian mechanics vis-a-vis lecture method*, The Ethiopian Journal of Higher Education **4**, 23-35 (2007).
[8] Arons, A. B., *Teaching introductory physics*, (John Wiley & Sons, New York, 1997).
[9] Hestenes, D., *Toward a Modeling Theory of Physics Instruction*, Am. J. Phys. **55**, 440-454 (1987).
[10] Kim, E. & Pak, S. J., *Students do not overcome conceptual difficulties after solving 1000 traditional problems*, Am. J. Phys. **70**, 759-765 (2000).
[11a] Halloun, I. & Hestenes, D., *The initial knowledge state of college physics students*, Am. J. Phys. **53**, 1043-1055 (1985).
[11b] Halloun, I. & Hestenes, D., *Common sense concepts about motion*, Am. J. Phys. **53**, 1056-1065 (1985).
[12] McDermott, L. C., *Millikan Lecture 1990: What we teach and what is learned: Closing the gap*, Am. J. Phys. **59**, 301–315 (1991).
[13] Hake, R. R., *Interactive-engagement vs. traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses*, Am. J. Phys. **66**(1), 64-74 (1998).
[14] Van, A. H., *Overview, Case Study Physics*, Am. J. Phys. **59**, 898-907(1991).
[15] Slavin, R. E., *Cooperative Learning - Theory, Research and Practice*, (Prentice Hall, Englewood Cliffs, NJ, 1990).
[16] Slavin, R. E., When and why does cooperative learning increase achievement? Theoretical and empirical perspectives. In Hertz-Lazarowitz, R. & Miller, N. (Eds.), *Interaction in cooperative groups: The theoretical anatomy of group learning* (Cambridge University Press, New York, 1992), pp. 145-173.
[17] Newble, D. and Cannon, R., *A handbook for teachers in universities and colleges: a guide to improving teaching methods*, (Kogan Page, London, 1991).
[18] McLean, M., Van, W. J. M., Peters-Futre, E. M. & Higgins-Opitz, S. B., *The Small group in problem-based learning: More than a cognitive 'learning' experience for first-year medical students in a diverse population*, Medical Teacher **28**, 94–103 (2006).
[19] Fraser, B. J., *Science learning environments: Assessments, effects and determinants*, In Fraser, B. and Tobin, K. (Eds.), *International handbook of science education, Part 1* (Kluwer, Dordrecht, the Netherlands, 1998), pp. 527-564.
[20] Hanze, M. & Berger, R., *Cooperative learning, motivational effects, and student characteristics: An experimental study comparing cooperative learning and direct instruction in 12th grade physics clases*, Learning and Instruction **17**, 29–41 (2007).
[21] Stamovlasis, D., Dimos, A. & Tsaparlis, G., *A study of group interaction processes in learning lower secondary physics*, Journal of Research in Science Teaching **43**, 556–576 (2006).
[22] Harskamp, E., Ding, N. & Suhre, C., *Group composition and its effects on female and male problem-solving in science education*, Educational Research **50**, 307-318 (2008).
[23] Driver, R., *The Pupil as a Scientist*, (Open University Press, Buckingham, 1983).
[24] Von, E. G., *Radical Constructivism: A Way of Knowing and Learning*, (Falmer, London, 1995).
[25] Reddy, K., *Methods of teaching*, (APH publishing Corporation, New Delhi, 2004).
[26] Getinet, T., *Impact of Role Change in Teaching and Learning Physics on Students*, Staff and Educational Development International **15**, 53-62 (2011).
[27] Thornton, R. K. & Sokoloff, D. R., *Assessing student learning of Newton's laws: The Force and Motion Conceptual Evaluation and the Evaluation of Active Learning Laboratory and Lecture Curricula*, Am. J. Phys. **66**, 338–352 (1998).
[28] Lawrenz, F., Wood, N. B., Kirchhoff, A., Kim, N. K. & Eisenkraft, A., *Variables Affecting Physics Achievement*, Journal of Research in Science Teaching **46**, 961–976 (2009).
[29] Tebabal, A. & Kahssay, G., *The Effects of Student-Centered Approach in Improving Students' Graphical Interpretation Skills and Conceptual Understanding of Kinematical Motion*, Lat. American Journal of Physics Education **5**, 373-381 (2011).
[30] Kalu, I. & Ali, A. N., *Classroom interaction patterns, teacher and student characterisitcs and students' learning outcomes in physics*, Journal of Classroom Interaction **39**, 24 (2004).
[31] Teshome, T. & Kebede, K., *Quality assurance for enhancement of higher education in Ethiopia: Challenges faced and lessons learned*, an edited version of a paper read at the 10th biennial INQAAHE Conference, 30 March to 2 April (2009) in Abu Dhabi, United Arab Emirates, 193-204 (2010).
[32] Nicol, D. J. and Macfarlane-Dick, D., *Formative assessment and self-regulated learning: A model and seven principles of good feedback practice*, Studies in Higher Education **31**, 199–218 (2006).
[33] Gibbs, G. & Simpson, C., *Conditions under which assessment supports students' learning?* Learning and Teaching in Higher Education **1**, 3–31 (2004).
[34] Race, P., *Making Learning Happen: A guide for post-compulsory education*, (Routledge Falmer, London, 2005).
[35] Gijbels, D., Dochy, F., Van den Bossche, P. & Segers, M., *Effects of Problem-Based Learning: A Meta-Analysis*

from the Angle of Assessment, Review of Educational Research **75**, 27–61 (2005).

[36] Tsai, ch-ch, *Science Learning and Constructivism*, Curriculum and Teaching **13**(1), 31-51 (1998).

[37] Planinic, M., Boone, W. J., Krsnik, R. & Beilfuss, M. L., *Exploring alternative conceptions from Newtonian dynamics and simple DC circuits: Links between item difficulty and item confidence*, Journal of Research in Science Teaching **40**, 150–171 (2006).

[38] Ramaila, S. M., *The kinematic equations: An analysis of students' problem-solving skills*, Master of Science Degree dissertation, School of Science Education, University of Witwatersrand, South Africa (2000).

[39] Capon, N. and Kuhn, D., *What's So Good About Problem-Based Learning?*, Cognition and Instruction **22**, 61–79 (2004).

[40] Joung, Y. J. & Gunstone, R., *Children's Typically-Perceived-Situations of Force and No Force in the Context of Australia and Korea*, International Journal of Science Education **32**, 1595-1615 (2010), First published on: 04 September 2009 (iFirst).

[41] Getinet, T., *Practices and Problems in Teaching and Learning Physics at Preparatory Schools in SNNPR*, (Southern Nations and Nationalities People Region) of Ethiopia, Staff and Educational Development International **15**, 155-174 (2011).

[42] Black, P. & Wiliam, D., *Assessment and classroom learning*, Assessment in Education **5**, 7-74 (1998).

[43] Getinet, T., *Causes of High Attrition Among Physics PPC Students of Dilla College*, The Ethiopian Journal of Education **26**, 53-66 (2006).

[44] Shibeshi, A., Mekonnen, D., Semela, T. & Endawoke, Y., *Assessment of science education quality indicators in Addis Ababa, Bahir Dar, and Hawassa Universities, In Quality of Higher Education in Ethiopian Public Higher Education Institutions*, (Forum for Social Studies, Addis Ababa, 2009), pp. 161-263.

[45] Semela, T., *Who is joining physics and why? Factors influencing the choice of physics among Ethiopian university students*, International Journal of Environmental & Science Education **5**, 319-340 (2010).

[46] Potgieter, M., Malatje, E., Gaigher, E. & Venter, E., *Confidence versus Performance as an Indicator of the Presence of Alternative Conceptions and Inadequate Problem-Solving Skills in Mechanics*, International Journal of Science Education **32**, 1407-1429 (2010).

[47] Jimoyiannis, A. & Komis, V., *Computer simulation in physics teaching and learning: A case study on students' understanding of trajectory motion*, Computers & Education **36**, 183–204, 2001.

[48] Knight, R. D., *Physics: A contemporary perspective*, (Addison-Wesley, New York, 1997).

[49] Hazari, Z., Tai, H. R. & Sadler, P. M., *Gender differences in introductory physics perfor-mance: The influence of high school preparation and affective factors*, Science Education **91**, 847-876 (2007).

[50] Sadler, P. M. & Tai, R. H., *Success in introductory physics: The role of high school preparation*, Science Education **85**, 111-136 (2001).

[51] Rosnow, R. L. & Rosenthal, R., *Computing contrasts, effect sizes, and counternulls on other people's published data: General procedures for research consumers*, Pyschological Methods **1**, 331-340 (1996).

[52] Cohen, J., *Statistical Power Analysis for the Behavioral Sciences*, (Lawrence Erlbaum Associates, Hillsdale, NJ, 1988), p. 25, 44.

[53] Catherine, H. C. & Mazur, E., *Peer Instruction: Ten years of experience and results*, Am. J. Phys. **69**, 970 (2001).

[54] Springer, L., Stanne, M. E. & Donovan, S. S., *Effects of small-group learning on undergraduates in science, mathematics, engineering, and technology: A meta-analysis*, Review of Educational Research **69**, 21–51 (1999).

[55] Buck, J. R. and Wage, K. E., *Active and Cooperative Learning in Signal Processing Courses*, IEEE Signal Processing Magazine **22**, 76–81 (2005).

[56] Wright, J. C., Millar, S. B., Kosciuk, S. A., Penberthy, D. L., Williams, P. H. & Wampold, B. E., *A Novel Strategy for Assessing the Effects of Curriculum Reform on Student Competence*, Journal of Chemical Education **85**, 986–992 (1998).

[57] Lewis, S. E. and Lewis, J. E., *Departing from Lectures: An Evaluation of a Peer-Led Guided Inquiry Alternative*, Journal of Chemical Education **82**, 135–139 (2005).

[58] Roselli, R. J. & Brophy, S. P., *Effectiveness of Challenge-Based Instruction in Biomechanics*, Journal of Engineering Education **95**, 311–324 (2006).

[59] Hoellwarth, C., Moelter, M. J. & Knight, R. D., *A direct comparison of conceptual learning and problem solving ability in traditional and studio style classrooms*, Am. J. Phys. **73**, 459–462 (2005).

[60] Beichner, R. J., Saul, J. M., Abbott, D. S., Morse, J. J., Deardorff, D. L., Allain, R. J., Bonham, J. W., Dancy, M. H. & Risley, J. S., *The Student-Centered Activities for Large Enrollment Undergraduate Programs (SCALE-UP) Project* (2007), avalaible in <http://www.compadre.org/Repository/document/ServeFile.cfm?ID=4517&DocID=183>.