Context-Based Instructional Approaches and Preparatory School Students' Learning of Rotational Motion

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A Thesis Submitted to
The Department of Science and Mathematics Education, College of Education and Behavioral Studies

Presented in Fulfillment of the Requirements for the Degree of Doctor of Philosophy
(Physics Education)

Addis Ababa University
Addis Ababa, Ethiopia
2019

ADDIS ABABA UNIVERSITY
College of Education and Behavioural Studies
Department of Science and Mathematics Education

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Declaration

I declare that this dissertation is my original work and it has not been previously presented in Addis Ababa University or in any other Universities. To the best of my knowledge and belief, the dissertation contains no material previously published or written by another person except where due reference is made.

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November, 2019

Abstract

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This study aims to explore the effectiveness of context-based instructional approaches as compared to the traditional instruction on eleventh grade students' conceptual understanding, problem-solving skill and their affections toward rotational motion. The study was conducted using an embedded mixed-method research design. For the quantitative part, a multiple group quasi-experimental pre-test post-test control group research design was applied. Students written answers to the tests were also analyzed. Data was also collected from learners and teachers regarding their views on the instructional methods. A total of 166 eleventh grade students of three preparatory schools participated in the study. REACT strategy of context-based instruction and traditional instruction integrated with context-based instruction were used to teach the two treatment groups while traditional method was used in the comparison group. The treatment lasted for seven weeks, and the data were collected through conceptual understanding test, problem-solving skill test and affective characteristics questionnaire. Furthermore, classroom observation and interviews were also used to collect data. The study result revealed that context-based approaches produced a significantly better acquisition of rotational motion concepts than the traditional instruction. The approaches can also be used in the classroom instruction to develop better affections towards physics. Hence, teachers' should consider adopting school physics to context-based approaches for raising literate students. With regard to students' problem-solving skills, the result shows the existence of mean differences between the groups in favor of treatment groups although this difference was not statistically significant. When solving problems, students give much emphasis on mathematical equations and less emphasis to the concepts. In future studies, both recent problem-solving strategy trainings and active learning methodologies should be used simultaneously for enhancing students' problem-solving skills better. Physics text book writers and curriculum developers should have to also rethink of introducing latest problem-solving strategies in students' text books. On the other hand, in all the assessed variables, the combined method was slightly better than the REACT strategy as it can be used with optimum time efficiency (i.e., without being too slow or too fast). Hence, others are recommended to try combining traditional instruction with active learning strategies. Furthermore, the approaches are gender friendly.

Acknowledgement

Sincerest thanks to my supervisor Dr. Shimelis Assefa for the continuous advice, support, encouragement and patience throughout the duration of this research, without which this thesis most certainly would not have been completed. I would also like to thank the other members of the Science and Mathematics education department for their assistance and advice over the years. In particular, Dr. Mekbib Alemu, Dr. Kassa Mikael, and Dr. Mulugeta Atnafu had contributed a lot through sharing their ideas and giving comments on my dissertation work. They deserve my gratitude and gratefulness for their unreserved support. I wish to express my indebtedness to Addis Ababa University and Jigjiga University for the financial support they provided me in this research work.

My sincere thanks goes to all of the students who took part in this study, without their kind and voluntary participation, this research would not have been possible. The three school teachers (Ato Habtamu, Ato Alemayehu and Ato Fikadu) who granted me access to their classes through implementing the designed interventions and collecting the data deserve my heartfelt thanks and appreciations. My thanks also go to the education bureau heads and school principals who allowed me access to the schools who took part in the study.

It is difficult to name all my friends, colleagues and families that helped me throughout the times of my study. However, I wish to express my gratitude to my dear friends (especially Gosaye Gizaw, Messele Hunde, Kassahun Worku, Fantahun Tsegaye) and my colleagues (Wolde Belachew, Habtamu Wodaj, Eyasu Gemechu, Yenealem Ayalew and Awoke Kassa) for their enduring friendship and continued support. I also wish to express my gratitude to my wife, Selamawit Tsegaye, and my children, Naol and Yanet, for their endless support, love and encouragement during my study stay. I am also thankful to my brothers (Girma, Shimellis, Solomon and Aschalew) and the remaining members of my families. Their help and encouragement had contributed to the successful completion of my study. Furthermore, I would also like to express my feeling to all those who supported me with their opinions and encouraged me to succeed in the development and completion of this PhD dissertation.

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List of Acronyms

ACQ	Affective Characteristics Questionnaire
CBI	Context-Based Instruction
CBIAs	Context-Based Instructional Approaches
CORD	Center for Occupational Research and Development
CU	Conceptual Understanding
EGSECE	Ethiopian General Secondary Education Certificate Examination
PER	Physics Education Research
PSS	Problem-Solving Skills
QUAN	Quantitative
Qual	Qualitative
REACT	Relate, Experience, Apply, Cooperate and Transfer
RRMCS	Rotational and Rolling Motion Conceptual Survey
RQ	Research Question
STEM	Science, Technology, Engineering and Mathematics
STSE	Science, Technology, Society and the Environment
TI	Traditional Instruction

CHAPTER ONE: INTRODUCTION

This study was conducted with an intention to investigate the effect of context-based instructional approaches (CBIAs) on students' learning of rotational motion concepts. The rationale for this research and an overview of the thesis are given in this introductory chapter. The chapter starts through offering background issues leading to the statement of the problem. This is accompanied via the statement of the problem, objectives of the study and research questions. It then goes on to explaining the significance, delimitations and limitations of the study. In addition to these, definitions of terms that are ordinarily utilized in the thesis are given. Finally, an overview of the way in which the study was carried out is provided.

1.1 Background of the Study

Building a scientifically literate society is a widely agreed goal of science education. Scientific literacy is defined in many different ways. However, most of the definitions involve the ability of solving problems, making decisions based on evidences and evaluation of information in a reasonable manner (Glaze, 2018). It, thus, involves a deeper grasp of how scientific knowhow is developed, the strategies that takes place and the cultural as well as the social perspective of scientific discovery and investigation besides the capacity to remember and apply science concepts. These makes students to leave their science classes with the essential competencies wanted for making verdicts founded on reason and to understand the processes that trigger the science they encounter in their day to day life. This shows the crucial role played by science education in developing human resources that are essential for science and technological advancements.

Knowing this fact, in Africa, countries have been recommended to invest in science and technology so as to get rid of poverty and ensure sustainable development (Daboué, 2008). As a result, according to Association for the Development of Education in Africa [ADEA] (2012), several countries have tried to strengthen science education with an intention for developing human resources which will add to industrial development via scientific as well as technological advancement. In Ethiopia, in 2008, the Ministry of Education [MoE] came up with a strategy where 70% of overall university students' enrolment is in science and technology fields with the rest 30% in the social science fields. This enrolment professional mix conversion plan has emerged based on the country's aim for securing sustainable development through producing more graduates in Science, Technology, Engineering and Mathematics [STEM] fields. This has created a unique and defying scenario where science and mathematics education is positioned to the frontline (Eshetu, Dilamo, Tesfaye, & Zinabu, 2009).

However, as a consequence of well-known weaknesses of the traditional methods of teaching science and bad perceptions on science subjects, the students are observed while struggling to reach the high level of literacy mentioned earlier (Glaze, 2018). As a result, some students go into and away from schools with insufficient understanding of science as a way of knowing how it is carried out, the philosophical and historical frameworks of our contemporary sympathetic and science as a self-correcting set of process skill. Rather than providing the individual student with a knowhow, skill and attitude that allow the society to live a momentous and contented life and contribute positively towards the development of the society where he can derive utmost social, economic as well as cultural advantages (National Educational Research and Development Centre [NERDC], 2004), physics education , just like the other science education subjects, also faced some serious problems like content material overload, lack of transfer, incapacity to link concepts to everyday life scenarios, lack of ability to recognize the value of the content material to be learnt and insufficient science literacy (Bennet, Lubben, & Hogarth, 2006; Whitelegg & Parry, 1999). More often, students additionally believe physics as a troublesome subject (Saleh, 2012; Whitelegg & Parry, 1999), tedious and not relevant to their everyday lives (Efthimiou, Llewellyn, Maronde, & Winningham, 2006; Lye, Fry, & Hart, 2002).

The situations here in Ethiopia are not different from what has been seen elsewhere. The Ethiopian national learning assessment carried out every four years, at different levels, in five basic subjects (mathematics, English, physics, chemistry and biology) showed that the performance students' in physics is the smallest when compared with other subjects (National Agency for Examinations [NAE], 2010). In the assessment carried out in 2014, the percentage of students that accomplished a mean score of 50% throughout these 5 subjects stood at 23% in Grade 10 with only 3% of them accomplishing 75% or above in their mean score. Among the subjects, the students' performance in biology was fantastically big as 40% of students' attained a score of 50% or above while 11% of them achieved a score of 75% and above. This contrast with the students' performance in physics where 14% and 2% of students scored 50% and 75% or above, respectively. At Grade 12, performance is somewhat better, as 34% of students had achieved an average score of 50% on the five basic subjects and 4% of students had achieve an average score of 75%. With respect to the identical assessment performed in 2010, these rates divulge a minor decline on students' average performance, which shows an inference about the higher education institution entrants' quality (MoE, 2015). In line with this, the statistical data obtained from Bale zone education Bureau indicated that the physics scores of students in grade 10 Ethiopian General Secondary Education Certificate Examination (EGSECE) were not that much satisfactory. For instance, out of 8559 students who sat in the 2016 exam, the number of students who scored 'A' was 143 while those who scored 'F' was 405. In contrast, the number of students who scored 'B' and 'D' are comparable. During the following year, slightly better performance was observed as the number of students that scored 'A' is 722 while those who scored 'F' are 392 out of 8331 students that took the exam in the zone. This signifies that the quality of physics education in schools found throughout the zone to be in crisis just like the rest parts of the country.

In addition to these, in a survey conducted by Oli (2014) on 801 students and 118 science teachers with an aim to assess preparatory school students' educational accomplishment challenges in science education, the schools in Ethiopia have been found to be ineffective in their efforts to enhance the physics teaching and learning process. Learners' attitude toward science, the strategies of learning and unsuccessful methods of teaching are amongst the foremost factors that had been supposed to make the students physics academic achievement lower. Birhanu, Olayemi, Solomon, and Getnet (2008) also identified four major issues (i.e., lack of interest, poor skills of solving problems, poor understanding of physics concepts and lack of ability in practical work) that were faced by physics students which in turn have an impact on their academic performance. In addition to these, factors like self-concept, motivation, interest and trouble (anxiety) to the subject have an influence on the achievements of students (Endris, 2016). Similar results were also reported on a survey study carried out to assess the problems challenging the physics teaching and learning processes in the secondary and preparatory schools found in Wolaita and Dawuro zones (Solomon & Kedir, 2015). As a result, most of the learners in the secondary schools had low interest to learn physics when compared with other science subjects, and this resulted in low success in national examinations. Furthermore, among the science disciplines, the biggest gender related difference in student performance has been observed particularly in physics subject (Taasoobshirazi & Carr, 2008). Hence, this needs immediate improvements as the students' poor performance in physics should have to be a source of concern to the nation which desires to accumulate competent human power in science and technology.

Teaching method used in classroom is one of the problems that affect the physics teaching and learning. Among the local researchers that criticized the physics teaching methods practiced in Ethiopian schools and universities, Getnet (2007; 2012) and Fikadu and Mekbib (2018) showed the ineffectiveness of traditional method in assisting students to develop a true understanding of physics concepts. Getinet (2011) also reported that due to the problems (like teachers accentuate on calculations, lack of noticeable importance of the contents to learners life experience, nonexistence of experimental classes, learners' poor ability of language to apprehend plasma television instructions, teacher's little effort to enhance student learning, etc.) at preparatory schools, most of the learners don't seem to be in a position to cope up with university level physics courses and therefore become at risk of dismissal in their initial year university stay. This clearly shows the existence of a problem with the teaching methods used in Ethiopian physics classrooms as the practice is in contradiction with the policy intensions.

Being aware of this situation, the Ethiopian Education and Training Policy of 1994 laid emphasis on the importance of learner-centered pedagogies. Although the emphasis given to student-centered approaches on the policy is a step in the right track, in practice, it is a poorly understood concept (Derebssa, 2006). Hence, so as to provide ways forward to the above-mentioned problems in the learning and teaching of physics subject, research is needed to test various productive and teacher friendly teaching methods in Ethiopian contexts. This is because, according to Derebssa (2006), little strive was made by the policy as well as other education strategy documents to supply elaborations and to point out how it can be translated into the classroom level teaching and learning process. It is, therefore, a shared duty of educators and practitioners to make certain that that science literacy is precedence and that the methods of teaching across levels needs to struggle to meet that goal.

Thus, considering the apparent significance of physics in the scientific and technological development of a country and its helpfulness in the majority fields of human endeavor, it is imperative to look for better teaching methods in the teaching of this subject in our schools. This is because many learners in schools are not capable of making associations among what they are learning and the way that information was used, and hence the manner by which the information is processed and their motivation for learning don't seem to be touched by the traditional methods of classroom instruction (Handoyo, 2007). Handoyo argued that students have a tough time in appreciating the academic concepts since they are usually taught using a lecture method; however they badly want to apprehend the concepts through relating it to the workplace and to the bigger society wherein they live and work. Hence, if one needs to create environments which bolster conceptual change in learners, context should be well thought-out as part and parcel of student learning (Finkelstein, 2005). This indicates that science concepts have been realized most strongly when students can use the concepts in actual -life or real- world scenario (Enger & Yager, 2001; Kurnaz & Çepni, 2012). But, globally, a review of literature shows that science teaching lacks explicit linkage of the content of science with students' everyday experiences (Kyle, 2006) which could give an explanation for the perception of science education by lots of students as irrelevant, difficult and uninteresting. Moreover, the stress on theory and therefore the absence of context, i.e., weakness to link physics with standard of living and society makes teaching physics disliked and hard to understand (Tsaparlis, Hartzavalos, & Nakiboğlu, 2013). The weakness found in displaying the relevance of physics to the society is one of the reasons for learners' terrible performance in physics (Belay & Kumneger, 2016).

Recognizing that the traditional, lecture-based instructional methods were not effective, educational researchers have presented arguments that science education should implicate more hands on, context-based learning (Panek, 2012). The context based approach to physics came out in response to learners' perception that physics is impersonal, objective and inappropriate to day to day lifestyles (Lye, Fry, & Hart, 2001). Daboué (2008) additionally advocated that science education in Africa need to be based on the realities and contexts of African countries. Context-based instructional approaches (CBIAs) are, thus, the innovative approaches to science education preferred in several countries to boost learners interest in science and to conjointly augment the coherence of the ideas studied in nationwide curricula (Bennett & Lubben, 2006; Gilbert, 2006; Pilot & Bulte, 2006).

1.2 Statement of the Problem

According to Mestre, Dufresne, Gerace, Hardiman, and Touger (1993) and Peşman (2012), the most important dreams of teaching physics are to enable students to have a deep conceptual understanding (CU) of the subject and to assist them develop powerful problem-solving skills (PSS) thereby enhancing their motivation in physics. These goals are in line with the major goal of science education discussed in the previous section. However, according to Taasoobshirazi and Carr (2008), traditional classroom instruction succeeds these goals partly; making most of the students to be confused with the basic concepts of physics. This makes the students to have poor skills of solving problems and poor motivation. Contrary to this idea, students mostly solve physics problems mechanically without giving due attention to the concepts they learn (Bolton, 1997; Styer, 1998). In such cases, the focus of the students is to obtain the final answer expressed in numbers. This plays a crucial role in making the students not to develop an understanding of physics concepts. This is because, although it is an issue of debate, students fail to develop the conceptual understanding of the contents taught through only solving such quantitative problems (Kim & Pak, 2002). In other words, students cannot develop their PSS without first acquiring the necessary understanding of concepts as it was evidenced by Hake (1998) and Knight (2002). This is because learners' frequently not succeed to solve problems without having the necessary concepts. Poor understanding of physics concepts in turn makes students` to perform lower in class as well as national level physics exams. These problems were also noticed in the teaching and learning of physics in the secondary schools found throughout Ethiopia, despite the fact that redoubled significance has been placed on the science teaching (MoE, 2008). Thus, this study is inspired by issues that are posing grave challenges to the future of science education on the whole and physics education specifically.

In Ethiopia, the contemporary curriculum calls for emphasis on an active learning and teaching approach and therefore needs teachers to make use of these teaching learning methods (Derebssa, 2006). Despite the government encouragement for the use of student centered teaching and learning strategies, teachers are observed ignoring the implementation of these active learning methodologies (Adula & Kasahun, 2010; Sintayehu, 2014). Consequently, traditional lecture methods, wherein teachers speak and learners listen, govern most classrooms which end up in students' poor understanding of ideas (Derebssa, 2006; Fikadu & Mekbib, 2018). This suggests that teaching method is one of the factors that affect the physics teaching and learning process in the schools found in Ethiopia. This was also the view that was supported by Solomon and Kedir (2015).

Improving students' learning outcomes will require efforts on several fronts. One part of giving an answer for such a problem entails helping learners to better control their learning via the exploitation of better methods of teaching. Hence, it is a must to look for effective pedagogy to be applied in our physics classes as one's teaching efficiency significantly increase depending on one's ability to make a choice of suitable teaching method (Garcia, 1989). Luckily, cognitive and educational researchers have developed and evaluated simple learning strategies that may assist learners in realizing their learning goals (Dunlosky, Rawson, Marsh, Nathan, & Willingham, 2013).

One of the student centered teaching methods that got much weight on literatures is the CBIAs. Context-based teaching and learning method is an approach employed in science/physics teaching through the utilization of contexts and application of science for enhancing scientific concepts, ideas as well as principles on learners (Bennett, 2003). Thus, it refers to an approach to a classroom instruction that uses everyday contexts and circumstances that learners encounter in their real life as a starting point for an instruction. Context-based teaching approach therefore entails the affiliation of the teaching of a concept within its context as a science-based discipline or concept and its linkage to learners' lives within the universe. It conjointly offers a lot of attention to technology, natural occurrence, socio-scientific problems, the character of science and therefore the interrelation s among science, technology and society in curriculums of science (Mai, 2015). This contradicts with the more traditional methods of teaching that first present the ideas, concepts as well as principles of science just prior to going to the applications.

Among the different types of context based teaching strategies, Relating, Experiencing, Applying, Cooperating and Transferring (REACT) strategy is one of them (Center for Occupational Research and Development [CORD], 1999). This strategy focuses on teaching and learning in context that was structured to encourage these five fundamental elements of learning. On the contrary, according to Rayner (2005), there might be a peril in altering an instruction at time from a traditional non-contextual approach to an utterly contextualized approach on account that this kind of active teaching and learning method wants additional time than the customary lecture method that the learners are well-known with it. Because of this reason, the researcher combined the traditional or the conventional method of teaching with a context-based instruction (CBI) as another type of CBIA.

Until now, the effect of CBIAs on high school students' learning of physics has been examined by several research studies. However, clear findings regarding the cognitive aspects of students' learning are still missing even though positive motivational effects of such approaches have been reported (Podschuweit & Bernholt, 2018). Furthermore, its influence on other higher order skills such as conceptual understanding (CU) and PSS had not been investigated as such (Panprueksa, 2012; Pesman, 2012). Besides, in accordance to King and Ritchie (2013), there are additionally reasons which disallow the execution of context-based approaches. These include teachers' lack of cognizance on how these methods are produced and also the way learners learn in a context-based studying environment is now not fully understood. Ültay and Ültay (2014) also recommended the requirement for well planned research studies for appraising the effectiveness of CBIAs as research proof backs recommendations for teachers to use contextualized physics instruction was not enough. Besides, some methodological issues being relevant to the studies regarding the efficacy of CBI are additionally mentioned on the associated literature (Taasoobshirazi & Carr, 2008).

So in this study, through the utilization of an embedded mixed-method research design that is expected to alleviate the above-mentioned problems, CBIAs and students' learning of rotational motion was investigated. Furthermore, the study conducted by Oli (2014) confirmed the existence of gender differences in physics learning. Even though the gender gap in physics is expected to be reduced by making use of a CBIAs (Wilkinson, 1999), different studies conducted so far reported the existence of gender difference. The reasons behind such a controversy have to be investigated in detail (Pesman, 2012). Thus, the effect of these instructional approaches was additionally examined with respect to gender.

Of the topics of physics, rotational motion was chosen for examination since there's a bit study on topics related to rotational motion in physics education research (Duman, Demirci & Şekercioğlu, 2015; Mashood & Singh, 2015) although it is a hard, conceptually rich area that wants more attention from the physics education research society (Mashood & Singh, 2015). The studies that were conducted so far also reported the existence of a trouble in the area. For instance; the study carried out by Rimoldini and Singh (2005) to divulge 669 undergraduate learners' rolling and rotational motion concepts disclosed that students have a problem in understanding the torque concept, and that they are typically confused with torque and force concepts. A similar finding was also reported in a study conducted by Pol, Harskamp, Suhre, and Goedhart (2008) for revealing secondary school and undergraduate students' concepts of torque. Another study associated with torque was done by Klammer (1998). His study result confirmed that students have misconceptions regarding the concepts of torque. Bostan-Sarıoğlan and Küçüközer (2013) additionally conducted a study aimed towards revealing the earlier knowhow of 133 grade 10 learners regarding torque, conservation of angular momentum and Kepler's second law of motion. Their finding suggests that learners' former knowhow on the concepts of torque and angular momentum was once contradictory with scientific ideas. The study conducted by Duman et al. (2015) on 100 mathematics major university students also demonstrated that learners have trouble and misapprehension on the basic concepts of rotational motion like rolling, moment of inertia, rotational energy and torque concepts.

1.3 Objectives of the Study

The general objective of the present study was to explore the comparative efficacy of CBIAs implemented in grade 11 students' learning of rotational motion in sections previously dominated by the traditional instruction. The specific objectives of the study are:

- To investigate the efficacy of CBIAs on learners' acquisition of concepts.
- To investigate the efficacy of CBIAs on learners' skills of solving problems.
- To investigate the efficiency of CBIAs on learners' affection to learn physics.
- To examine the effectiveness of CBIAs on learners' gender with respect to the above three assessed variables.
- To investigate students and teachers views about CBIAs.

1.4 Research questions

The main research question (RQ) of the present study was stated as: would there be any differences between the groups of students taught with CBIAs and those taught with TI in their learning of rotational motion? To successfully answer this question, it was further divided into the following specific RQs.

RQ1: Would there be any differences in the students' acquisition of rotational motion concepts among the students taught with CBIAs and those taught with TI?

RQ2: Would there be any differences among male and female students exposed to CBIAs in their acquisition of concepts?

RQ3: Would there be any differences in the students' skills of solving problems related to rotational motion among the students taught with CBIAs and those taught with TI?

RQ4: Would there be any differences among male and female students exposed to CBIAs in their skills of solving problems?

RQ5: Would there be any differences in the students' affections towards physics in general and rotational motion in particular among the students taught with CBIAs and those taught with TI?

RQ6: Would there be any differences among male and female students exposed to CBIAs in their affections towards physics in general and rotational motion in particular?

RQ7: How do learners' and teachers' perceive about the features of CBIAs?

1.5 Significance of the Study

This study was conducted to analyze the relative effectiveness of CBIAs on students' learning of rotational motion concepts. It is expected that learning with a CBIAs could help students notice the importance of physics and realize that physics in their everyday life. The findings in this study is expected to exhibit the way for developing and passing classroom practices that makes everyday contexts more vital to the teaching and learning of physics. Hence, this study result most likely has the potential to make students beneficial through creating opportunities that makes them to be engaged in real-world physics. This enables the students' to link the conceptual knowledge and real-world societal issues. Hence, CBIAs may be thought of as a solution to teach rotational motion as well as other physics topics to make learners more capable and attracted in learning the subject. The outcomes obtained from the present study may also give power to teachers of physics to enforce modern approaches that abet linkage among ideas and contexts that are familiar with learners. It may also offers curriculum developers a clue about the significance of adopting school physics to CBIAs and also introduction of latest problem-solving strategies. Thus, the finding of this research is expected to be useful for curriculum developers and educational authorities besides school physics teachers and students.

Furthermore, since studies that investigate the effectiveness of CBIAs can be believed to be few in quantity with some methodological problems (Taasoobshirazi & Carr, 2008), the present study is anticipated to contribute to the literature with its findings through resolving the methodological problems mentioned in literature.

1.6 Scope / Delimitations of the Study

This study was conducted on three classes of grade eleven students in the preparatory schools found in Robe, Batu Terara and Ginnir towns in Bale zone of Oromia regional state, Ethiopia. Out of the topics covered in the student's textbook, the study only focused on topics related to rotational motion. However, it had been better if the study was carried out for a quite longer duration of time (say, for a semester) so as to look for its impact. But just for the sake of time and financial constraints, the study period was delimited to seven weeks. In addition to these, for making the study manageable, the study was once more limited to CU, PSS and affection variables among the available different variables like retention.

1.7 Definition of Terms

Terms and concepts used in the current study are operationally defined as shown below.

Conventional or Traditional Instruction: refers to a teacher centered or business as usual instruction that was implemented in the actual classrooms.

Context-Based Instructional Approaches: refers to instructional approaches that utilizes everyday contexts and scenarios that learners face in their real life as a starting point for developing scientific ideas understanding. This includes:

- **Context-Based Instruction:** refers to a student centered teaching methods that are specially designed to be used with a context or based on the context.
- **Traditional method integrated with a context-based instruction:** refers to a teacher-student interactive teaching method where the traditional teaching method is fully integrated with a CBI teaching strategy.

Students Learning: refers to the outcomes obtained from the learning of rotational motion in terms of students' CU, PSS and affection to learn physics as measured by students' scores in corresponding tests and views of students' and teachers' about CBIAs.

Conceptual Understanding: refers to students understanding of concepts which enable them to solve unfamiliar problems.

Conceptual Achievement: refers to the numerical scores obtained from the CU test.

Problem-solving Strategy: refers to the ways/approaches used for solving problems.

Problem-solving Skill: refers to the ability of solving physics problems using the problem-solving strategies.

Affection to learn physics: refers to learners' attitude toward physics as well as motivation in physics as measured by the affective characteristics questionnaire (ACQ).

1.8 Structure of the Dissertation

This thesis entitled "Context-Based Instructional approaches and Preparatory School Students' Learning of Rotational Motion" consists of five chapters. These are the introduction, review of related literature, research methodology, data Analysis and discussion as well as the summary, conclusions and recommendations chapter.

The introductory chapter comprised of the concise information concerning the different parameters that existed in the study: background of the study, a statement of the problem, objectives of the study, research questions about the study, the significance of the study, the scope of the study, definition of terms and organization of the study. Chapter two is about the review of related literature which comprises of literatures which are associated with the topic of investigation. The reviews were organized into different sections like conventional instruction, constructivism, CBIAs and literatures related to the variables addressed in this study. The third one is the methodological chapter. It deals with topics which are related to the method of study, the area of study, study's population and sample, techniques of sampling, tool used in the study, a range of statistical techniques employed for data analysis and strategies for scoring the data. Chapter four provides data analysis, interpretation and discussion of the statistical results. Discussions of the results are given at the end of this chapter. The fifth chapter presents the summary and conclusions. Recommendations and limitations of the study are also given in this chapter. In the reference section, various books and journals that are referred are mentioned.

Finally, in the appendix, the tools and other necessary documents used in the study are appended.

CHAPTER TWO: REVIEW OF LITERATURE

Many academic researchers have conducted research in physics education with the aim of understanding how students learn physics. On the other hand, other studies had explored the methods used for improving students learning outcomes. This chapter will review such literatures in physics education areas with an emphasis on context-based instructional approaches (CBIAs). The purpose of the review is to get informed about relevant theories and practices in physics education and, therefore, to prepare the ground for the present study. The chapter embarks on with an overview of what traditional instruction and constructivism means. Afterwards the meaning, underlying theories and strategies of CBIAs underpinning the current study are presented. It, then, continues to exploring the literature related to CBIAs. The meanings and previous research studies that are especially associated with the variables addressed in this particular study are also reviewed. The chapter concludes by presenting the present study's conceptual framework.

2.1 The Nature of Traditional Instructions Used in Physics Classrooms

Physics education has tended to predominately use pedagogical approaches associated with the theory of learning that originated from the behavioral psychology (Walsh, 2009). The focus of behavioral psychology is on the study of observable changes in behavior rather than studying the changes that exists in one's mind. For behaviorism, the meaning of learning is associated with a process of altering or observing noticeable behavior as a consequence to strengthening one's response to stimulus. One's mind is, thus, considered as a mirror reflecting reality or a sponge soaking up knowledge coming from the teacher. Hence, according to Jonassen (1991), behaviorism mostly hinges on controlled, teacher directed instructional approaches. This enables the students' to receive the knowhow of the topic while the teacher is transmitting it. Because of its dependence on an objectivist epistemology, behaviorism is also called objectivism. Objectivists have faith in the presence of a knowledge which is reliable. Thus, the focus of the students' is to grasp this knowhow from their teachers (Jonassen, 1991).

As a result, in traditional physics classroom, transmitting the correct information to the students is considered as a priority in teaching physics (Redish, 2003). This should be done through teacher-centered types of instructions. In such classrooms, the teacher presents the content through lecture, calculates examples on the board and rarely does laboratory demonstrations while the role of the students is attending the lectures and taking notes. They ask questions or give comments rarely. According to Taasoobshirazi and Carr (2008), this type of instruction is called 'business as usual' in the class.

This type of instruction is also commonly exercised in the teaching of physics in schools and universities found in Ethiopia (Derebssa, 2006; Getnet, 2012). Such kind of instructional methods eventually makes students to consider physics learning as one which is based on memorizations and computations (Peşman, 2012; Tural, 2013). It also leads the students towards inadequate understanding or misconception in physics topics (Cahyadi, 2004). As a result, many physics education researchers (Hake, 1998; Tesfaye, 2007; 2012) are in agreement with the little understanding of physics concepts as well as PSS reaching the students who were instructed using the traditional physics instruction.

2.2 Constructivist Learning in Physics Classrooms

2.2.1 The Meaning of Constructivism

Contrary to the objectivist view, the notion of making meaning and knowledge construction is considered as the foremost principles of constructivist learning theory (Crotty, 1998, Fosnot, 1996; Phillips, 1995). Knowledge is considered as impermanent, nonobjective, internally developed, incremental, socially and culturally mediated (Fosnot, 1996). Thus, according to the constructivist view, reality should only be understood through a personal and subjective means (Tobin & Tippins, 1993). So, knowledge does not occur outside of the pupil, and hence it is constructed by the learners themselves.

Although constructivism was defined in different ways, the widespread concept relies upon the meaning of knowing and the learners' active role. The attention given to the learner during the teaching and learning process shows the attention given to the importance of prior beliefs, knowhow and ability that is there in the individuals mind (Jones & Brader-Araje, 2002). Students' prior knowledge can notably affect the meaning making process of individuals beyond instruction. This is because students go to classes with numerous past experiences; knowhow and thinking's that they use in the teaching and learning process. Hence, based on the knowledge that the learners already have, they are expected to actively construct or even create meaning and understanding (Duit & Treagust, 1998). The interaction among their prior knowledge and the newly acquired information and experiences makes the students to actively and purposefully construct their own knowledge; which in turn enables them to make sense of the scientific phenomena (Richardson, 2003; Schunk, 2004). It is, therefore, necessary for the learner to relate their previously existing knowledge with the new knowledge to be taught (Brown, 1978). Hence, the conception held by each student guides his/her understanding of new ideas (Tobin, 1993; Treagust, Duit, & Fraser, 1996). Therefore, it is possible to consider learning as the modification of an existing knowledge (Bell, 1991).

The emphasis given by the constructivist learning theory to the individuals’ active role during the teaching and learning process and the significance of meaning construction are the elements that made the theory interesting to educators (Jones & Brader-Araje, 2002). Its due emphasis on the societal context and bigger society of learners has caused a major shift from instructions rooted in individual to instructions which is based on the bigger community of peers, young students and those who are elder (Jones & Brader-Araje, 2002). Hence, its major contribution to education would be through its shift from knowledge as an end result to knowhow as a process. It, thus, recommends teachers with instructional methods that fit with recent study findings on learning.

Therefore, through considering learning as a process which is active, teachers should design instructional methods leading students’ to deeper and long lasting understandings rather than relying on methods based on rote memorization (Jones & Brader-Araje, 2002). This should be done through incorporating learners’ prior experiences or preconceptions and also by eliciting cognitive conflict. Hence, teachers should be aware of the role of prior experiences in the teaching and learning processes. Following is a discussion of the main categories of constructivist learning theory.

2.2.2 Characteristics of Constructivism

Simpson (2001) explained four characteristics of constructivism that influence learning. According to the first characteristic, students interpret stimuli on the basis of what they already know and construct understanding that make sense to them. Hence, learners construct their own understanding of the topics under investigation. The explanation about the dependence of new learning on current understanding is the second characteristic of constructivism. New learning is, thus, interpreted in the immediate context of current understanding. The third one is about the facilitation of learning by social interaction. This about the opportunities played by social interaction for the students to articulate their own ideas, compare them to others and changes them if necessary. The final one is about situated learning within authentic task. According to this characteristic, learning takes place when students are actively involved in authentic tasks that are rooted in a context which is familiar to them. Authentic tasks can simulate real world problematic situations and provide students with practice in thinking in realistic, life-like situation. It also increases students' motivation to learn.

These four general characteristics of constructivism that Simpson expressed can be applied to the constructivist classroom. To do this, in the first place, the teacher needs to bring out students' prior experience and knowledge so as to find out already existing misunderstanding. The second step is the teachers' intervention so as to intervene on the students learning with appropriate activities. The third is to establish social situations with the students in an attempt to make sense of experiments in terms of what the learners previously know. The last one is creating variety of occasions for the learners to represent their knowledge in a range of authentic assessment techniques in preference to separate test situations and should focus on the process of learning as much as on the final outcome.

2.2.3 Main Categories of Constructivism

Constructivism is considered as a broad group of theory, rather than one single theory, which explains knowledge acquisition and learning (Jordan, Carlile, & Stack, 2008). The various kinds of constructivist thoughts are commonly categorized in accordance with their major emphasis. According to Jordan et al. (2008), on one side, there is a frequent idea that persons construct and filter their own understandings of the world that is anchored in their prior conception; on the other side, there is a category of radical constructivism that is advocated by the Ernst von Glasersfeld. According to von Glasersfeld (2007), since everyone is liable for the world s/he is experience, knowledge is a process and product of an individual’s mind, and hence the degree to which knowhow expresses external reality should not be considered as a single reality. Every one of them is based on the belief that individuals interpret and make sense of their own experience and the information they get.

According to Jordan et al. (2008), the constructivist learning theories that have utmost relevance to learning and education are categorized into three: trivial, social and critical. The following is the discussion of these categories.

i. Trivial (Cognitive) constructivism

It refers to the obvious view that knowledge is actively constructed by the individual learner, not passively received from an external source to an individual (Aljohani, 2017; Jordan et al., 2008; Peter, Abiodun, & Oke, 2010). Individuals are thus responsible for constructing mental models or 'constructs' of things for developing their personal understanding (Jordan et al., 2008). It is thus based on an individualistic viewpoint that is rooted in the work of Jean Piaget, the founder of constructivist notion. When learners come across a new knowhow or circumstances that defy their prior thinking, learners are likely to become mystified and hence a status of disequilibrium or imbalance is produced. Hence, they start to rethink and restructure their mental constructs. They must then change their thoughts to reinstate the status of equilibrium or balance. For this purpose, they make sense of the new information by relating it with what they previously know, i.e., by trying to assimilate it into our existing knowledge. The newly received knowhow should have to be accommodated with the formerly existing information. This makes the new knowledge not to be adopted, but rather modified. This recurring and dynamic process directs students towards deeper understanding and enhanced learning. Since new information is being accommodated within the students' formerly existing knowledge, the learners may perceive the newly acquired information in different ways. The prior experience of the students is indispensable to actively construct the new knowledge. The process of meaning making is thus based on the assimilation, accommodation and schema models of Piaget (Aljohani, 2017; Jafari & Davatgari, 2015; Jordan et al., 2008). Hence, teachers should have to be alert to the diverse mental constructs that learners bring to the teaching and learning process (Jordan et al., 2008).

ii. Social constructivism

It lays emphasis on the significance of culture and context to understand the thing that happens in the society and also develop knowledge based on this understanding (Derry, 1999). In this class of constructivist thinking, the manner in which individuals see, understand and attach meanings to their experiences is shaped by the culture and social communities as the society shape the how and what people think (Jordan et al., 2008). Thus, knowledge is formed in the circumstances of the existing environment. Vygotsky's work has laid down the basis of social constructivism in educational settings (Gail & Brader-Araje, 2002). Vygotsky (1978) spotlighted the role that is played by the society in the development of an individual. According to him, we learn everything on two levels. Primarily, through interaction with others which is then integrated into the individual's mental structure. A more knowledgeable colleague should have to provide "scaffolding" of the subject matter to help the learners' growing understanding. The second level is the notion that the potential for cognitive development is limited to a zone of proximal development. This zone is the region of examination where the students is cognitively prepared but wants support and social interaction to fully grow. For social constructivists, the process of knowing is entrenched in social interaction (von Glasersfeld, 1992). Explicitly, a person's knowhow of the something is bound to individual's knowledge and is arbitrated through interaction (language) with one another (von Glasersfeld, 1989). In other words, social constructivists explain that knowhow is the product of social interaction and usage of language. Thus, they maintain that it is possible for people to reach at common meanings and understandings that are negotiated through discussion. Simultaneously, it acknowledges the existence of multiple realities as no two people will have accurately identical discussions with just similar peoples. This is in contrast with the trivial constructivist's assumption that states knowledge acquisition as an individual process with individual outcomes, which relies on personal mental frameworks and processes.

Thus, in social constructivist classrooms, learning occurs through interactions with other learners, teachers, and the world in general (Vygotsky, 1978). These enable the learners to be actively involved in a democratic environment, and interaction becomes decisive in learning (Gray, 1997), and hence learning from a social constructivist angle is an active process that involves others. Strategies of teaching that use social constructivism as a referent comprise contextualized teaching that may be personally give meaning to learners, negotiating taken-as-shared, meanings with learners, classroom discussions, small-group teamwork, and giving value for activities that give meaning over right answers (Wood et al., 1995).

iii. Critical constructivism

It refers to constructivism within a social as well as cultural environment; however a critical dimension that is intended for reform these environments is added to it so as to enhance the success of constructivism used as referent (Jordan et al., 2008). According to Manning (n.d.), critical constructivists argue that knowhow is temporary and culturally situated as the understanding of the world's knowledge is an interpretation among peoples that crafted it in a contextualized space. Hence, knowledge and phenomenon are built socially in a conversation amid culture, institutions, and historical contexts. Thus, critical constructivism fosters the creation of dialogue so as to reach at common understanding. This shows that knowledge is formed in the minds of individuals by the peoples around them. Hence, the critical constructivists encourages individuals to become self reflective of their being able to overcome primary social views and eloquent counter views (Bentley, Fleury, & Garrison, 2007). It is therefore the practice of finding out substitute discourse and new means of thinking while also divulging conquered knowledge.

Critical constructivism encourages greater personal and social awareness that is used to develop freedom of thought which recognizes authoritarian tendencies and links knowledge to power through inspiring individuals to take constructive measures (Manning, n.d.). According to him, they hypothesizes the relation among power and knowledge, upholding that in societies only little groups and organizations can obtain fame and become authorized as knowledge owners, and powerful groups uphold their knowledge construction legality by constantly discouraging alternative knowledge. The thought of Michel Foucault, according to Jordan et al. (2008), was used to explain the critical constructivism's worry with power relations. His inspection of power relations notifies the work of Paulo Freire and Jürgen Habermas, the two critical constructivists. The critical constructivist's assertion that knowledge is situated and contextual means that generalizations for practice are not right. Educators should have to be responsive to the unequal power relationship that exists among education suppliers, teachers and students.

The epistemological supposition that meaning or knowledge is not discovered but built by the peoples mind is the common view for the entire constructivist learning theories.

2.3 Context-Based Instructional Approaches

2.3.1 Meaning of Context-Based Approaches

CBIAs have been defined by different researchers and educators from different countries. For instance, for Rose (2012), context-based learning stands for problem-based, learner-centered instructional methods which create opportunities for the students to have a meaningful learning that is pertinent with the context of real-world societal problems. Williams (2008), on the other hand, noted that CBI is a method that positions learning of students in practical settings and involves the realization of procedural knowhow. For Young and Paterson (2007), it is a philosophical variation of problem-based learning. On the other hand, according to Williams et al. (2012), problem-solving is considered as a main process of CBI as it helps students to develop PSS for real-life contexts.

Briefly speaking, CBI gives stress on developing students to turn out to be real-life problem-solvers (Vermeer, Boekaerts, & Seegers, 2000) by making use of active learning situations that mirror real-life settings (Fechner, 2009). Bennett et al. (2006) also explained that CBIAs are instructional methods applied in the teaching of science where science applications and contexts are used as the basis for the developing scientific thoughts. Again for Souders and Prescott (1999), contextual learning is anchored in the idea that most efficient learning takes place when information is presented within a framework that is familiar to the student.

CBIAs convey the learning to lives of the students' and demonstrate how the utilization of contexts would develop their interest which in turn boosts their understanding (Pilot & Bulte, 2006). It involves teaching through real life contexts by combining the complexity of applying science ideas to the everyday experience of the world which aims to develop students' application ability. So, instead of content or concepts to coerce the teaching, contextual teaching gives due attention to the usage of contexts (Whitelegg & Parry, 1999). Through contextual teaching, students' link physics to their lives in the everyday life which in turn makes them to be highly motivated (Rayner, 2005; Vos, 2014).

Therefore, teachers ought to use instructional activities that give due emphasis to everyday life problems in preference to theoretical problems. This is due to the fact that every day life problems are attractive while theoretical problems are ordinary, purposive and tedious (Boujaoude, 2000). CBIAs are also meant to make the students' active participants in the process of the teaching and learning (Holman & Pilling, 2004). It, thus, incorporates the social as well as the cultural environment that comprises the learner, the educator and the school (Demircioğlu, 2008).

Thus, in CBIAs, emphases were given to the importance of the contents of science to students' everyday experiences. Its thoughts are rooted in students' previous knowhow, experience and the learners' accountability for their own learning in a meaningful social context. In this teaching approach, the emphasis is on making science more pertinent and useful to lives of the students' through applications of concepts and real-life examples across home and daily life settings (Resnick & Hall, 1998).

The CBIAs finds its place among the curriculums of a number of countries. Among these countries, USA, England, Netherlands, Germany, Swaziland and South Africa are the sample countries where CBIAs are in effect (Bennett et al., 2006). With the intention to incorporate CBIAs in physics courses, the Turkish preparatory schools physics curriculum had also been modified since 2008 (Taasoobshirazi & Carr, 2008). Such an attempt was not that much significantly observed in the physics curriculums of Ethiopia as the features of context-based science curriculum explained by Van Loggerenberg-Hattingh (2000) was not clearly observed in our curriculums.

2.3.2 Theories that Underline Context-Based Approaches

According to Gilbert (2006), the constructivist learning theory is a theory that has particular importance for the use of contexts in classroom teaching and learning processes. Gilbert further noted that situated cognition and activity theory are the theories that are particularly associated with the use of contexts as these theories grew out of constructivism. These are discussed one by one as follows.

Constructivism, as it was discussed in the previous section, believes that learners build their own understanding of a phenomenon through experiencing and talking about on those experiences that are rooted in their previous knowhow. In this view, knowledge is transferred to new state of affairs through linking the new information with their prior thoughts and experiences (Berns & Erickson, 2001). Also in science education, individuals build their own meaning from their own experiences sooner than obtaining knowhow from other sources (Bennett, 2003). Hence, to arrive at higher-order thinking skills like problem-solving and critical thinking providing a constructivist view, CBIAs confer learners with real learning activities using learners' real-world experiences as the basis for teaching scientific ideas (Briner, 1999). The amalgamation of autonomous learning practices and the utilization of context are in harmony with constructivist theories of learning (Gilbert, 2006).

Situated cognition theory depicts learning as one which is intrinsically social in nature (Hansman, 2001) through giving attention to the importance of the context wherein something is erudite. According to this theory, learning was meaningful if and only if it is not remote from the social as well as physical situations within which it is generated (Brown, Collins, & Duguid, 1989). Students take part in contextually pertinent settings of learning that enables them to discover and apply novel ideas, work out problems, gain access to expert viewpoint, partake and put into practice. It thus depends on sensible scenarios of solving problems. Hence, situatedness of knowledge mainly denotes to being part of the activity, context and culture wherein it happens. Constituents of situated cognition comprise genuine content, activities and assessment; observations of multiple roles and outlooks; shared knowledge creation; reflection, articulation and scaffolding. In accordance with these, anchored instruction is one of the models of instruction that is developed based on situated learning. It has a resemblance with the features of CBIAs in terms of engaging learners with their real life experiences and engaging them in authentic practices of learning (Taasoobshirazi & Carr, 2008).

Activity theory has also a remarkable standpoint for context. It views the constituents of the activity (i.e., object, actions as well as operation) as being the context itself (Nardi, 1992) devoid of taking into account the student and the object that is being studied as separate entities. Furthermore, context should not be something which is free from the activities learners play with objects. Activity theory is reflected in classrooms through the use of cognitive apprenticeship which is meant to direct and assist students all through the process of problem-solving as it is the case in CBIAs.

The CBIAs designed for this study are expected to allow learners to build their own understanding of the topics being taught based on their previous knowhow and experiences (constructivism). This should be done with the help of the guidance of their teachers that supports them during the teaching and learning process (activity theory) through engaging them in a range of individual and group activities that is extracted from the context used (situated cognition).

2.3.3 Theoretical Framework of the Study

Learning is a process of sense-making activity where the student seeks to accommodate novel idea with the already existing mind configurations. The newly obtained information is related to comparable information where context or overlap of concepts is the leading factor. Through this lane of argument, according to Klassen (2006), context should be considered as one that is crucial for the teaching and learning process in view of the fact that information should not exist in segregation in long-term memory and still in the process of reasoning; there are continuous efforts to create associations amongst concepts.

According to contextual learning theories, students learn something when they got the opportunity of processing the new knowledge in a manner that makes meaning to them with their own reference frames (Handoyo, 2007). This is because the mind naturally looks for meaning in context (i.e., with regard to the individuals' existing surroundings) through finding sensible and valuable associations. Hence, so as to achieve the desired outcomes of learning, contextual learning theories concentrate on the various features of environments of learning through encouraging teachers to choose and/or design environments of learning that include a range of experiences (social, cultural, physical as well as psychological). Since concepts are familiarized by making use of the discovering, reinforcing and relating processes, such environments enable learners to find out meaningful associations among ideas which are abstract and real world practical applications (Handoyo, 2007). Hence, the constructivist theory of learning was found to be relevant to this study.

Constructivism is seen as a contemporary learning theory wherein knowhow is not conveyed but is built by the students' mental interaction between the physical as well as social world (Fosnot, 1993). Since learners go to science classrooms by having understanding of things which are frequently not in agreement with the correct conceptions of science that needs to be taught, the constructivist learning theory mainly requires the identification of both valid and invalid students' prior conceptions (Vosniadou & Brewer, 1987). In addition, in accordance with Vygotsky (1978), cognitive development embarks on through the interaction among the students and another more knowledgeable person (a teacher or other learners in a group). By doing so, the social processes are then converted into the student's internal cerebral processes. In other words, the interaction amongst persons can play a crucial role on how individuals learn (Rogoff, 1984; Harland, 2003). In the perspectives of constructivism, learner-learner and learner-teacher interactions in a classroom are essential elements of learning. According to the Vygotskian view, the role of a teacher in "scaffolding" and "anchoring" students' learning provides guiding social interaction. Hence, according to the constructivist view, knowledge is developmental, created internally and mediated socially (Fosnot, 1996). Hence, it is possible to consider knowledge as a mapping of events and conceptual operations that are feasible to what the students' are familiar with (von Glaserfeld & Steffe, 1991). The theory, thus, gives emphasis on the process of constructing knowledge by the learners under the influence of social contexts.

Out of the learning theories discussed in the previous section, the trivial and social constructivist theories take the learners prior knowledge into consideration. They also give attention to the learners' personal as well as social construction of knowhow.

Furthermore, for critical constructivists, knowledge is situated and contextual. Hence, embedded in the trivial, social and critical constructivist theories, the CBIAs used in this study can be used to promote students learning rooted in the scheme that the roots of conceptual change for various learners are idiosyncratic, varied and sensitive to context. Therefore, the trivial, social and critical constructivist theories of learning was used as a theoretical basis for enhancement of the students' learning of rotational motion as these theories consider students prior knowledge and also recognizes students' personal as well as social processes of knowledge construction.

2.3.4 Characteristics of Context-Based Approaches

There are some characteristics of CBIAs that distinguish it from other teaching methods. According to CORD (1999), contextual based instructions should have to be rich in all the following ten standards.

- New concepts should have to be offered in real-life scenarios and situations which are similar to the learners.
- Concepts given in examples as well as exercises should be given in the context of their application.
- New concepts should be conveyed based on students' prior knowledge.
- Examples and student exercises have to include several actual, credible problem-solving situations that are important to students' for their present or likely upcoming lives.
- Examples and exercises given to the students should have to develop on the students a feeling that say, "I need to learn this".

- Learners should collect and examine the data by themselves as they discover the important concepts.
- Opportunities that enable learners' to collect and examine their own data for enhancement and expansion should have to be provided for the learners.
- Lessons and activities should assist learners to use concepts and information in valuable contexts that makes them to see the expected futures like possible job and new places like workplaces.
- Learners should take part frequently in interactive groups through sharing, talking and reacting on the concepts being taught and processes of making decisions.
- Lessons, activities and laboratory sessions should have to enhance learners' reading as well as further skills used for communication purpose besides the scientific reasoning and achievement.

In addition to these, Berns and Erickson (2001) also mentioned a number of key features that needs to be considered in a contextual instruction. These are explained as follows.

- During the lesson plans preparation, teachers need to consider learners' social, emotional and intellectual growth.
- Learners need to take part in group works enabling them to learn from one another.
- Learners should be responsive to their strengths and limitations and wonder how to learn and conquer complexity through situations that leads them towards self-regulated learning.
- Learners' individual differences need not be disregarded. This is useful for selecting the contexts through which the concepts are presented in class activities

in an attempt to decrease the bias amid diverse characteristics of learners, particularly gender bias.

- Since learners differ in their skills, activities need to embrace a broad variety of intelligence types.
- In each of the step the instructional steps, question needs to be included so as to increase learners' higher order thinking skills as well as PSSs.
- The assessment ought to be authentic through evaluating learners' skill in knowledge application as opposed to assessing the remembering of factual information.

As mentioned above, linking content with context is an essential element of conveying meaning to the teaching and learning process (Johnson, 2002). In an effort to search for meaning, the link that one creates enhances knowledge and intensifies insight. Therefore, for making learning meaningful, topics needs to be connected with the context of the learner`s day to day experiences. In doing so, the students can be actively engaged independently or in a group and become responsible in their learning activities. This indicates the significance of collaboration in the contextual teaching and learning process. Hence, students should participate in groups having few students so as to find out individual strengths and limitations, learn to admire one another, listen with an open mind and build agreement. This in turn increases the student's critical and creative thinking ability. In addition to these, context based teaching and learning also asks the educator to identify and understand his/her students, including their interests, aptitude, learning styles, emotional disposition and treatment by classmates. This is because the teacher cannot motivate his/her students if they are unaware of the problems and drawbacks of the students. If the teachers did these things, school can be a fun place to study. Besides these, setting a high academic rank that a learner is expected to attain is an indispensable constituent of the teaching and learning process that is based on context. By using authentic assessments, the students challenge themselves in applying the newly obtained information as well as skills to real life scenarios for an important purpose. Therefore, all the above characteristics clearly make the students to be actively engaged in classroom activities. In the following sections, the strategies of CBIAs used in this particular study are presented.

2.3.5 Strategies of Context-Based Approaches

There are several strategies that were designed to be used with contextual teaching and learning. One of such teaching strategies is the REACT strategy (CORD, 1999; Crawford, 2001; Davtyan, 2014). According to these authors, this strategy focuses on teaching and learning process in context that was structured to include five crucial learning stages: Relating, Experiencing, Applying, Cooperating and Transferring. Relating is the way of learning with reference to learners' life experiences or already existing knowhow. It is the most powerful stage of contextual teaching strategy and is also the heart of constructivism. Experiencing is learning by doing through searching, discovery and invention. If learners do not have pertinent experiences or pre-existing knowledge, teachers can overcome this problem and help the students construct new knowledge with hands-on experiences that take place inside the classroom. Applying is learning by placing the concepts to use in real life activities. It assists the learner to notice the worth of learning. Cooperating is learning through sharing, reacting and discussing with one another. It is also an essential instructional stage for an instruction that is based on context. Transferring is the use of knowhow in new contexts or novel situations which is not dealt in class (CORD, 1999).

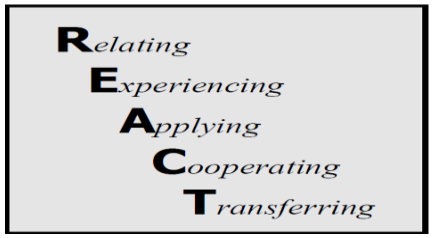


Figure 1: Key components of the REACT strategy (Adopted from Center for Occupational Research and Development (CORD), 1999, P. 3).

According to Ingram (2003), REACT strategy was founded on the bases of the constructivism, and it plays a crucial role in enhancing students' critical thinking and problems solving abilities which would in turn improve learners' understanding of concepts. For instance, in mathematics teaching and learning process, the REACT strategy can be used for improving students' mathematical problem solving ability through accommodating heterogeneous students' ability (Herlina, 2014). In some studies (Demircioğlu, Vural, & Demircioğlu, 2012; Ultay, 2012), the strategy had played a momentous role in enhancing learners conceptual understanding. Furthermore, the strategy has also a positive consequence in boosting students' motivation and attitudes towards physics (Ültay, 2012). Thus, the REACT strategy of CBI was selected to be used in this study.

On the other hand, since this kind of constructivist teaching method needs more efforts than the commonly used lecture method that the learners are accustomed to it, there are researchers that argue for the risks of moving from the passive learning methods to active learning methods, in one step. For instance, according to Rayner (2005), the risks of moving an instruction in one stride from a traditional non-contextual approach to a completely contextualized approach are high. These researchers recommend the use of combined methods (active learning methods with traditional methods of teaching) in the processes of the teaching and learning. The combined method of teaching uses the strategies exercised by both passive learning and active learning methods. So it is a kind of teacher-student interactive method. The method heartens the learners to look for pertinent knowledge sooner than the teacher dominating the transmission of knowledge to the students. Although there are scarcities of literature in the area, some research evidences showed the effectiveness of this method of teaching in enhancing learners' performance (Damodharan & Rengarajan, 1999). Taking this idea into consideration, the researcher intended to investigate the effect of the combined teaching method (i.e., the traditional method of teaching integrated with the REACT strategy of CBI) on the students learning of rotational motion.

2.4 Studies Related to Context-Based Approaches

Numerous studies have been conducted in physics education so as to investigate the effects of CBIAs on learners' outcomes of learning as well as their affective responses to physics. Among the researches' conducted, Whitelegg and Edwards (2001) explored the effects of learning physics using an everyday life approach and examined the transfer of physics phenomenon concept across the different real-life contexts like Jazz and pop unit to teach sound waves and physics for sport unit to teach forces and Newton's law. According to the outcomes of the study, learners felt that the approaches used made the physics more understandable and attractive. Students also saw how physics concepts were related to their interest outside. Kruatong (2007) also used the contextual approach to enhance high school learners' understanding and application of the concepts of heat and thermodynamics. The obtained results showed that understanding and application of students were improved after the students' were taught the heat and thermodynamics concept.

The dissertation carried out by Tekbıyık (2010) focused on integrating context-based physics teaching with 5E learning cycle (Engage, Explore, Explain, Elaborate, and Evaluate) methods of teaching. He used a one group experimental design (with a pre-test and post-test) conducted on 83 grade 9 students so as to examine the efficacy of context-based approach that is combined with 5E learning cycle on topics related to Energy. Initially, the researcher prepared teaching materials for both the teachers and learners rooted in CBIA integrated with 5E model. Through the use of the prepared teaching materials, the intervention lasted for 5 weeks. The data has been gathered by making use of the conceptual achievement test, physics attitude scale, classroom observation form as well as semi-structured interviews. Parametric tests like paired sample t-test, ANOVA and ANCOVA had been used to analyze the quantitative data. The study outcomes were organized in relation to the types of high schools (i.e., public, Anatolian and vocational). Concerning the achievement of learners and their attitude towards physics, the results of the statistical analysis revealed the presence of a statistically significant mean differences among the pre-test and post-test scores of the students for each of the dependent variables as well as every one of the school types.

Like Tekbıyık (2010), Toroslu (2011) had also conducted a study that focused on two main issues. One of which is to examine the effectiveness of 7E learning cycle (Elicit, Engage, Explore, Explain, Elaborate, Evaluate and Extend) integrated with a real-life

CBI on learners' science process skills and understandings of concepts on the topic of energy. The second one is to eradicate the misconceptions of learners on the energy topic. So as to attain these objectives, pre-test post-test control group quasi-experimental research design was utilized. Three different types of tests (i.e., misconceptions test, achievement test and science process skills test) were used to collect data during the intervention period that lasted for 8 weeks. Mann-Whitney U test and ANCOVA had been used to analyze the collected data. The analysis result showed the existence of statistically significant mean differences on learners understanding of concepts and science process skills among the groups of students who were taught with 7E learning cycle combined with real-life CBI and those taught with TI. But the method used was not successful in avoiding misconceptions of the students'.

Another study that was conducted by making use of CBIAs is the dissertation that is conducted by Peşman (2012) so as to principally investigate the effect of method-approach interaction on the topics related to impulse and momentum. Pesman considered methods of teaching (i.e., learning cycle and TI) as well as approaches to teaching (i.e., contextual and non-contextual) independently. For examining the data gathered from 226 study participants, a 2x2x2 factorial research design was employed. Since one of the study's objectives is to find out the effect of CBI on learners' achievement and attitude towards physics, MANCOVA and follow-up ANCOVAs had been exploited to explore the collected data wherein the learners' prior year's physics grade point average (GPA) and pre attitude test scores was considered as the covariates. With respect to the conceptual scores attained from achievement test, the outcomes of the study showed the existence of statistically significant mean differences among the contextual and non-contextual groups favoring contextual groups. Nevertheless, no statistically significant mean differences had been reported in between the contextual and non-contextual groups in their scores of attitude.

In a case study research conducted by Ültay and Ültay (2012) for evaluating grade 11 Turkish students' success on buoyancy force using a context-based approach, it was reported that the approach had improved students' achievement. But it is reported that it was not that much successful in keeping the new knowledge in students' mind. In another study conducted in Taiwan, Panprueksa (2012) used the FEACA (Focusing, Exploring, Analyzing, Conceptual Developing and Applying) model that lay emphasis on contextual approach so as to see its effect on grade 9 learners' outcomes of learning the topics of force and motion. The study results revealed that the FEACA model was successful in developing learners' understanding of concepts, analytical thinking and application of knowledge. Furthermore, students' opinion scores toward the FEACA model were at high level of performance. The study conducted by Ultay (2012) used the REACT strategy of CBI on impulse and momentum topics. The study revealed the enhancement of student's conceptual learning but suggested for more studies to be conducted using this strategy.

In a study conducted by Eyenaka, Ekanem, and Uwak (2013) on senior preparatory school learners learning of alternating current circuits in Physics, the effect of context-based teaching method was investigated. With regard to gender and location of schools, the study results showed that contextual strategy of teaching had been notably better than the expository method in improving learners' transfer of knowledge in simple alternating current circuits in physics. In Jakarta, the action research conducted by Nurafifah, Siswoyo, and Serevina (2014) to investigate the effect of context-based instructional method on students learning of physics came up with a finding that the method improved the learning outcomes of students in physics.

The quasi-experimental study conducted by Kuhn and Müller (2014) on grade10 students learning of topics related to energy with context-based science instruction which is based on a story from a newspaper demonstrated significant encouraging effects. The same is reported for motivational variable (that have a number of subscales), achievement as well as transfer of knowledge. The outcomes of the study also demonstrated that the method is robust to the various features of individual and classroom types like gender, non-verbal intelligence and type of school; and has as a minimum mid-term temporal stability. Thus, their study result indicated the importance of news paper story problems as a helpful ingredient of context-based science instruction. The study conducted by Bahtaji (2015) in mechanics course indicated that the students' scores increase much higher when learning using CBI was well designed although context-based learning increased the performance of students in transfer as well as achievement test.

All the above-mentioned studies reported a positive result of CBIAs on students learning outcomes like achievement, understanding, retention, motivation and attitude. However, as compared to traditional method of teaching, the application of context-based teaching approach on 110 Turkish University students on the potential energy, kinetic energy and rotational kinetic energy topics created no significant effect on students' exam scores although students' have positive feelings towards the approach (Tural, 2013). This shows the existence of inconsistencies on students' cognitive outcomes as a result of learning through the CBIAs.

On the other hand, three major weaknesses were reported in a review and critique of research on context-based physics instruction and assessment conducted by Taasoobshirazi and Carr (2008). The first limitation is that, due to the lack of pre-prepared activities, it is not easy to devise a context-based curriculum. In the second place, there is a shortage of studies that examines the effectiveness of context-based physics instructions in enhancing learners' physics achievement when compared with the TI. Furthermore, inconsistencies were reported on the efficacy of CBIAs in the studies carried out previously. As a result, they suggested the need for conducting more studies by mentioning the existence of insufficient research that encourages teachers to use CBI. A third limitation mentioned by Taasoobshirazi and Carr is the significant methodological problems in studies that have been done so far. One of the reported methodological defects is that research findings that integrated a group work makes it hard to agree on whether the improved learners outcomes was the result of context-based materials or the utilization of group work.

In addition to these, in a thematic review of literature conducted by Ültay and Ültay (2014)on studies related to context-based physics instruction, a pedagogical model that shows teachers' the how of implementing the steps did not exist. Consequently, they explained the need of proposing a model which helps teachers and researchers in using the CBIAs. They actually suggested the necessity for conducting more studies by making use of the REACT strategy or other suitable strategies for implementing CBI. They also suggested studies through the use of context-based approaches on some specific physics topics. The results of the studies should be examined and discussed. So as to indicate the limitations observed in the use of alternative assessment and measurement techniques in context-based physics studies, Ültay and Ültay reported the usage of one data collection tools by most of the studies. Furthermore, since teachers are the practitioners of the instructional approach or method, their outlooks, insights and involvement should have to be considered as imperative and their professional development need to be scrutinized carefully as explained by Ültay and Ültay.

In general, research works that investigated the efficacy of CBIAs can be thought to be too little in number with also some problems in methodology. One of the methodological problems mentioned by Taasoobshirazi and Carr (2008) is that it is not well known whether the study outcomes are attributable to either the exploitation of context-based approach or the utilization of teaching activities that make learners active. Hence, this needs to be examined. To address the methodological problems mentioned earlier, Peşman (2012) conducted a study with an intention to identify the difference among approaches to teaching and methods of teaching. In his research, he explored how the learning cycles as well as the traditional teaching method with and without the contextual approach contributed to grade 11 learners' performance and attitude on the topics of momentum and impulse. Such type of distinction enabled him to see the effect of a method of teaching that is combined with the approaches of teaching or how the approaches of teaching influences the efficacy of a method of teaching. The result of the study showed that the contextual approach had worked in a better manner with the traditional instruction than the learning cycle in terms of students' achievement (Pesman, 2012). This might indicate the concern raised by Rayner (2005) which explained about the risks of transforming an instruction in one stride from a conventional non-contextual approach to a completely contextualized approach. The researcher of the present study agrees, to some extent, with the idea of Pesman. But one thing that he missed is about the teaching methods that are specifically designed to work only with CBI. The REACT teaching strategy and the FEACA model are some of the examples of instructions designed to work with CBI. Hence, the researcher strongly believes that the methodological problem mentioned by Taasoobshirazi and Carr (2008) was due to not properly knowing the features of CBI. This is because strategies that make learners active during the teaching and learning process are properly incorporated in the CBIAs as it is discussed earlier. In such cases, it is not possible to make such kind of variation among methods of teaching and teaching approaches. However, it is possible to make such a distinction on a traditional teaching method by taking it with the contextual as well as non-contextual approaches. As a result, the researcher of this study believes that Pesman did not properly address the methodological problems mentioned in the literature.

Furthermore, from the recommendations given on Peşman (2012) study, the researcher identified the following research gaps.

- The need for investigating the effect of some other methods of teaching with either the contextual or any other teaching approach.
- The need for selecting interesting contexts for students.
- The need for investigating the reasons behind the existence of gender difference as female and male students benefitted differently from the context-based approaches.

Besides this, for developing other higher order thinking such as PSS, studies should also be conducted through the science instructional model emphasizing contextual approach

(Panprueksa, 2012; Pesman, 2012). In addition to these, from a thematic review of literatures conducted by Ültay & Ültay (2014), the following gaps are identified.

- The need for suggesting an effective pedagogical model to be used with a CBI.
- The need to use more than one data gathering tools, and
- The need for examining the views and perceptions of implementers or teachers.

Moreover, majority of the studies reported here are conducted in Turkey and only a few of the reported studies are conducted in Africa. The researcher was unable to find a study related to CBIAs which was conducted in Ethiopia, and hence the effectiveness of studies related to context-based physics instructional approaches might not yet be seen in the physics teaching context of our country. So, the researcher observed the need for conducting more studies with better designs, and hence, a study on other physics topics have to be carried out so as to find out the effects of CBIAs on students' learning of physics. As a result, this study was conducted by taking some of the concerns mentioned above into account and examines the relative effectiveness of the REACT strategy of CBI and the TI integrated with a CBI as compared to the conventional method on students' learning outcomes of rotational motion in Ethiopian context. In the following sections, the variables that are addressed in the study are discussed one by one.

2.5 Conceptual Understanding in Physics Classes

Teaching for understanding of concepts is the goal of every classroom instruction, especially in the science classroom (Panprueksa, 2012; Peşman, 2012**)**. Since concepts are essential to science classrooms, learners need to understand the concepts in order to make the teaching and learning process successful. CU can be explained in terms of breadth and depth (Alao & Guthrie, 1999). Breadth refers to the extent distributed and represents the main part of a specific domain. In contrast, the term depth is used to denote the knowledge of science principles that describes the link among the concepts. Breadth and depth are linked to each other and are the key aspects of conceptual understanding. For Carpenter and Lehrer (1999), understanding is the most important facet of learning. When learners obtain knowhow of something with understanding, they can use that knowhow so as to study new contents of a subject matter and also solve new problems. If they failed to understand the topic, they should not use their skills for solving unfamiliar problems as well as broadening their knowledge to new topics. Hence, with no understanding of the concepts of science, it would be almost impracticable for the learners to participate on many of the open discussion forums dealing with scientific results or policy issues associated with science and technology (Enger & Yager, 2001). Hence, they cannot apply their skill in solving unfamiliar problems and extend their knowledge to new topics. Therefore, in order to develop conceptual understanding, students should have concrete experience with concepts before moving to abstractions, and they also need chances to try and do, not just only read about science.

In order to get concepts that are new or alter those incompatible ones, learners are expected to go through quite a few processes (Zirbel 2005). To do this, in the first place, they have to intentionally observe and comprehend the nature of the problem. Secondly, they have to assimilate additional info so as to fit it into the previously existing neural networks. Thirdly, they have to accommodate new concepts through critical analysis and reorganization of their thoughts for the sake of evaluating their prior beliefs. Finally, they have to achieve proficiency in the newly attained and understood concept in order that the concept itself serves as a foundation for more advanced and extended concepts. This shows that throughout the course of action of conceptual change, the thing that takes place in the learner's mind is a restructuring of her or his view, the formation of new neural arrangements and the reorganizing of prior ones. Therefore, in order to help students understand the natural world, learners' previous experience should have to be considered as the instruction's beginning point. Teachers should have to give attention on creating a better learning environment that enables students to learn with understanding.

On the other hand, although a number of diagnostic tools have been prepared and exploited in order to categorize and measure learners' concepts understanding, the typical multiple choice achievement tests is an assessment tool that is commonly practiced in classrooms found in Ethiopia. Even though there are many merits of using multiple-choice tests (such as that they can be administered to a lot of learners at a time and the results could be marked in a relatively shorter time than workout problems), there are problems with multiple-choice tests in accurately measuring the intended concept (Kaltakçı & Eryilmaz, 2010). Hence, responses to multiple-choice tests offer limited value to researchers as students' answers cannot be looked at and analyzed deeply, (Rollnick & Mahooana, 1999). Furthermore, because one cannot follow up with the answers given by the students', students' misconceptions may be the result of lack of knowledge, carelessness and chance factor (Hasan, Bagayokoz, & Kelleyz, 1999; Peşman & Eryilmaz, 2010). As a result, other diagnostic tools like the two-tier tests have been commonly utilized so as to categorize learners' scientific concepts misunderstanding (Gurel, Eryılmaz, & McDermott, 2015; Treagust & Haslam, 1986; Wang, 2004). According to Kılıç and Saglam (2009), due to incorporating learners' reasons and explanations for their responses to the first tier, two-tier tests is considered as a more sophisticated tool relative to the other tests. Furthermore, they described two-tier tests as a valid and reliable tool that allows teachers to evaluate their learners understanding of concepts more efficiently by being easy to score and apply. Thus, since two-tier tests take into consideration learners' reason or explanation for their chosen answer and also attach their responses to misunderstanding of the concepts being assessed, these tests were carefully planned to be a great enrichment over the earlier ones (Wang 2004). Hence, probably, these tests may play a crucial role in enhancing science conceptual understanding of learners' when implemented effectively. From the time when Treagust (1986) published his seminar paper that focus on how to prepare two-tier tests, numerous science education researchers have constructed and also used two-tier diagnostic tests (Gurel et al., 2015).

When using two-tiered tests for assessing students understanding, the criteria identified by Abraham and Williamson (1994) have been employed to categorize learners responses and make judgment on the degree of their understanding. This is explained as follows:

- Sound Understanding: Valid responses for each concept statement are obtained representing the sound understanding of that concept.
- Partial Understanding: Answers signifying partial understanding of the concept are described by the learner stating a minimum of one of the components of the scientifically accepted concept.
- Partial Understanding with Specific Misconception: Responses that show understanding of concepts to some degree (i.e., one with some misconception).
- Specific Misconceptions: Replies that include illogical or incorrect information.

- No Understanding: These are replies that are described by at least one of the subsequent ways: repeating the question, containing irrelevant information or an unclear response, replying “I don’t know”, or no answer was given to the item (Abraham & Williamson, 1994).

On the other hand, physics classes which had been taught using the traditional method fail to convey robust CU even for those learners who do well on classroom exams (Finkelstein, 2005). Taasoobshirazi and Carr (2008) also supported this argument saying traditional classroom instruction leaves most students confused with basic physics concepts. These are the problems that were also noticed in the Ethiopian secondary schools physics teaching and learning processes despite the increased emphasis given to science education (MoE, 2008). The study carried out by Oli (2014) has revealed that the schools in Ethiopia were ineffective in their endeavors to enhance the physics teaching and learning process as well as learners’ performance in physics. Accordingly, when compared with other science subjects, many of the learners in the secondary schools have low interest for learning physics, and this made the learners to poorly perform in national examinations (Solomon & Kedir, 2015).

Many researchers have tried to clarify what it means to learn with understanding and teach for understanding. Gabel (2003) has identified numerous effective teaching methods to promote the CU of science. These teaching strategies can be incorporated into various teaching-learning situations. But, according to Finkelstein (2005), if one desires to generate proper environment which endorse conceptual change in learners, context ought to be considered as component and parcel of student learning. This illustrates that science concepts have been learned better when learners make use of the concepts in a real-life or real-world scenarios (Enger & Yager, 2001). Furthermore, studies that investigated the impact of CBIAs on students' CU are limited as most of the studies focus on students' achievement. Subsequently, the main focus of the present study is to examine the effect of CBIAs on learners' understanding of the rotational motion concepts.

In order to find out students' conceptual achievement scores, the well known method of classifying the responses obtained from two-tier items and used by many researchers (Cocstu & Ayas, 2005; Fikadu & Mekbib, 2018; Ozkan & Selcuk, 2015; Tarakçı, Hatipoğlu, Tekkaya, & Özden, 1999) was used. In accordance with this classification, the responses of the learners' in the first-tier and second-tier conceptual test items are given the least 0 mark for "No understanding" category, a mark of 1 point for "Specific misconception" category, a mark of 2 points for "Partial understanding" category and a score of 3 points for "Sound understanding" category.

2.6 Problem-Solving in Physics Classes

Problem-solving is considered as a multifaceted process which is useful for our everyday life experiences. It is also decisive to the Science Technology Engineering and Mathematics (STEM) teaching and learning processes (Docktor et al., 2016). Mostly, in an attempt to teach and evaluate students' learning of the contents of physics, teachers who teach physics are usually observed while exploiting problem-solving techniques. This asserts the value of problem-solving for a physics teaching and learning processes (Gerace & Beatty, 2005).

In accordance with McCormick (1997), procedural and conceptual knowledge are the two forms of knowhow that are useful so as to solve technical problems. Procedural knowledge refers to the process skills that are used in solving problems while conceptual knowledge refers to the knowhow, skills and tools which are indispensable for solving problems.

The processes of problem-solving takes place when learners' want to determine a situation that they do not know a definite set of procedures to pursue so as to reach to a solution (Newell & Simon, 1972). Yet, researchers and teachers require more information about the processes of solving problems in order to make their learners efficient problem solvers (Armagan et al., 2009). Thus, efforts should have to be made so as to improve PSS through education as it is a cognitive activity (Seminara, 1996).

Having the skills of solving problems enables us to give solutions to the problems that we face in all parts of our life in addition to those found in academic life (Armagan, Sagır, & Çelik, 2009). To prop up the enhancement of PSS, it is essential to have tools that can be used to demonstrate the distinction among novice and expert problem-solvers classroom performance (Docktor et al., 2016). For Reif and Heller (1982), the major difference among them was on learners' usage and organization of knowledge in their efforts of solving problems. According to Selçuk, Çalışkan, and Erol (2008), those who use the strategies of problem-solving properly and knowingly are expert problem solvers while those who cannot exploit it effectively are novice problem solvers. Thus, novices rush into finding the final answer devoid of understanding the idea of the problem while experts make use of more qualitative reasoning and arguments in greater detail prior to using arithmetical formulas (Walsh, 2009). Physicists systematize their knowledge in an incredibly organized manner and hence they can appeal to this knowhow every time, even in the sequence that it is wanted. Conversely, novice physics learners fail to organize knowledge in such a manner. This is due to the fact that their understanding consists of random information and equations having little meaning of concepts (Van Heuvelen, 1991).

The gap that exists among expert and novice solvers of problems had been studied very well. This was done with a focus on categorizing the difference among learners and experts in an attempt to find out how learners turn out to be more ‘expert’ like in their procedures they follow while solving problems (Larkin, McDermott, Simon, & Simon, 1980; Schultz & Lockhead, 1991; Priest & Lindsay, 1992; Reif & Allen, 1992; Leonard, Gerace, & Dufresne, 2002; Brand-Gruwel, Wopereis, & Vermetten, 2005). Nevertheless, beginner physics learners seldom realize this upper-level expertise on problem-solving. They only start to construct a logical structure of knowledge that they support them to access and use it correctly when solving problems (Sabella, 2008; Sabella & Redish, 2007).

Unlike expert physicists, students do not have coherent knowledge structure for solving problems of physics. In lots of the literature, this variation among experts and novices are discussed under the following two categories: organization of knowledge and usage of knowledge (Mestre, 1994). According to a review of research carried out by Mestre on problem-solving with an emphasis on the cognitive facets of learning demonstrated that skillful problem-solving is the product of a momentous, appropriately cross-referenced and hierarchically structured knowledge base in addition to the qualitative reasoning rooted in conceptual knowledge. So as to underline the function of conceptual knowledge in problem solving, learners' need to be heartened to incorporate a qualitative strategy during problem solving (Leonard et al., 1996). Being accompanied by others (Dufresne, Gerace, Hardiman, & Mestre, 1992; Hardiman, Dufresne, & Mestre, 1989; Mualem & Eylon, 2007), Mestre (1994) calls for a reform that accentuates on problem-solving instruction promoting qualitative reasoning.

According to Yu, Fan, and Lin (2014), numerous strategies of problem-solving described the process from low to high complexity. For instance, in previous studies, in order to solve problems, Dewey (1910) emphasized on the following five phases. These are: a felt level of problem complexity, location and problem definition, recommendation(s) of probable solutions, construction of a recommended solution, and accept or discard the recommended solution as per the results obtained from observations and experimental test. Gick (1986) anticipated a simplified representation of coherent processes of problem-solving that incorporated the steps of: constructing a problem representation, probing for solutions and putting the solution into practice. Afterward, Ge and Land (2003) explained the process of ill-structured problem-solving as: illustrating the problem, developing possible solutions, providing explanations for generated or selected solutions and controlling and evaluation. A typical model for solving problems that was developed by Deek, Turoff, and McHugh (1999) consists of the following six steps: problem formulation, planning, designing, interpreting, testing and solution delivery. On the other hand, the seven steps of problem-solving cycle described by Sternberg (2009) comprises: identifying the problem, defining the problem, formulating the strategy, organizing the information, allocating the resources, monitoring and evaluating. The model that was synthesized by Shahat, Ohle, Treagust, and Fischer (2013) for the processes of problem-solving in science education consisted of eight phases. These phases are: identification and formulation of the problem, triggering prior knowhow associated with the problem, definition and representation of the problem, formulation of a predictable outcome, exploration of a probable means of tackling the problem, doing a preferred solution process, setting up data and scheming, looking back to the idea and evaluating the obtained results.

Conversely, after testing many dissimilar combinations of categories and marking many written solutions to a problem with different raters, Docktor et al. (2016) reached at the five categories of the Minnesota Assessment of Problem-Solving (MAPS) rubric as being the easiest and reliable tool that can be implemented at large scale. This rubric comprises of the useful description, physics approach, specific application, mathematical procedures and logical progression parts; and is hardened to evaluate learners' written solution to a problem. The rubric ought to be utilized by instructors in order to guide their pedagogy (Docktor et al., 2016).

In the rubric, according to Docktor et al. (2016), useful description evaluates learners' process of information systematization (i.e., from the identification of a problem to a suitable and valuable representation which encapsulate useful information through the use of symbols, diagrams and/or in writing). Physics approach evaluates a learners' process of choosing suitable concepts and principles of physics to be applied while solving the question. It is used to reflect the expert like process of picking pertinent principles of physics that should be related to the situation under investigation prior to using them on the particular problem context and proposing a solution. Specific application of physics evaluates the learners' process of using the concepts and principles of physics to the exact circumstances of a problem. It frequently entails to relate the objects, quantities and constraints in a question via the definite relationships in physics. Specific application, thus, comprise a statement of description, qualitative relations among quantities, formulas, given conditions as well as a consideration of suppositions or constraints in the question. Mathematical procedure evaluates the learners' process of picking exact arithmetical procedures and pursuing rules of mathematics to find the required quantities. On the other hand, the learners' process of focusing on a target through signifying internal consistency is assessed under the category of logical progression. This category ensures whether the overall solution process goes forward in a consistent way towards the goal that is intended to be achieved where the backing for every step is obvious even if not necessarily stated clearly. The process thus may embrace modification, readdressing, or instinctive leaps (Docktor et al., 2016).

By considering this rubric as a method of teaching, Awoke, Ayele, and Zerihun (2017) applied it in the treatment group learners after explaining to them. As a consequence of the training, their study result showed a positive effect on learners' CU. Nonetheless, it is hard for the learners' to build up an understanding of the concepts of physics topics by only solving quantitative problems (Kim & Pak, 2002). So, it is hard to improve learners' CU and ensuing PSS through only using the problem-solving strategy rubrics as an intervention. Nevertheless, Awoke et al (2017) utilized the rubric by considering it as a problem-based method of teaching. But, because the rubric is an instrument used for the assessment of PSS, it can be employed in learner-centered as well as teacher-centered classroom instructions as it was not a method of teaching by itself.

In contrast, previous studies conducted by different researchers reported evidence about the improvement of learners' PSS by the use of learner-centered methods (Awoke, Beyene, Beyene, & Shiferaw, 2016; Heller et al., 1992). Among the learner-centered teaching methods that got much prominence through literatures, CBIAs is one of them. So far, the effect of CBIAs on high school physics learners' has been investigated by several research studies. It is reported that the approaches are good in enhancing learners' achievement and affection towards the learning of physics (Taasoobshirazi, & Carr, 2008). Nevertheless, its effect on a number of other higher order skills like PSS had not been investigated by many researchers (Panprueksa, 2012; Pesman, 2012). As said by Shimeles (2016), lack of CU may weaken learners' performance in procedural understanding tests. Moreover, according to many researchers (Crouch & Mazur, 2001; Kim & Pak, 2002; McDermott et al., 2002), CU ought to be improved ahead of PSS. For that reason, understanding of concepts in consequence of CBIAs may bring about the formation of new procedures and PSS.

So, in the present study, the effect of CBIAs on learners' PSS in physics was examined. To do this, the learners' written solution to the workout PSS test had been marked through the use of the MAPS rubric.

2.7 The Affective Dimensions of Physics Learning

According to Schibeci (1983), there are two different arguments for the significance of the affective domain to the processes of the teaching and learning. The first one is the argument that affective factors and achievement are inextricably linked, and hence, one that is concerned in students' achievement (i.e., in cognitive domain) should have to also be worried with the affective factor domains. However, Schibeci opposed to this argument because of the existence of weak relationship between attitude and achievement in science as reported in the meta-analysis conducted by Willson (1983). But for Gungor et al. (2007), the argument made by Schibeci could be acceptable if one considers the affective factors to consist of only attitudes. However, variables like self-esteem, self-concept, interest in science, values, etc. are also considered as affective factors (Simpson & Troost, 1982). On the other hand, since researchers used different instruments, the same sub dimensions were not included under the variables they studied. For example, some research have used interest as a sub dimension of attitude (Aiken, 1979) while others did not included interest at all (Doepken, Lawsky, & Padwa, 2007). As a result, the studies reported different results (Haladyna, Olsen, & Shaughnessy, 1982).

The other argument for taking into account the affective domain as an essential thing is that, in education, giving due attention for affective factors is more important than giving attention for cognitive factors. Payne (1977) clarified this second stand by saying that affective variables:

a) Affects individual’s capacity of effectively participating in a democratic community,
b) Are essential to make one’s life healthy and successful, and
c) Interact with one’s occupational and vocational job pleasure.

In addition to these, even if it were not more important than cognitive factors, affective factors are still as important as cognitive factors (Gungor, Eryilmaz, & Fakioglu, 2007). Hence, teaching methods should not be selected considering the cognitive variables only. The attitude and motivation variables should also be well thought-out (Kroh & Thomsen,

2005) as the ignorance of the affective components of education yielded the present situation of science education (Osborne, Simon, & Collins, 2003). In other words, students in many countries, think that science is not related to them.

Affective factor studies in science and mathematics education are found in literature. However, according to Gungor et al. (2007), many studies did not investigate the affective factors related to physics in the literature. Furthermore, in studies in physics education, an effort to include a wide variety of variables in the affective domain is few even though some researchers (Alsop & Watts, 2003; Simpson, Koballa, Oliver, & Crawley, 1994) included attitude, motivation, belief and interest as example measures of affective factors. Besides, Alsop and Watts (2003) added self-confidence and self-efficacy to these measures.

As described in the arguments, some think affective factors as attitudes in the science education literature while others consider it in a broad manner, including attitudes toward physics (physics attitude) and motivation in physics (Gungor et al., 2007). In general, as it is also pointed out by Duit, Niedderer, and Schecker (2007), the variables associated with attitude and motivation could have a crucial position in the processes of science teaching and learning. The physics attitude is delineated as ‘‘a tendency to react favorably or unfavorably’’ to physics subjects (Anastasi & Urbina, 1997, p. 404) while motivation in physics is defined as ‘‘the process of arousing, sustaining, and regulating activity, a concept limited to some aspect such as the energetic of behavior or purposive regulation’’ (Good, 1973, p. 375). Hence, attitude is an inclination to positively or negatively replying to things, peoples, ideas, or a place while motivation is an interior feeling that provokes, direct and maintains learners’ character (Koballa & Glynn, 2007).

It is thus assumed that attitude affects motivation and motivation in turn affects learning. Consequently, in the context of this study, students' affections related to physics were taken in its broader sense.

According to Koballa and Glynn (2007) and Nieswandt (2005), a range of attitudinal and motivational instruments had been used throughout literature. From among them, the affective characteristic questionnaire (ACQ), an instrument which was constructed and validated by Abak (2003) so as to measure attitude and motivation is commonly used in studies in physics education. ACQ consists of importance of physics, physics interest, student motivation in physics subject, achievement motivation in physics subject, physics self-efficacy, physics self concept, locus of control in physics and physics anxiety. The term importance of physics is used to mean the value prone to physics or perception about the value of physics. It consists of two sub dimensions: importance of physics subject in general and importance of a particular physics topic. The physics interest refers to feelings of enjoyment and involvement. It also consists of three sub dimensions: personal interest in physics subjects, situational interest in particular to physics topic and aspiring extra activities linked to physics. Student motivation refers to any intrinsic or extrinsic award affecting learners' success (Abak, 2003) while achievement motivation is related with selection of performance tasks, diligence on these tasks, drive to work out them and performance on them (Wigfield & Eccles, 2000). Self-concept refers to how learners consider their physics ability in a broad manner (Abak, 2003). Self-efficacy is a term which is used to denote one's faith regarding his/her potential to reach out the targeted performance levels (Bandura, 1994). It hence, refers to individual's context-dependent verdict about his/her abilities while self-concept is an individual's wide-ranging judgment about his/her ability (Abak, 2003). On the other hand, according to Koballa and Glynn (2007), anxiety is considered as a general nervousness, a feeling of apprehension and a sentiment of stress. The physics anxiety consists of two sub dimensions: physics subject anxiety (subject anxiety) and physics test anxiety (test anxiety).

According to their sub dimensions, the ACQ are presented in two different approaches in the literature (Gungor et al., 2007): the unidimensional model presented in Figure 2A, and the multidimensional model presented in Figure 2B. The unidimensional model proposes that all the variables are clustered under a latent variable called affective characteristics. This model is referred to as attitude scales and define attitude as a multifaceted construct containing motivation, interest, importance, self-confidence, self-concept, anxiety as well as enjoyment sub scales (Aiken, 1979; Gogolin & Swartz, 1992; Schibeci & Riley, 1986). On the other hand, the multidimensional model proposes that the affective characteristics are grouped under two separate latent variables of attitudinal and motivational variables. According to Gungor et al. (2007), this model was derived from the literature (Fraser, 1981; Kremer & Walberg, 1981; Uguroglu & Walberg, 1979).

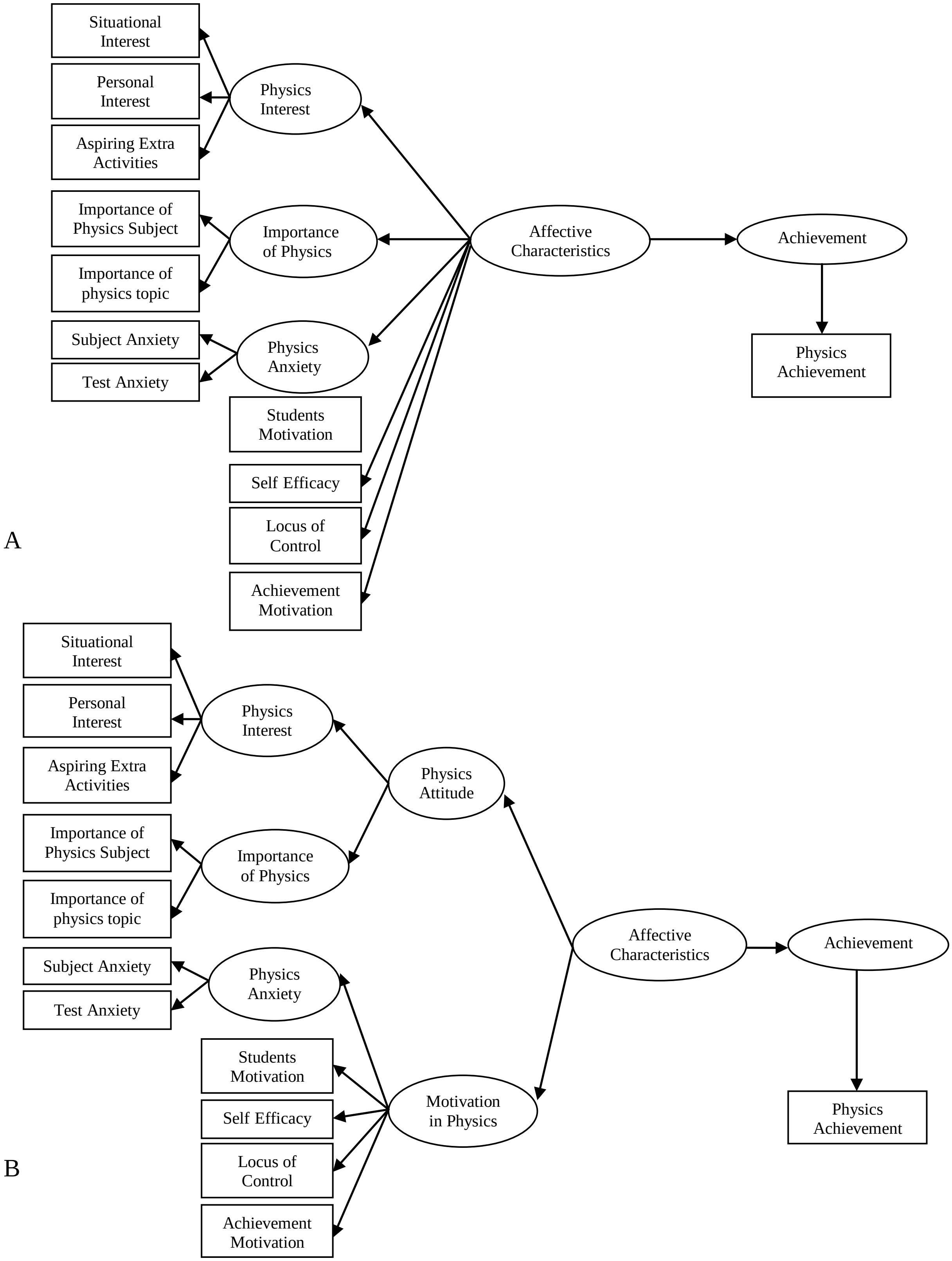


Figure 2: Models of the association among physics achievement and related affective characteristics A. Unidimensional B. Multidimensional (Adapted from 'Gungor et al., 2007, p.104).

In Ethiopia, a significant level of adverse learners' affection toward science in general or physics in particular has been observed (Oli, 2014) as large number of learners considers science as a hard subject. This adverse feeling towards science was more visible on female learners. Instructional methods that give surplus emphasis on theoretical teaching that results in poor performance of learners may have greatly contributed to such types of feelings. Hence, the type of instruction that the learners are exposed to could play a key role in enhancing learners' affection toward science in general and physics in particular. The research on students' affections (attitudes and motivations) toward physics should focus on the instructional methods that positively contribute to learners' attitudes and motivations. The positive outcomes of a variety of instructional methods on learners' attitude toward and motivation in physics were reported by some researchers.

CBIAs can engage students in a range of activities and gives emphasis to the importance of science to learners' life worlds through relating to contexts or everyday life experiences. With CBIAs, learners create associations among situations; configure the new information via their prior knowhow so as to apply it in new circumstances. Through such processes, learners could become accountable for their own-learning (SNAB cited in Çam & Köse, 2008). Thus, to implement CBIAs in a better manner, learners' outlook and feelings, which comprises a fundamental element of instructional methods, should be taken into consideration. Learners' positive or awful attitudes towards the instructional methods could have thus an imperative impact on the efficiency level of instructional method (Baran, Maskan, Baran, Türkan, & Yetişir, 2016).

The results of majority of context-based studies reported the efficacy of CBIAs on enhancing learners' attitude and motivation towards science (Barber, 2000; Bennett et al., 2006; Gutwill-Wise, 2001; Kaschalk, 2002; Parchmann et al., 2006; Ramsden, 1992, 1997; Rayner, 2005; Sutman & Bruce, 1992; Whitelegg & Parry, 1999; Wilkinson, 1999). However, the effect of these instructional approaches on students' affection towards physics, in its broader sense, was not investigated as such. The studies that were conducted also reported contradictory results. For instance, Pesman (2012) reported no improvements on students' affections towards physics as result of the use of CBIAs.

In Ethiopian context, no such studies were conducted so far. Consequently, studies need to be carried out to find out learners' affections towards these approaches for addressing the problems related to performance in physics subject. Hence, the current study explores the effect of CBIAs on learners' affections towards the learning of physics in general and rotational motion in particular.

2.8 Gender Related Differences in Physics

It is a well-documented fact that the areas of Science, Technology, Engineering and Mathematics (STEM) are commonly dominated by males. Hence, male and female learners vary in their attitudes towards the learning of science, frequently favoring male students over female students. According to Koballa and Glynn (2007), both the physiological as well as the sociological factors are considered as the basic reasons that created this difference. Consequently, female learners' negative attitudes towards the learning of science which in turn have an impact on their performance have been the major issue of concern for various studies. One of the major objectives of meta-analysis carried out by Weinburgh (1995) on 18 studies that included 6753 participants in total was to scrutinize how male students and female students vary in their attitudes towards the learning of science. The finding pointed out that female learners had less positive attitudes towards the learning of science than male learners.

In Ethiopia, the study conducted by Oli (2014) confirmed the existence of a considerable gender related differences in the learning of science as fewer numbers of female learners attends college or university level science education than their male counterparts. According to Oli, the cultural factors and stereotypes could be the primarily contributing factors that made female learners not to attend science subjects at the expected level. Although this disparity can also be attributed to cognitive styles and individual students learning capability, it looks insignificant as compared to the social and cultural factors (Oli, 2014).

With regard to students PSS, the study conducted by Zhu (2007) also demonstrated the existence of gender related differences in arithmetical PSS in favor of male learners. Furthermore, according to Awoniyi (2000), male learners perform better than female learners in subjects containing calculations or requiring quantitative ability. This makes the students to score lower in national examinations. For instance, the survey conducted by Oli (2014) in grade 11 and 12 preparatory schools indicated that the mean score of female learners were smaller than the mean scores of male students in the overall academic achievement tests. This outcome obviously supports the well-known fact about the existence of gender differences in science achievement (Sanchez & Wiley, 2010).

Among the science disciplines, the biggest gender related disparity in achievement has been observed particularly in physics subject (Taasoobshirazi & Carr, 2008). According to Adigwe (1992) and Casey (2001), when compared to female students, male students got a higher score in problem-solving tests. The lagging behind of female students' in physics achievement is always bothering for teachers, particularly when they are concerned with the teaching of problem-solving skills (Ding & Xu, 2011). As a result, the differences in the persistence of male and female learners learning physics subject have been focus areas for researchers in physics education. This is because, according to Murphy and Whitelegg (2006), female students consider physics as an inappropriate subject for them in their future aspirations more than male students. In general, participation of girls' in physics education is low, inequitable and inefficient. Hence, if they were not encouraged and supported to attract them to science fields and careers, competent female workforce may not be obtained in professions related to science (Oli, 2014).

The roles of instructional methods that reduce the gap between male and female students become crucial at this point. Consequently, Zhu recommended the need to think of the means that is used to develop the problem solving skills of all female and male learners', for instance through the use of appropriate instruction. However, some studies investigating the efficacy of instructional methods do not consider gender though there are evidences for the existence of gender related differences (Nieswandt, 2005). According to Taasoobshirazi and Carr (2008), physics instructional approaches based on context may furnish female learners with a number of practical activities that would assist them in developing their physics understanding of concepts. Since context-based physics instructional approaches may make physics pertinent to students' life by making use of familiar examples and experiences, it may possibly be helpful particularly for female learners as it was witnessed in the study conducted by Whitelegg and Edwards (2001).

After conducting an interview on 38 learners found in three secondary schools, Whitelegg and Edwards find out that the exploitation of context in physics classes was predominantly appreciated by female learners. Most likely, female students are expected to join physics instructions that make use of CBI (Wilkinson, 1999), and thus it can be useful for bringing female students into the subjects of physics. Context-based physics instructional methods could have thus the capability to minimize the gender gap observed in physics education.

The gender related disparity in students' physics performance and motivation was also explored by other researchers. For instance, for Taasoobshirazi (2007), context-based instructional methods can play a significant role in reducing the gender related difference through making physics more relevant to them. The review carried out by Lubben, Bennett, Hogarth, and Robinson (2005) showed that female students who were taught with a context-based or Science Technology and Society (STS) approach produced a considerably higher positive attitude for joining science fields when compared with male students found in these classes. This is because, after a context-based approach, female students got equal CU of science like the male students found in their classes. Lubben et al. (2005) also conducted a review which aimed to examine the effects of context-based and STS instructional approaches on male and female learners. Initially, the review intended to include 61 studies although they finally reduced to 14 studies that matched with their inclusion criteria. The results of each of the studies are categorized as one having high, medium-high or medium quality. The outcomes of the study confirmed that both male and female learners who were taught with CBI had a significant more positive attitude towards the learning of science when compared with their peers that are taught with TI. The disparity among male and female learners' attitudes towards the learning of science was narrowed because of CBI. The characteristics of the activities incorporated in CBI brought the pleasure observed on male and female learners. On the other hand, female learners enjoy materials based on context in a better manner if they got the opportunity to partake in non practical activities while male learners demonstrated better pleasure when engaged with practical work (Lubben et al., 2005).

Based on the preliminary assessment of ChiK (Chemie im Kontext), the study carried out by Nentwig, Demuth, Parchmann, Gräsel, and Ralle (2007) revealed similar outcomes as no significant differences was detected among male and female learners' achievement in science subjects. Hence, all the above study outcomes imply the power of CBI in reducing the gap among male and female learners' attitudes towards the learning of science.

On the other hand, even though the gender gap in physics is expected to be reduced by making use of CBIAs (Lubben et al., 2005; Nentwig et al., 2007; Taasoobshirazi, 2007; Whitelegg & Edwards, 2001; Wilkinson, 1999), there are also studies that reported the existence of gender difference. For instance, the study conducted by Pesman (2012) reported that male and female students benefitted differently from a contextual approach. The reasons behind such a controversy have to be investigated in detail (Pesman, 2012). Thus, the effect of these instructional approaches was also examined with reference to gender.

2.9 Conceptual Framework of the Study

In line with the constructivist theories of learning and the context of the present study, the CBIAs are expected to enhance the students learning of the rotational motion concepts. This is because these approaches, as one of the constructivist learning approaches in physics, facilitate students' active engagement in the construction and reconstruction of conceptual knowledge. Furthermore, CBIAs provide teachers the opportunity to relate the contents to real world situations. By doing so, a teacher can motivate his/her learners to make associations among the knowledge they learnt and its relevance to their lives (Handoyo, 2007). The preparation of the CBIAs used in the present study encompasses the selection of the topic of investigation (the content), context selection and organization of content and context into the activities of the teaching and learning (linkages). Partly, the conceptual framework of the present study was adopted from Hung's (2006) 3C (Content, Context, Connections) 3R (Researching, Reasoning and Reflecting) model for designing problems to be used in problem based learning. Since the focus of the current study is on the use of CBIAs so as to improve the students' learning of concepts and PSS similar to those stated in Hung's model, the researcher considered Hung's model as a suitable framework for dealing with the research problems. Hence, the framework is anchored in the utilization of context so as to teach the content, make linkage among content and contexts and the use of practical activities in the classrooms.

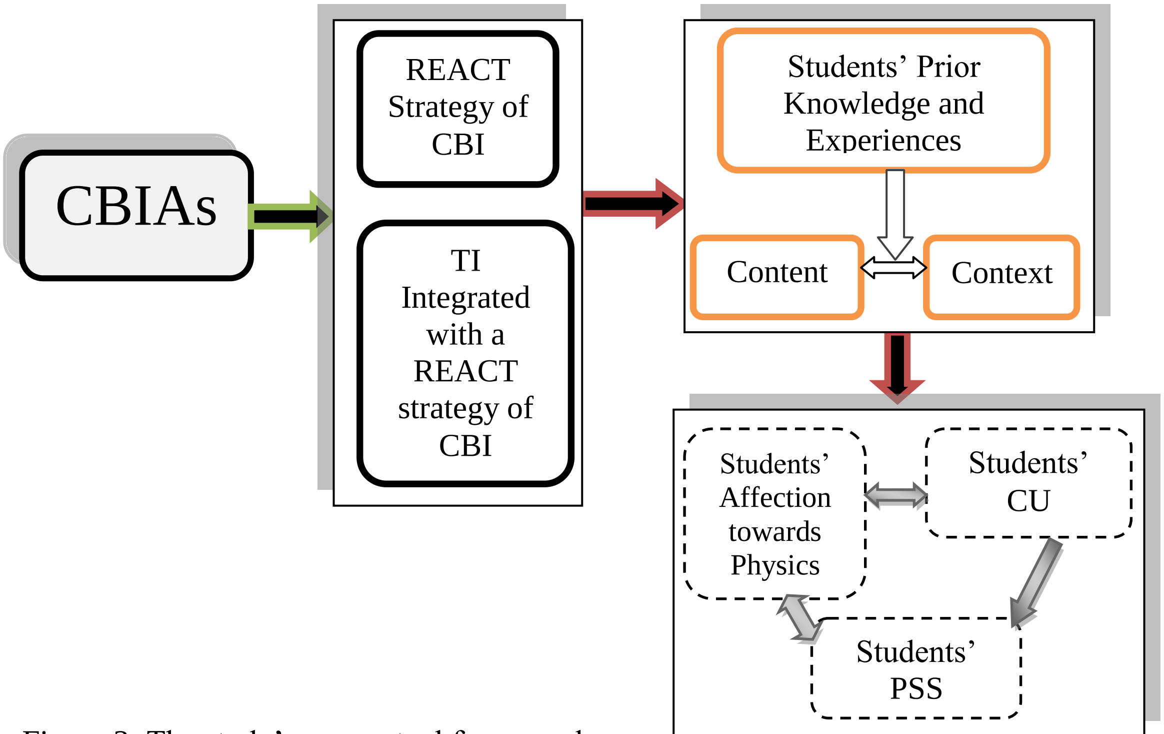


Figure 3: The study's conceptual framework

Notice that the variables involved in the study are clear in the framework presented in Figure 3. In the illustration, students' conceptual understanding, problem-solving skill and students affections towards physics in general and rotational motion in particular are the dependent variables. Since many researchers (Crouch & Mazur, 2001; Kim & Pak, 2002; McDermott et al., 2002) argue that CU must be developed before PSS, understanding of concepts as a result of CBIAs may lead to the generation of students' PSS which in turn enhance students affection towards physics in general or rotational motion in particular. The enhancement of students' affection may also contribute something on students' conceptual understanding. Conversely, the instructional methods used and students' gender are considered as the independent variables of the study. Each of these variables is assumed to be dependent on one another.

CHAPTER THREE: RESEARCH METHODOLOGY

The current study is undertaken to analyze whether or not context-based instructional approaches (CBIAs) can enhance preparatory school students' learning of rotational motion in a class previously dominated by the traditional forms of instruction and learning. So as to address this purpose, this chapter presents a discussion of the research methodology used in the study. The chapter, thus, begins with a broad overview of the philosophical perspective that provides a justification for the choice of a mixed methods design. This is followed by the discussion of the methods of data collection and analysis. The procedure followed, the treatments implemented and ethical considerations will also be discussed.

3.1 Research Paradigm and Method

According to Creswell (2014), a paradigm or a world view is a well-known philosophical orientation about the world and the nature of lookup that a researcher brings to a study. Additionally, the paradigm definition of Weaver and Olson (2006, p. 460) shows how research could be influenced and driven by a certain paradigm by saying, "paradigms are patterns of beliefs and practices that modify inquiry within a discipline through providing lenses, frames and methods thru which investigation is accomplished". Hence, to elucidate the researcher's shape of inquiry and methodological choices, an examination of the paradigm adopted for the present study was discussed.

Positivism, that is additionally called the "scientific method", provides stress to the position that the social world ought to be studied the manner that natural phenomenon are studied. It is based totally on a realist ontology, which assumes that "there exists a truth out there, driven via immutable herbal laws" (Guba, 1990, p. 19). Therefore, positivism deals with causal relationships and primary regularities among exceptional components of the world. Positivists have an objectivist epistemology, which needs for the researcher that, so as to find out the actual world, he need to “put questions directly to the nature and permit nature to answer back” (Guba, 1990, p. 19). Additionally, the investigator ought to maintain a detached, objective read so as to grasp the facts (Duffy, 1986). Values and different biasing factors are excluded so as no longer to impact the effects of the research. In contrast, the qualitative research methods were originated in the social sciences to allow researchers to investigate social and cultural occurrence. Its philosophical foundation is based on the interpretive paradigm that supports the view about the existence of multiple realities. The interpretivist paradigm is also known as the “constructivist paradigm” in view that it is anchored in the reality where realities are more than one and socially constructed. Interpretivists undertake relativist ontology, whereby a single phenomenon can have a couple of interpretations and there is no basic system by which fact can be determined. Their intention is to grasp a deeper perception of the phenomenon and its complexity in its special context, not to generalize to a total populace (Creswell, 2007). Speaking epistemologically, interpretivists suppose that information is obtained through a method that compliments the variations among individuals and also the objects of scientific discipline and so needs the social scientists to know the subjective meaning of social action. Interpretivists don't typically start with a theory, rather they “generate or inductively develop a theory or pattern of meanings” (Creswell, 2007, p. 9) throughout the study process. They treat individuals as analysis participants and not as objects. They try to capture diverse outlooks and observe the phenomenon from diverse angles.

On the other hand, mixed research technique is one wherever the investigator utilizes the qualitative research method in one stage of a probe study and also the quantitative research method for one more so as to understand the research well (Creswell, 2005). According to Greene, Caracelli, and Graham (1989) and Tashakhori and Teddlie (1998), quantitative and qualitative methods harmonize one another and helps someone to have a more complete analysis of the research problem when used in combination in one study

Due to the nature of majority of the research questions, a larger weight was placed on the quantitative part of data collection and analysis. As a result, the researcher normally instigates from the positivism viewpoint to prepare instruments, measure variables and analyze statistical results. However, the last research question contains issues that need to be addressed using qualitative data collection and analysis. Therefore, there is a shift to using the assumptions of interpretivism as the researcher goes to the qualitative phase that values multiple outlook and in-depth description. Therefore, recognizing that neither quantitative nor qualitative methods are individually adequate to examine the nature of the research questions raised in this study, it is essential for the researcher to combine the quantitative/positivist paradigm with the qualitative/interpretive paradigm. A mixed-method research is thus adopted with the intention that the quantitative data from the quantitative method and the narratives from the qualitative method could harmonize one another so as to obtain a better insight into and for greater understanding of the study results. Since the uses of different assumptions were encouraged within each phase (Creswell & Plano Clark, 2007), the overall philosophical paradigm in this method alter and shift from the positivist to the interpretivist paradigm. This enabled the researcher to adopt the pragmatist position for understanding the reality of the phenomenon being investigated better.

3.2 Research Design

A research design can be viewed as the logic or master plan of the study throwing light on how to perform the study. It is like an architectural outline that indicates how all of the main parts of the study work together in an effort to deal with the questions raised in the study (Tripathy & Tripathy, 2017). It can, thus, be seen as the actualization of logic in a set of procedures optimizing the soundness of data for a particular research problem. From among the distinct types of mixed method research designs, the design employed in this study most likely resembles to what Creswell and Plano Clark (2007) described as an embedded mixed-method design. It is the nature of the research questions raised in this study that guided the researcher towards the selection of this research design.

In the embedded design, quantitative and qualitative data are collected concurrently or in sequence; however, one type of data plays a supportive role for the other type of data (Creswell and Plano Clark, 2011). The rationale for gathering the second type of data is that it arguments or supports the main type of data. According to Creswell and Plano Clark (2007), this kind of design is predominantly valuable when a researcher desires to embed a qualitative part in a quantitative design just like the case in this study.

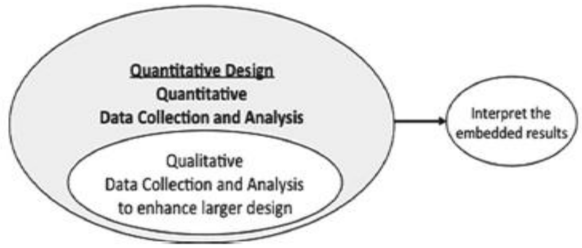


Figure 4: Embedded design (Adapted from Subedi 2016, p.573)

Thus, in the current study, the qualitative data is employed to support the quantitative data. For the quantitative part, a non-equivalent pre-test–post-test control groups, quasi-experimental design has been used so as to compare the comparison group with the two treatment groups. The use of non-equivalent groups' quasi-experimental design is necessitated by the difficulty of randomly assigning subjects to the comparison and treatment groups, which is inherent in a school setting. According to Babbie (2011), non-equivalent groups' quasi-experimental design involves the use of an existing comparison group that is similar to the treatment groups which are not formed by random assignment of students to groups. The symbolic representation of the quasi experimental design used in the current study is demonstrated in table 1.

Table 1: Quantitative research design

Treatment group 1	N	O_1	X_1	O_2
Treatment group 2	N	O_1	X_2	O_2
Comparison group	N	O_1		O_2

Note. N represents the non randomization of subjects to groups; O_1 represents the pre-tests; O_2 represents the post-tests; X_1 represents the REACT strategy of CBI; X_2 represents the traditional method integrated with a CBI

The methodological weakness of non-equivalent groups' quasi-experimental design was recognized in the study. It consists of the intricacy of controlling extraneous variables and the statistical difficulty of contrasting non-equivalent groups obtained from participants that are not randomly assigned to the comparison and treatment groups (Trochim, 2006). Hence, as an effort to reduce the effect of disparity in the two treatment groups and one comparison group, actions were taken. In the first place, participant groups were chosen based on a criterion intended to make all the three groups equal, i.e., based on their previous achievement. Second, after pilot testing, the instruments used to collect data were administered to all groups as pre-tests, before the intervention, with the intention to compare learners' performances on the assessed learning outcomes (Creswell, 2009). Third, MANCOVA, an analysis which equate the groups through controlling the initial difference (Creswell, 2009; Field, 2009; Trochim, 2006) was used to analyze the post-test scores.

For the qualitative part, the students written answers to CU as well as PSS tests were also analyzed. In addition to this, data was also collected from treatment group learners regarding their views on the treatments using a semi structured focus group interviews. According to Morgan (1997), focus group interviews are properly designed discussions intended for obtaining views in a distinct area of interest in a liberal, non-intimidating atmosphere. Focus group interviews are assumed to bring out cooperative reasoning that could improve the quality of students' answer in addition to activating forgotten details (Maree, 2007). They are also known to supply a diversified array of responses (Merton, Fiske, & Kendall, 1990) that might augment the outcomes of the present study. Furthermore, focus group interviews are expected to supply plenty of information within a limited time whilst shunning one-to-one soliciting of information that could be threatening to some students. Furthermore, one-to-one semi-structured interviews were also hardened to gather deep information on the interventions from the two teachers who taught the treatment group students. A one-to-one interview entails a conversation where the interviewer decides on the general direction and pursues specific topics addressed by the interview participant (Babbie, 2011).

The obtained data from the interviews was essential for substantiating or triangulating the responses gathered from the interviews and the quantitative data on the efficacy of CBIAs in enhancing students' learning. In addition to this, data were also collected from the classroom observations. This is necessary to have a broad judgment on the diverse features of the instruction such as interaction among the teacher and the learners, learners' involvement on the lessons and classroom environment of each group. Hence, qualitative techniques play a supportive position in supplementing and triangulating elements of the quantitative information to furnish higher insights into the results.

3.3 Study Area and Participants of the Study

The study was carried out in three preparatory schools found in Robe, Goba and Ginnir towns in Bale zone. Bale zone is one of the administrative zones in Oromia national regional state which is located in the south-eastern part of Ethiopia. The selected schools were located in Robe, Goba and Ginnir towns. Although students' physics achievement is low in the zone just like the situation there throughout the country, these three schools were selected from among the schools found in the zone on the basis of obtaining schools with relatively similar status as these schools were more or less found in comparable towns.

Among the two grade levels (grade 11 and 12) in each of the selected preparatory schools, grade 11 was selected purposely because the topic chosen for the examination is the rotational motion which is offered to grade 11 students. From the available teachers in the schools, three teachers (one from each school) that are approximately equivalent to each other in terms of their experience, qualification and willingness to participate in the study were selected so as to control for teacher variable. Then, three sections (one from each school) that are more or less equivalent to each other based on their first semester result (as the study was carried out in the second semester of the academic year) were selected from the available sections of grade 11 taught by the selected teachers. Through a lottery method, the sampled section from Batu Terara, Robe and Ginnir preparatory schools were randomly assigned to treatment group I, treatment group II and comparison group, respectively prior to administering the instrument as a pre-test. The study participants are presented in Table 2.

Table 2: Number of students in each of the groups

		Group			
		Treatment group I	Treatment group II	Comparison group	Total
Gender	Male	31	28	35	94
	Female	22	28	22	72
	Total	53	56	57	166

Thus, the numbers of students in treatment group I, treatment group II and the comparison group are 53, 56 and 57, respectively. When we look at the gender distribution of the learners that are part of the study, they did not have that much great difference as 57% of the sample students were males whereas around 43% of them were females.

3.4 Variables of the Study

Five variables are involved in the study where the number of dependent is three while the independent variables are two as shown in Table 3.

Table 3: Name, type and nature of the variables in the study

Name	Type	Nature
Instructional method	Independent variable	Categorical
Gender	Independent variable	Categorical
CU	Dependent variable	Continuous
PSS	Dependent variable	Continuous
Students affection	Dependent variable	Continuous

3.5 Topic of Investigation

From among the eight units included in grade 11 physics textbook, the topic selected for the investigation is the rotational motion. It consists of topics like moment or torque of a force and rotational equilibrium from unit seven (the unit on 'Equilibrium') in addition to the main unit on 'Rotational motion' (i.e., unit 6). The subtopics included in unit 6 are rotation about a fixed axis, torque, angular acceleration, rotational kinetic energy, rotational inertia, rotational dynamics of a rigid body, parallel axis theorem, angular momentum, angular impulse, conservation of angular momentum and center of mass of a rigid body. The quantities and concepts found in the rotational motion topics have translational counterparts. The main difference between these two different types of motion is that linear motion entails the motion of an object from one place to another in a straight line while rotational motion entails the rotation of an object about an axis.

Practically every quantity in translational motion has a rotational equivalent. Instead of linear acceleration, there is rotational (or angular) acceleration. In place of force, there torque. Instead of momentum, there is angular momentum. Instead of velocity, there is an angular velocity, and in place of mass, there is moment of inertia. The analogies among translational and rotational motion are summarized in Table 4.

Table 4: The analogies between translational and rotational motion

Translational motion		**Rotational motion**	
Quantity	**Equation**	**Quantity**	**Equation**
Displacement, **s**	-	Angular displacement, θ	-
Velocity, **v**	$v = \frac{\Delta s}{\Delta t}$	Angular velocity, ω	$\omega = \frac{\Delta \theta}{\Delta t}$
Acceleration, **a**	$a = \frac{\Delta v}{\Delta t}$	Angular acceleration, α	$\alpha = \frac{\Delta \omega}{\Delta t}$
Mass, m	-	Moment of inertia, I	$I = mr^2$
Force, **F**	$F = ma$	Torque, τ	$\tau = I\alpha$
Work, W	$W = F \bullet S$	Work, W	$W = \tau \bullet \theta$
Power, P	$P = \frac{W}{t}$	Power, P	$P = \frac{W}{t}$
Kinetic energy, KE	$KE = \frac{1}{2}mv^2$	Kinetic energy, KE	$KE = \frac{1}{2}I\omega^2$
Linear momentum, P	$P = mv$	Angular momentum, L	$L = I\omega$

In addition to this, there are also equations that relate the translational quantities with the translational quantities. For instance, equations like $s = \theta r$, $v = \omega r$ and $a = \alpha r$ are used to relate these quantities where r is the radius. When moving from translational to rotational motion, many of the concepts don't really change at all. We just replace translational quantities with rotational ones. For example, Newton's First Law says that, unless acted upon by an unbalanced force, an object in motion remains in motion, and a body at rest remains at rest. That law is true for rotation, too. But instead of a linear force, we have a rotational torque. Newton's First Law thus becomes: a spinning body will stay spinning and a non-spinning body won't start spinning, unless acted upon by an unbalanced torque. A torque is just a force that acts off-center and causes an object to spin. Therefore, each and every laws of physics ruling rotational motion has a translational counterpart. These analogies were used in the learning and teaching of rotational motion.

3.6 Data Collection Instruments

This study was performed with an intention to explore the effect of using CBIAs on students' learning of rotational motion. With the goal of finding answers to the research questions, data were mainly collected through five different measuring tools: CU test, PSS test, ACQ, observation checklist and interview schedules. Details of these instruments are presented as follows.

3.6.1 Conceptual Understanding Test

The understanding test consisted of eighteen two-tier test items with the first-tier assessing students' knowledge of rotational motion and the second-tier exploring students' reasons for their choice made in the first-tier. Out of the eighteen two tiered-test items used in this particular study, seventeen of them are selected from among the thirty items prepared by Rimoldini and Singh (2005) for assessing students understanding of rotational and rolling motion concepts (Rotational and Rolling Motion Conceptual Survey (RRMCS)) typically covered in an introductory physics course. For selecting these items, a table of specifications was ready to envision the connection between the items and rotational motion concepts. To do this, the learning competencies that were expected from grade 11students learning of rotational motion topic were analyzed.

Following this step, the questions that were enclosed within the instrument were decided by matching the questions with the objectives declared in the syllabus. On the other hand, the remaining item (i.e., item 18) was taken from “PSI AP Physics I” (n.d.) for assessing the parts that had not been covered by the selected items, i.e., the conservation of angular momentum topic. The resulting test of 18 items was administered to the students before and after the intervention.

3.6.2 Problem-Solving Skill Test

This test comprises of six workout problems related to the rotational motion and was prepared by the researcher himself based on the objectives stated on the syllabus. The test was designed with an intention to assess students’ skills of solving problems. This test was once administered to the students prior to and after the intervention as before.

3.6.3 Affective Characteristics Questionnaire

So as to find out students’ affection towards physics in general and rotational motion in particular, an adapted version of ACQ that was prepared by Abak (2003) was employed in the present study. The reason for choosing this questionnaire for use in this study is that it treated students’ affections related to physics in its broader sense, i.e., it consists of attitude and motivation rather than treating them separately. The questionnaire contained 53 items where all of them were scaled on a 5-point Likert scale. The students thus rated each item of the questionnaire from strongly disagree (1) to strongly agree (5). The English version of this questionnaire was distributed to all the groups before and after the intervention as the questionnaires was written with short and easily understandable sentences.

3.6.4 Classroom Observation Checklist

So as to ascertain whether or not the characteristics of the treatments were put into action as planned, a confirmation checklist for each type of instructional methods was prepared by the researcher. The observation checklist prepared by Peşman (2012) and used in his study served as a reference while preparing the checklist for this study. As a result, primarily based on the foremost characteristics of the instructional methods, three observation checklists (one for each intervention) rooted in a 3-point likert scale (yes/ partially/ no) was prepared. The checklist was used to evaluate whether or not the teachers of the treatment groups followed the principles of CBIAs and to make certain the treatment verification. In addition to this, the checklist assisted the researcher to have an overall judgment on the varied aspects of the instructional methods used.

3.6.5 Interview Schedules

A focus group interview was accustomed to collect qualitative data from the two treatment group students. Furthermore, one-to-one interview was once used to gather data from the two teachers who taught the treatment groups. The interview schedule consisted of several questions formulated by the researcher to obtain participants' opinions and views that accounted for differences in students' performance.

3.7 Validity of Instruments

Validity is used to examine whether or not a measure of a concept truly measures that concept, i.e., the degree to which the concept measures the factor it was intended to measure (Singh, 2007). Content validity, face validity, criterion validity and construct validity are ways of ensuring the validity of instruments. The content and face validity of each of the instruments was evaluated by three senior teachers of physics involved in instrument validation in addition to the supervisor. Hence, both forms of validity were established on the basis of personal judgments as the use of expert judgment is commonly used in educational research for validation (Demircioglu, Demircioglu, & Calik, 2009; Donkor, 2010; Hattingh & Killen, 2003; Kasanda et al., 2005). Based on the feedbacks, modifications had been made, in line with the suggestions made by means of the experts. To check for the construct validity, the scores of the quantitative instruments (CU and PSS test) obtained from pilot study (to be discussed in the next section) were compared with students' previous achievement. The criterion validity was also ensured as there was a statistically significant mean difference among the pre-test and post-test scores of each group.

3.8 Reliability of Instruments

Reliability shows the concern with the consistency of measures, i.e., the capacity of an instrument to measure similar things on every occasion it is used (Singh, 2007). To check for the reliability of the items, the instruments was pilot tested on 40 students found in another nearby school (Goro preparatory school) that was not involved in an actual study. After the pilot study, the item difficulty index as well as discrimination index was calculated for the CU items. The value calculated for the item difficulty level and discrimination index was bigger than 0.63 and 0.3, respectively after discarding two items from the CU test which does not meet the criteria of a good item. In addition to this, the reliability of the CU and PSS tests was calculated by making use of the formula that is used to calculate Kuder Richardson (KR-20) coefficient of reliability. For an instrument to be considered reliable, KR-20 coefficient scores must be greater than 0.60

(Wasserman & Bracken, 2003). They further noted that this formula could be used not only if the items are assumed to have equal difficulty but it can also be used whenever a researcher cannot assume that all items are of equal difficulty. As a result, the obtained reliability coefficient of the CU test was 0.68 while that of the PSS test was 0.72, and they are all in the ranges of acceptable values. So, they can be used for the intended purpose, and hence, the tests were administered to the participating learners.

On the other hand, the reliability of the ACQ was determined using Cronbach's alpha. The Cronbach's alpha coefficient of reliability for the entire questionnaire was found to be 0.74, and it is thus within the range of acceptable values (Fraenkel & Wallen, 1996).

The reliability of the observations was once decided through a manner of repeated utilization of the observation schedule. On the other hand, the following measures were taken into consideration so as to boost the reliability of the semi-structured interviews: 1) the researcher conducted all the interviews in endeavor to reduce subjectivity and decrease variability (Donkor, 2010); 2) the questions were asked within the sequence within which they appeared in the schedule of the interview; 3) the participants were interviewed under similar conditions; and 4) all the interviews were carried out after completion of the study period for about 20 to 30 minutes with the selected participants.

3.9 Instructional Methods

During the intervention period, the same contents were taught to each of the three groups, and they were prepared in line with the syllabus. However, the two treatment groups were taught using the CBI and traditional teaching method integrated with a CBI while the comparison group students were taught using the traditional teaching method. These are discussed one by one as follows.

3.9.1 Context-based instruction

In treatment group I, the REACT (Relating, Experiencing, Applying, Cooperating and Transferring) strategy of CBI strategy of context-based instruction was used to teach the students'. This is one type of student-centered teaching and learning method. The teaching process, thus, began by divulging learners' prior ideas regarding the topic of investigation. This enables the instructor to get idea about learners' previous knowhow. The new information is also related to everyday situations. Then, so as to help the students compare the target concepts with their experience, the teacher provided them a learning environment which is suitable for them. At this phase, the students learnt the topics through exploring the concepts. For helping the students to get experience related to the concept, the teacher also gave them exclusive learning activities. The aim is to permit students to expertise activities that are directly associated with real-life work. Afterward, students got the opportunity to learn by applying the concepts to everyday experiences which enable them to see the worth of learning. This enabled them to learn the concepts by relating it to real life activities and also solve problems. They tried to interpret the results they obtained. This makes them to understand the concepts through connecting it with real life. At the cooperation stage, the students learnt the topics through sharing, responding and discussing with other learners. This can be actualized via group activities. Finally, at transferring stage, students transfer their skills and knowledge from one setting to a different one. In other words, the teacher heartened the learners to use what they learnt in new scenarios. The sample instructional activity used in this group was appended in appendix VIII.

3.9.2 Traditional method integrated with a context-based instruction

In order to analyze the concern (i.e., the risk of moving an instruction in one step from a traditional non-contextual approach to a fully contextualized approach) raised by Rayner (2005), the researcher used the combined method of teaching (the traditional teaching method integrated with a REACT strategy of CBI) on treatment group II. This consists of relating, presenting, applying, transferring and evaluating phases with cooperation and discussion at all phases. Therefore, the method used in this group is a type of teacher-student interactive method. Through the use of this method, as before, the teacher initially revealed the ideas of the learners'. Then, the learners' responses were taken and they were discussed through linking the concept with a context. The contexts used in the teaching and learning process is similar to the one used in the previously discussed group. After that, the teacher shifted from contextual discussion to presentation of the physics content where the teacher lectures the students. At this stage, the teacher solved problems after explaining the concept to the students. Following the presentation, the context-oriented questions raised earlier were addressed again through relating it to the new content. These students were provided with a suitable learning environment that enables them to compare the concepts with their experience or common contexts. The teacher also encouraged the students to explain the concepts they learnt in new scenarios through providing another application allowing students to use their new knowledge. Finally, the teacher evaluated whether the students had understood the new topics correctly. The sample instructional activity used in this group was also appended in appendix VIII.

3.9.3 Traditional teaching method

The conventional or traditional method of teaching is used to teach the students in the comparison group. This is the business as usual, teacher-centered teaching method that consisted of the stages of introduction, presentation, stabilization or summary and evaluation. This is the format that is usually exercised by the school teachers all over the country.

3.10 Procedure

The study begins with the researcher's interest in CBIAs. The review of literature started prior to the identification of research problem and continued until the completion of the dissertation. Globally conducted studies, books and articles linked with effective science teaching through real-life contexts were examined. Based on the review of the literature, the problem of investigation was determined. After that, specific research questions had been proposed. Then, the materials used during the interventions were begun to be developed by making use of lesson plans. Meanwhile, some of the instruments used for gathering data were adapted from literature while others were developed by the researcher as discussed above. Afterwards, these instruments were validated and subjected to pilot study.

After material and instrument development process, permission for carrying out the study was taken from the concerned organizations and bodies. This is mentioned thoroughly in the dissertation's ethical issues section. After that, the selected sections (intact groups) were randomly assigned to the two treatment groups and comparison group as it was discussed earlier. Then, the two physics teachers selected for teaching the treatment groups were given training on how to implement the treatments in the classroom before the intervention. On the prepared materials, the researcher had discussed with the teachers. Based on the feedbacks obtained from the teachers, some parts of the teaching materials had been revised accordingly. The teachers had thus got sample lesson plans before the commencement of the study. Furthermore, just before the lessons started, the CU and PSS performance tests had been administered to the two treatment groups and comparison group students in order to divulge if any substantial difference across the groups exist or not. In addition to these, the students' in each of the groups filled the ACQ prior to the treatment.

During the study period, weekly on Friday, the researcher and the teachers evaluated the implementation of the instructional methods. After the evaluation, the subsequent weeks lesson instructions have been reviewed and designed together prior to the instructions. Hence, the researcher supported the teachers through giving feedbacks and suggestion to ensure the proper implementation of the intervention. The researcher also observed three randomly selected classrooms in each of the three groups so as to verify the implementation of the interventions. The researcher sat noiselessly at the rear seat of the room while observing each of the three groups. Thus, the researcher rated the checklist without interrupting the instructions. Occasionally, the researcher had also been taken some extra notes. The results obtained from classroom observation checklist and notes indicate that the teachers who taught the two treatment groups handled their classrooms as planned by the researcher. As a result, in each observed class period, the students were well engaged in the activities and the teachers also properly related the concepts to the context.

The implementation of the instructional methods lasted for seven weeks. Every week, students had four physics periods, i.e., they had overall 28 periods to study the rotational motion concepts. When the intervention ends, the instruments (i.e., the CU test, the PSS as well as the ACQ) were administered to the comparison group and the two treatment groups of students. Furthermore, when the study period is over, five randomly selected groups from each of the two treatment groups were interviewed through focus group discussion so as to have an in-depth data onto the issues under investigation. The two teachers who taught the treatment groups were also interviewed. The process for carrying out the interviews entailed prologue of the interview topic by the researcher. This was pursued by a series of punctual questions connected to the themes under investigation. The interview schedules lasted for about 20 to 30 minutes. Participants argued and debated the questions with minimal involvement and intervention from the researcher.

3.11 Method of Data Analysis

As mentioned earlier, the study was conducted using an embedded mixed-method design. In this design, the researcher gathers both forms of data concurrently or sequentially and triangulates both data so as to return to conclusion as portrayed in the following diagram.

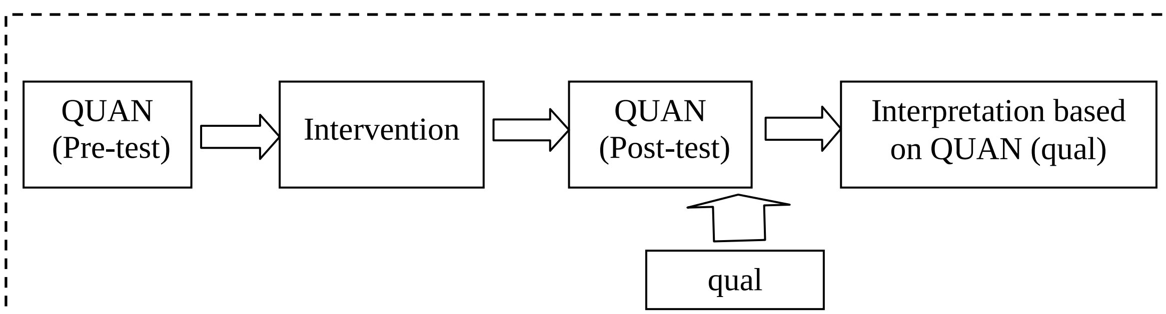


Figure 5: Embedded mixed method design data collection and analysis (Adapted from Subedi, 2016, P. 574).

Thus, in order to analyze the effects of the REACT strategy of context-based physics instruction as well as traditional method integrated with the REACT strategy of CBI on students' learning of rotational motion, the raw data received from the quantitative and qualitative phase of the study are analyzed as delineated within the succeeding sub sections. This is followed by the discussion of triangulation of the results.

3.11.1 Analysis of Quantitative Data

All students who took part in the study were given codes wherein their quantitative results from the pre- and post-intervention were recorded. To do this, each of the quantitative instruments (i.e., the CU test, PSS test and ACQ) was scored as discussed below.

In order to determine students' CU scores or conceptual achievement, the most frequent method of categorizing two-tier items which was proposed by Abraham and Williamson (1994) and exercised by many researchers (Cocstu & Ayas, 2005; Fikadu & Mekbib, 2018; Ozkan & Selcuk, 2015; Tarakçı et al., 1999) were used for examining the data obtained from the rotational motion CU test.

Hence, the scoring of the test was achieved by the evaluation of the data in both the first and second tiers as shown in Table 5. By making use of this criterion, the highest scores that one can get from the CU test are 54. But for the sake of analysis, this was converted to 20.

Table 5: Classification criteria of the students' responses to the test items

Understanding Level	**Student response classification criteria**	**Criteria for evaluating the two-tier test items**	**Categories score**
Sound understanding	Answers that include all components of the ideas that are accepted scientifically	Correct response – Correct reason	3
Partial understanding	Answers that encompass a minimum of one aspects of the acceptable ideas which show understanding of concepts, however, that may also contain some sort of misconception	Correct response – No reason / Wrong response – Correct reason	2
Specific misconception	Answers that contains descriptive, illogical or incorrect information.	Correct response – Wrong reason	1
No understanding	Repeats some section of, or question as it is; irrelevant or uncodable answers. 'I don't understand'	Wrong response – Wrong reason / Wrong response – No reason	0
No response	'No answer'; 'I don't know'; 'I don't have any idea'	No response – No reason	0

Note. Adopted from Ozkan & Selcuk, 2015, p. 758.

On the other hand, the five categories of the Minnesota Assessment of Problem-solving (MAPS) rubric (see Appendix VI) were used for scoring students' written solutions to the PSS test. According to Docktor et al. (2016), the rubric consists of summarizing the information obtained from the problem into a useful description, choose an appropriate physics approach derived from principles, applying specific application of physics to conditions in a specific situation, following suitable mathematical procedures and having a structured, goal-oriented logical progression that directs towards the solution process.

This rubric was appropriate to a variety of topics in physics and a variety of problem types, ranging from those commonly found in textbooks to context-rich problems (Docktor et al., 2016). For each written solution to a problem, the total rubric score was obtained by giving a score between 0 and 5 for each of the five rubrics and then adding up every one of the scores together. This total score (with the highest score of 25 for each of the items) was then divided by the number of categories of the rubric (i.e., 5). Thus, the highest score that one can get from the problem-solving skill test is 30. But, this obtained value was converted to 20 for analysis purpose.

For scoring the results obtained from the ACQ, the usual way of scoring Likert-scale questionnaires were used. Thus, a score of 5 was given if a student strongly agreed with the ideas of the item. If the student strongly disagreed with the idea of the item, a score of 1 was obtained from that item. On the other hand, some of the items (i.e., item 4, 10, 11, 14, 30, 31, 32, 33, 34, 35, 36, 37, 38 and 39) were negatively stated in the questionnaire. During the coding process, these items were reversed and thus the scoring became vice versa. As a result, the highest score that one can get from the questionnaire was 265.

Then after, a data file was formed by the researcher with the data gathered through administration of these data collection instruments. The variables enclosed within the data file were students ID numbers, gender, group, pre-test CU score (pre-CU), pre-test PSS score (pre-PSS), pre-test affective score (pre-affection), post-test CU score (post-CU), post-test problem-solving skill score (post-PSS) and post-affective score (post-affection) of the students. As a first step, data cleaning regarding missing data was carried out before running the analysis. This was done by removing students which were not there while collecting the data either before or after the treatment. Cases of students who responded to the instruments carelessly were also examined carefully before the analysis. Hence, for the analysis, a new data sheet that contains no missing value was obtained. This was thus used for the descriptive as well as inferential statistical analysis purpose.

Descriptive statistics like mean, standard deviation, skewness, kurtosis and histograms were examined for every of the groups so as to make sure that the assumptions of parametric statistics are not violated. The descriptive statistics showed no serious violations to the assumptions of the parametric statistics. Thus, multivariate analysis of covariance (MANCOVA) was used to conduct an inferential statistics because of the presence of three dependent variables with a covariate. This technique is useful for equating the groups on more independent variables through controlling type 1 error. According to Pallant (2007), analysis of covariance lets us for a powerful comparison of groups' means through minimizing the error variances. In conducting MANCOVA, the students' pre-CU, pre-PSS and pre-affective scores were considered as covariates; the instructional methods and gender were considered as the independent variables while the students' post-CU, post-PSS and post-affective scores were the dependent variables. Subsequent to the MANCOVA, follow-up ANCOVAs were computed separately for each of the dependent variable so as to check the effects of the instructional methods. In addition to this, the data`s obtained from the classroom observation was conjointly analyzed in order to have an overall figure on the varied aspects of the instructional methods, interaction between the teacher and the students, involvement of students in the lessons and classroom atmosphere.

3.11.2 Analysis of Qualitative Data

Sample students written answers to the post-CU and post-PSS tests were also analyzed so as to explain the quantitative data further. The data obtained from interviews were also analyzed. So as to identify the sources of the transcripts, the selected groups of students were given codes. Thus, audio recordings taken from focus group discussion were transcribed into written texts, and each transcript was written against their groups' ID. After that the data was analyzed as follows. The transcribed and coded scripts were assigned to the themes mentioned in chapter 4. Each interview theme containing many transcribed texts was cautiously inspected to determine the overall (or general) views and opinions of the students. The same procedure was used for analyzing the views of the two participating teachers. These overall views and comparisons were used as a foundation for discussing the outcomes of the study.

3.11.3 Triangulation

In an embedded mixed method research design, both forms of data should be collected concurrently or in sequence as it is described earlier. In accordance with Creswell and Plano Clark (2007),

> A study that includes both quantitative and qualitative methods without explicitly mixing the data derived from each is simply a collection of multiple methods. A rigorous and strong mixed methods design addresses the decision of how to mix the data (p. 83).

The researcher, therefore, should have to know how to blend the two different kinds of data sets. Thus, in the embedded design, according to Plano Clark et al. (2013), a researcher need to start analyzing the quantitative and qualitative data individually so as to deal with the different research questions and then pass to more integrative strategies so that the secondary outcomes complement and enhance the grasp of the primary research questions and results. Thus, the researcher integrated the quantitative and qualitative results in the discussion sections of the study. The obtained results were combined to properly answer the research questions and develop a more vigorous and meaningful image of the problem under investigation. This is done by organizing them into main study themes (i.e., effect of CBIAs on the variables assessed in this particular study). The discussion is supported by related literature that reflects both quantitative and qualitative studies on the topic. Thus, merging the quantitative and qualitative outcomes was necessary so as to explain the statistical tests result.

3.12 Internal and External Validity of the study

By internal validity it means that the difference seen on the dependent variables of the study are directly associated with the independent variables, not because of some other unplanned variables (Fraenkel & Wallen, 2000). According to these authors, subject characteristics, mortality, location, instrumentation (instrument decay, characteristics of data collector and bias), testing, history, maturation, attitude of subjects (Hawthorn effect, John Henry effect and demoralization effect), regression and implementer threats are some of the potential threats to internal validity of a study. The following is the discussion of the measures taken for controlling these possible threats.

Somewhat, the design of the study (pre-test-post-test control group) is helpful in controlling threats like characteristics of the subject, mortality, instrument decay, testing, history, maturation as well as regression (Fraenkel & Wallen, 2000). Yet, these threats would possibly be still observed within this design. Since it was impossible to randomly assign students to the treatment groups and comparison group, students' characteristics can still be a threat to the research. However, the pre-CU, pre-PSS and pre-affective scores of the students are confounding variables of the study, and hence they are considered as covariates to statistically equate the students on these variables. Other participants' characteristics like students' intelligences, prior knowledge and socioeconomic tiers are supposed to be uniformly distributed among the three groups.

Attitudinal threat might be the foremost vital threat in experimental studies. Hawthorne and John Henry effects can also create short term effects because of the particular emphasis given to the treatment groups and the need of the comparison group to surpass treatment groups' students' performance, respectively. For example, the treatment groups' students' performance may become better due to the strange nature of the CBIAs or the comparison group students may perform poorly because of perceived inequality. For minimizing these effects, the researcher considered intact groups of students that are found in different schools.

As a consequence of the administration of pre-tests, testing threat may arise due to the fact that students' progress might arise from the practice on the pre-test, discussion of opinions about pre-test and students' consciousness of what is vital to learn. Nevertheless, these stuffs are legitimate for every of the comparison and treatment groups and hence it is not considered as the characteristic of the students' in the treatment groups. Therefore, this threat is negligible for this particular study.

Attempts were made to manage threats related to history and location through giving the tests to every of the groups roughly one week after the end of the intervention, in similar conditions. The characteristics and biases related to the data collector are managed by coaching the teachers so as to make them use standard procedures while gathering the data. In this study, problem related to implementation is not an issue of concern due to the fact that teachers are nicely informed about the implementation procedures. During the intervention period, their classrooms were also observed randomly by the researcher. In addition to this, during the period intervention, several meetings had been conducted between the teachers and the researcher with the intention of guarantee the standard of the implementation procedures. With the purpose of controlling for a mortality threat, test administration times were determined by taking teachers' suggestion into account, and before administering the test, the students in each group were informed many times. As an additional measure for controlling the mortality threat, missing data analysis was performed very well as there have been few absent students at the time of each test administration.

On the other hand, external validity refer to "the extent that the results of a study can be generalized from a sample to a population" (Fraenkel & Wallen, 2000, p.124). Like other experimental studies, this study also looks for the means of generalization of its findings. The study's accessible population was eleventh grade students in the preparatory schools found in Bale zone. According to the information obtained from Bale zone Education Bureau, there are around 18 preparatory schools in the zone, three of which were included in this study. The physical conditions of the classrooms throughout the zone are also similar to every other as they are now not technologically-equipped There exist students' desks and blackboards only. The plasma televisions there in the schools were also not operational. The average students' number in each classroom is around 50. Furthermore, the socioeconomic statuses of students' families in the neighborhood are more or less similar. Hence, it is possible to generalize the findings of the present study to the accessible population.

3.13 Ethical Issues

This research requires the participation of various individuals to obtain relevant information regarding students' performance on REACT strategy of context-based physics instruction as well as on traditional method integrated with CBI. Therefore, as part of this study, ethical applications were made to those subjects who took part in the study.

Prior to the implementation step, the supervisor examined all the materials and measuring tools used in the study. Then, after proposal approval, the Department of Science and Mathematics Education of Addis Ababa University gave the researcher the necessary legal permissions for conducting the study. Subsequently, permission to conduct the study in the schools was sought beforehand from the study area towns' education bureaus and the principals of the schools. After clearance is received from these authorities, the researcher started conducting the study following reaching a consensus with the participating teachers and students. While conducting the research study, the researcher was conscious of the ethical issues mentioned by Fraenkel and Wallen (2000). This consists of defending participants from any sort of harm, making sure confidentiality of data and keeping away from deception of the subjects. Accordingly, the current study was designed carefully so that all the participants have been shielded from physical and psychological hurt. So, its essence and potential benefits including its objectives, the roles of learners and the teachers was thoroughly explained to the participating students and teachers. The need to use an audio recorder during an interview was explained and permission was sought from them. It was also guaranteed that nobody else has the right to use to the data collected for this research, and thus all the data collected during the study was stored in a safe place. Furthermore, a code was used for recording data from all the participants. Hence, participating teachers and learners was assured of the anonymity and extent of confidentiality of the study results. Deception issue was not of concern for this study. While marking and processing the data, efforts were also made to lessen the possibility of the researcher bias by showing it to colleagues.

CHAPTER FOUR: RESULTS AND DISCUSSION

In an attempt to seek response to the research questions, this chapter discusses the analysis of all the data collected before and after the implementation of context-based instructional approaches (CBIAs). The chapter starts with the quantitative data analysis through first providing information about students pre-existing differences and checking whether the quantitative data meet the assumptions of the statistical procedure used. Then, the results obtained after performing MANCOVA analysis were presented. In addition to these, follow-up ANCOVAs had been computed to analyze the instructional methods effect, separately, on every of the dependent variables. The qualitative part that provided detailed thematic analysis of post-intervention interview transcripts to explore students' and teachers' views of CBIAs was, then, presented. This is necessary for refining, broadening or clarifying the general picture of the research problem. This is, then, accompanied via the triangulation of the quantitative and qualitative outcomes in detail under the discussion section with reference to prior research.

4.1 Students Pre-existing Differences

So as to reveal whether there was any significant difference across the groups or not at the start of the study, the CU test, the PSS test and the ACQ were administered to students of the two treatment groups and the comparison group as pre-test. But, since the students did not learn the topics, they are not expected to score high marks in the pre-test. Thus, the mean score results obtained after administering the instruments as a pre-test were tabulated as shown in Table 6 with respect to the three groups and gender.

Table 6: Cross-tabulation of gender versus groups on pre-test scores

		Group								
		Treatment group I			Treatment group II			Comparison group		
		N	*M*	*SD*	*N*	*M*	*SD*	*N*	*M*	*SD*
Pre-CU scores										
	M	31	2.97	1.44	28	3.23	1.21	35	2.57	1.19
Gender	F	22	2.79	1.12	28	2.67	0.99	22	2.25	1.52
	Total	53	2.9	1.3	56	2.95	1.13	57	2.45	1.33
Pre-PSS scores										
	M	31	0.90	.29	28	0.62	.33	35	0.22	.26
Gender	F	22	0.36	.25	28	0.28	.27	22	0.18	.26
	Total	53	0.63	.29	56	0.43	.31	57	0.20	.26
Pre-affective scores										
	M	31	186.32	17.21	28	191.54	18.41	35	195.71	19.17
Gender	F	22	183.55	20.66	28	185.29	21.2	22	190.68	15.01
	Total	53	185.17	18.58	56	188.41	19.92	57	193.77	17.71

As can be seen in Table 6, the mean of students' pre-CU scores for the comparison group is 2.45 whereas it corresponds to 2.9 in the treatment group I and 2.95 in treatment group II. The mean of the students' pre-PSS scores of students in the comparison group is 0.20 whereas it is 0.63 in the treatment group I and 0.43 in the treatment group II. Once more, when we look at the students pre-affective scores, it is observed that the pre-affective mean scores for treatment group I students' is 185.17 and that of treatment group II is 188.41 where it correspond to 193.77 for the comparison group students.

To determine whether the difference between students' pre-test mean scores were statistically significant or not, ANOVA was conducted. To do this, initially, it was useful to check for the normality assumptions of each of the pretest scores. For checking the assumption of normality, skewness and kurtosis values have been determined. According to George and Mallery (2003), a range of values between -2 and +2 can guarantee the assumption of normality. Given that the skewness and kurtosis values obtained from the pre-test scores in every of the groups and sub-groups were found to be in the mentioned range, the assumptions of normality had not been violated. Thus, the result obtained after running the ANOVA is presented in Table 7.

Table 7: Mean comparison of pre-test scores by groups

Variable	*Sum of Squares*	*df*	*Mean Square*	*F*	*p*
Pre-CU scores					
Between Groups	8.62	2	4.31	2.72	.069
Within Groups	257.92	163	1.58		
Total	266.55	165			
Pre-PSS scores					
Between Groups	1.36	2	.68	8.15	.000
Within Groups	13.56	163	.08		
Total	14.91	165			
Pre-affective scores					
Between Groups	2087.13	2	1043.57	2.97	.054
Within Groups	57351.06	163	351.85		
Total	59438.19	165			

The analysis results confirmed that there had been no statistically significant mean differences between the groups on the pre-test CU scores (F (2,163) = 2.72, p = .069) as the p-value obtained is above .05. So, prior to the intervention, groups were almost similar in their mean CU scores. However, the results of the analysis showed the existence of a statistically significant mean difference between the groups on the pre-PSS scores (F (2,163) = 8.15, p = .000) although the mean difference between the groups looks small. The result of Tamhane's T2 post-hoc tests showed that the pre-test PSS mean scores of the two treatment groups were significantly higher than the mean scores of the comparison group. On the other hand, with regard to students' pre-affective scores, no statistically significant mean difference (F (2,163) = 2.97, p = .054) between the groups was observed. Furthermore, before the treatment, the mean of male students looks slightly greater than those of female students in every of the groups' for each of the assessed variables (pre-CU scores, pre-PSS scores and pre-affective scores).

Hence, in an attempt to compensate for the non-equivalence of groups, an analysis that controls the initial differences in the pre-test mean scores should be used so that the post-test scores were analyzed against equivalent pre-test scores. As the researcher took already existing classes, the study participants were not randomly assigned to every of the groups. Thus, these already existing groups of students had been assigned randomly to the two treatments and one comparison group. According to Hinkle, Wiersma and Jurs (2003), Multivariate Analysis of Covariance (MANCOVA) has two important benefits for this type of design. In the first place, it helps to fine-tune for an already existing (prior to the research) variations between the intact groups. In the second place, it helps to increases the accuracy of the study by reducing error variances through partitioning the disparity created by the covariates. Furthermore, MANCOVA can be used to regulate one or more covariates at once (Pallant, 2007). Due to this fact, MANCOVA was used to answer the research questions raised in the first chapter of the study.

To do that, firstly, the covariates that need to be included in the inferential statistics are determined. Then, the explanation of the steps used to verify the assumptions of MANCOVA will be followed.

4.2 Identification of covariates

According to Stevens (2009) and Tabachnick and Fidell (2007), any continuous variable which is correlated theoretically with the dependent variables is considered as the study's possible covariates. Covariates help the researcher for controlling the already existing differences between the two treatment groups and comparison group. In the present study, initially it is possible to consider the students' pre-CU, pre-PSS and pre-affective scores as covariates as one expects them to correlate with the students post- CU, post-PSS and post-affective scores. However, the ANOVA analysis performed earlier showed the existence of a statistically significant mean difference between the pre-PSS scores of the groups only. Based on this result, the students' pre-PSS scores will be considered as a covariate throughout the inferential statistics.

In the second place, correlations amongst every one of the variables had been computed with an intention to observe the associations among the potential covariates and the dependent variables. Commonly, covariates are determined through considering its relation among the dependent variables; if not, it might not be effective as anticipated. One of the techniques for determining the set of covariates is first looking for the correlations among the possible covariates and then picking the proper ones from among them. Thus, the variables which should be selected as covariates must be correlated significantly with a minimum of one of the dependent variables. Furthermore, the correlations among the possible covariates should not be greater than .80 (Stevens, 2009; Tabachnick & Fidell, 2007). The correlation analysis result among the variables is presented in Table 8.

Table 8: Correlation among potential covariates and dependent variables

	Pre-CU	Pre-PSS	Pre-affection	Post-CU	Post-PSS	Post-affection
Pre-CU	1					
Pre-PSS	-.084	1				
Pre-affection	.252**	-.214**	1			
Post-CU	.427**	-.278**	.103	1		
Post-PSS	.221**	.396**	.256**	.476**	1	
Post-affection	.331**	-.267**	.819**	.290**	.366**	1

Note. **correlation is significant at the .01 level.

The examination of the correlations between the variables showed that the students' pre-CU, pre-PSS and pre-affective scores had significant correlations with a minimum of two of the dependent variables. Correlations among these variables were also not greater than .80. Thus, in the inferential analyses, considering these three variables' as covariates set appears to be appropriate. Consequently, the students pre-CU and pre-affective scores were considered as covariates in addition to the pre-PSS scores of students.

4.3 Assumptions of MANCOVA

As mentioned in the previous section, the covariates are measured prior to the intervention and they are not strongly correlated with one another. In addition to these, the covariates are also measured as reliably as possible. These ensure some of the assumptions of MANCOVA. There are also a number of additional assumptions. These assumptions are discussed in the subsequent sections under the titles: sample size, normality, equality of variances, multicolinearity, independence of observations, linearity and homogeneity of regression.

4.3.1 Sample size

In conducting MANCOVA, having a bigger sample enables the researcher to get off from the violations of other assumptions like normality. Furthermore, in each cell, it is good to have additional cases than the number of dependent variables (Pallant, 2007; Tabachnick & Fidell, 2007). In this study, there are a total of six cells because there are two levels of the independent variable (i.e., gender) in each of the three dependent variables. The number of cases in each cell is presented in the MANCOVA output. In this study, this assumption is confirmed as there are additional cases than the number of cases required per cell.

4.3.2 Normality

Before conducting multivariate analysis, evaluating both the univariate and multivariate normality of the variables is necessary (Pallant, 2007). It is possible to look for Shapiro-Wilk's test results or the skewness and kurtosis values so as to check for the normality of the continuous variables distributions. As it is discussed earlier, the values of skewness and kurtosis which are in the range of -2 and +2 can guarantee the assumptions of normality (George & Mallery, 2003). Just like the covariates, all the values associated with the dependent variables in every of the groups lies between -2 to +2 and is thus acceptable for normality assumption. In addition to this, as said by Tabachnick and Fidell (2007), 'robustness' is guaranteed with a minimum sample size of 20 in each cell. Therefore, the univariate assumptions of normality were not violated.

For multivariate normality, Mahalanobis distances were computed through the use of the regression menu in the SPSS. Mahalanobis distance refers to the location of a case from the centroid of the other cases; where the centroid is the spot which is created through the intersection of all the variables means (Tabachnick & Fidell, 2007). The computation of the value of the Mahalanobis distance enables the researcher to pick out cases which have odd score patterns across the dependent variables. In the present study, the utmost value for the Mahalanobis distance was calculated as14.51 for the dependent variables. On the other hand, according to Tabachnick and Fidell (1996), the chi-square table was hardened to find the critical value through considering the dependent variables number as the degrees of freedom. It is indicated in the table that, for three dependent variables, the critical value was expressed as 16.27. Given that the calculated maximum value for Mahalanobis distance is not greater than the critical value, no significant multivariate outliers were detected in the data. In addition to this, the new variable that appeared in the data file was sorted in order to search for the existence of any scores that exceeds the critical value. Since all the values are less than the critical value, the multivariate normality assumption was thus assured.

4.3.3 Multicollinearity and singularity

In order to get more accurate results with MANCOVA, the dependent variables are expected to be correlated moderately. A low correlation among dependent variables needs separate univariate analysis of variance to be conducted. A high correlation (.8 or above) among the dependent variables refers to multicollinearity (Pallant, 2007) and this happens when one of the variables appears as an aggregate of the other variables. This is described as singularity and might be prevented by knowing the character of our variables and how the scores are obtained. One ways of checking for multicollinearity assumptions is checking for the strength of the correlations between the dependent variables. As indicated in Table 9, no sturdy correlation was observed in between the dependent variables. Consequently, the assumptions against multicolineratiy and Singularity were met.

Table 9: Correlation between the dependent variables

	Post-CU	Post-PSS	Post-affection
Post-CU	1		
Post-PSS	.476**	1	
Post-affection	.290**	.366**	1

Note. ** Significant correlation at the .01 level.

4.3.4 Homogeneity of variance-covariance Matrices

According to Tabachnick and Fidell (2001), MANCOVA functions in a better manner whenever the variance-covariance matrices among every cell of the study are sampled from a similar population and might rationally be pooled to form one estimate of error. This is considered as the homogeneity of variance-covariance matrices assumption. So as to examine whether or not the data disobeys this assumption, Box’s test for equality of covariance matrices was once investigated as it is indicated in Table 10.

Table 10: Box's test for equality of covariance matrices

	Box's Test of Equality of Covariance Matrices
Box’s M	92.363
F	2.926
df1	30
df2	47179.263
p	.009

In view of the fact that the significance value shown in the table exceeds 0.001 (Pallant, 2006), no violation of the assumptions was observed.

4.3.5 Equality of variances

MANCOVA works based on the premise that samples have been selected from populations that have equal variances. This guarantees the similarity of the variability of scores across every of the groups. Levene's test for equality of variances is used to control this assumption. It is expected to obtain a result which is not significant for the variables. If statistically significant results were obtained, it means that the variances of groups are not identical. In the results indicated in Table 1, post-CU scores are significant, and hence the groups' variances were not identical. However, in situations where the groups' size is reasonably the same, the violation of the Levene's test assumption is somewhat robust (Pallant, 2007). Thus, the violation of this assumption is not a problem as the groups' sizes were more or less similar in the current study.

Table 11: Levene's test for equality of error variances

	F	*df1*	*df2*	*p*
Post-CU	5.706	5	160	.000
Post-PSS	1.998	5	160	.082
Post-affection	1.307	5	160	.263

4.3.6 Independence of observation

Independence of observation had been strived to be obtained through controlling students' interaction during the administration of the instruments to the students. In addition, while entering the data, all the data gathered had been checked for the violation of any of the assumptions.

4.3.7 Linearity

The assumption of linearity needs a direct association amongst every couple's of the dependent variables. Through sketching a scatter-plot matrix among every set of the dependent variables, it is possible to check the violation of this assumption (Pallant, 2007). Since the scatter plot shows a linear relationship, it was verified that the linearity assumption was not violated.

4.3.8 Homogeneity of regression

According to Pallant (2007), this assumption was used to check whether there was an interaction between the covariates and the treatments or not. This was checked through the syntax shown in appendix VII and then running it in the SPSS as it was explained by Tabachnick and Fidel (2007).

As per the explanations given by Tabachnick and Fidell (2007), the value for alpha was set to .01. The result obtained after performing the syntax showed that the regression slopes assumption was met so as to use MANCOVA (F (45,416.18) = 1. 01, p = .458, Wilks' Lambda = .735) and follow-up ANCOVAs ((F (15,142) = .97, p = .488), (F (15,142) = 1.08, p = .384) and (F (15,142) = 1.08, p = .383), respectively for post-CU, post-PSS and post-affection). So, it is possible to say that there was no statistically significant interaction among the instructional methods and the covariates.

4.4 Results of the study

4.4.1 MANCOVA Result

In view of the fact that no serious violations to the assumptions have been ascertained, two-way MANCOVA was performed with SPSS software so as to respond to the main research question. The study's main research question states that:

Would there be any differences between the groups of students taught with CBIAs and those taught with TI in their learning of rotational motion?

For responding to this research question, the main research hypothesis indicated below was stated:

There is no significant difference among students taught with CBIAs and those taught with TI in their learning of rotational motion topic.

So as to give answer for this hypothesis, MANCOVA analysis was performed. In the MANCOVA analysis, the instructional methods to which each group was exposed and students' gender are the independent variables; post-CU, post-PSS and post-affection of the students are the dependent variables are whereas students' pre-CU, pre-PSS and pre-affection served as covariates. The results obtained after performing MANCOVA statistical analysis on eleventh grade students' means of the collective dependent variables (post-CU, post-PSS and post-affection) when students' prior scores were controlled is presented in Table 12.

Table 12: Results of MANCOVA for the collective dependent variables

Source	*Wilks' Lambda*	*F*	*Hypothesis df*	*Error df*	*p*	*Eta-Squared*	*Observed Power*
Pre-CU	.845	9.460	3.000	155.000	.000	.155	.997
Pre-PSS	.909	5.183	3.000	155.000	.002	.091	.920
Pre-affection	.296	122.819	3.000	155.000	.000	.704	1.000
Group	.571	16.705	6.000	310.000	.000	.244	1.000
Gender	.949	2.798	3.000	155.000	.042	.051	.665
Group * Gender	.928	1.955	6.000	310.000	.072	.036	.716

Based on the results given in Table 12, when we look at the interaction effect between the instructional methods and gender, the Wilks' Lambda value of 0.928 had not been statistically significant (F (6,310) = 1.955, p = .036, *partial eta squared* = .036). This means that the effect of interaction among the instructional methods and gender on grade eleven preparatory school students' population mean of the collective dependent variables (post-CU, post-PSS and post-affective scores) was not statistically significant when the learners' previous scores have been controlled. The nonexistence of a significant effect of interaction enables us to interpret the main effects for each independent variable safely (Pallant 2011).

The result, thus shows that the presence of a statistically significant mean difference on the population mean of the collective dependent variables (post-CU, post-PSS and post-affective scores) of grade eleven students' (F (6, 310) = 16.705, *Wilks' Lambda* = .571, p =.000) when the effect of the students' pre-CU, pre-PSS and pre-affective scores had been controlled. The difference detected among the groups was attained from the effect of the instructional methods or the treatments. Since an eta-squared value greater than

0.14 is said to be large (Cohen, 1988), the value of the partial eta-squared found in this study (0.244) corresponds to large effect size. It indicates that 24.4% of the variability in the dependent variables is expressed by the instructional methods independent variable. In addition to the effect size discussed earlier, the observed power (1.00) of the study implied that the detected difference across the treatment groups and comparison group was absolutely associated to the interventions effect. Furthermore, such a value also implied the practical significance of the effect of the applied instructional methods. The outcomes obtained from the observation checklist rating conducted in the treatment groups showed that the instructional methods put into action in both treatment groups were in accordance with the features of the context-based instructional approaches as the teachers employed the instructional methods with more than 85% of the listed criteria's in every phases of the instructions. As a result, the study's main research hypothesis was thus rejected as there was a statistically significant mean difference between the groups of students taught with CBIAs and those taught with TI in their learning of rotational motion topic.

On the other hand, when we investigate the instructional methods effect on gender, the results also showed the existence of a statistically significant mean difference among male and female students with respect to collective dependent variables post-CU, post-PSS and post-affective scores of grade eleven students' (F (3, 155) = 2.798, *Wilks' Lambda* = .949, p = .042) when the effect of students' pre-CU, pre-PSS and pre-affective scores were managed. For the difference detected among male and female students, the calculated eta-squared value was .051. This value showed that 5.1 % of the multivariate variance on collective dependent variables had been related with gender.

It was also indicated in the Table that the covariates, specifically pre-CU score (*Wilks' Lambda* = .845, *F* (3,155) = 9.460, *p* = .000, *partial eta squared* = .155), pre-PSS score (*Wilks' Lambda* = .909, *F* (3,155) = 5.183, *p* = .002, *partial eta squared* = .091) and pre-affective score (*Wilks' Lambda* = .296, *F* (3,155) = 122.819, *p* = .000, *partial eta squared* = 1.000) had played a crucial role in making adjustments on the dependent variables. This indicates that the groups are equated with each other since the covariates had trimmed off the initial differences between the groups.

Since there are three dependent variables, it is crucial to perform follow-up univariate analyses to spot the place where the significant differences lies (Pallant, 2011). One way of doing this is to perform univariate analyses of covariance (ANCOVA) as follow-up tests to MANCOVA on each of the dependent variables that have been observed as significant in the MANCOVA. Within the one-way ANCOVA analysis, it is necessary to run post-hoc tests for a variable that have three levels. According to Tabachnick and Fidell (2007), while running separate univariate tests, a Bonferroni type correction is needed for the inflated Type I error. Type I error, conjointly called a "false positive" a type of error of no longer accepting a null hypothesis when it is actuality true. Alternatively, it is the error of accepting an alternative hypothesis when the results can be attributed to chance. To find the adjusted alpha value, it is suggested by Tabachnick and Fidell (2007) to divide the value of alpha (commonly set at .05) by the number of dependent variables or separate univariate tests. Consequently, for the univariate tests, the alpha value is set at .017. This is attained by dividing .05 alpha values by the number of dependent variables, i.e., 3. The following section presents the results of ANCOVA for each of the dependent variables.

4.4.2 ANCOVA Results

ANCOVA performed to find out the instructional methods effect on post-CU scores of students' showed the existence of no significant effects of interaction among the instructional methods and gender (F (2,159) = 1.395, p = .251, *partial eta squared* = .017). Since the effect of the interaction is not statistically significant, it is possible to move on to assess the main effects of the interventions so as to answer the first research question. The first research question to which an answer was sought in the current study was that:

> *RQ1: Would there be any differences in the students' acquisition of rotational motion concepts among the students taught with CBIAs and those taught with TI?*

For answering this research question, the subsequent hypothesis was stated.

> ***H_{o1}:*** *There is no significant difference among students taught with CBIAs and those taught with TI in their acquisition of rotational motion concepts.*

The results of testing this hypothesis showed that the main effect comparing the groups showed the existence of a statistically significance difference among the students' post-CU scores of the groups when the effect of their pre-CU scores were controlled (F(2,159) = 41.859, p = .000). The result of the analysis is indicated in Table 13.

Table 13: Results of ANCOVA for post-CU scores

Source	*df*	*F*	*p*	*Partial Eta squared*	*Observed power*
Corrected Model	6	23.440	.000	.469	1.000
Intercept	1	142.590	.000	.473	1.000
Pre-CU	1	31.906	.000	.167	1.000
Group	2	41.859	.000	.345	1.000
Gender	1	.009	.923	.000	.051
Group * Gender	2	1.395	.251	.017	.296

It was, thus, observed that there was an association among the students' post-CU scores and the instructional methods that had been used. To investigate the instructional methods (treatments) effect size on the significant mean differences among the two treatment groups and comparison group post-test scores, the value computed for the partial eta squared was analyzed. The partial eta-squared value found in this study is .345 and it corresponds to a large effect size as per the guidelines given in Cohen (1988). This indicates that 34.5% of the variability in dependent variable is associated with the instructional methods used. This shows that the instructional methods used had a considerable effect on the post-test mean scores of the groups. Besides the effect size, the observed power (1.000) shown in the table signifies the practical importance of the effect of the treatments, too. This signifies that the instructional methods had benefitted the students of the treatment groups when compared to those found in the comparison group. In addition to this, the adjusted post-CU means scores of the students presented in Table 14 also shows that this difference is in favor of the two treatment groups. The descriptive statistics of the post-CU scores of each of the groups was presented in Table 14.

Table 14: Cross-tabulation of gender versus groups on post-CU scores

		Group											
		Treatment group I				Treatment group II				Comparison group			
		N	*M*	M_a	*SD*	*N*	*M*	M_a	*SD*	*N*	*M*	M_a	*SD*
Gender	M	31	7.78	7.62	3.12	28	8.38	8.03	2.57	35	4.97	5.12	1.46
	F	22	7.78	7.76	1.9	28	8.61	8.68	2.73	22	4.04	4.43	1.49
	Total	53	7.78	7.69	2.66	56	8.5	8.35	2.63	57	4.61	4.77	1.53

Note. M_a = adjusted mean

Thus, the students taught with CBIAs significantly scored higher CU mean scores than those taught with traditional teaching method when their previous score is controlled. As a result, there is no sufficient data to accept hypothesis H_{o1} which states about the existence of no significant mean differences between students taught with CBIAs and those taught with TI in their acquisition of rotational motion concepts.

In order to identify the group which has performed better, Bonferonni test, which is one type of post hoc test, was employed on the adjusted post-test means because of the existence of more than two groups. According to Pallant (2011), the term ‘adjusted’ is used to denote that the impact of the covariate has been statistically eliminated. Hence, to ascertain the observed differences source, the Bonferroni test result was reviewed and is presented in Table 15.

Table 15: The results of Bonferroni test according to the adjusted post-CU scores

(I) Group	(J) Group	*Mean Difference (I-J)*	*Std. Error*	*p*
Comparison group	Treatment group I	-2.915	.420	.000
	Treatment group II	-3.580	.413	.000
Treatment group I	Treatment group II	-.666	.412	.323

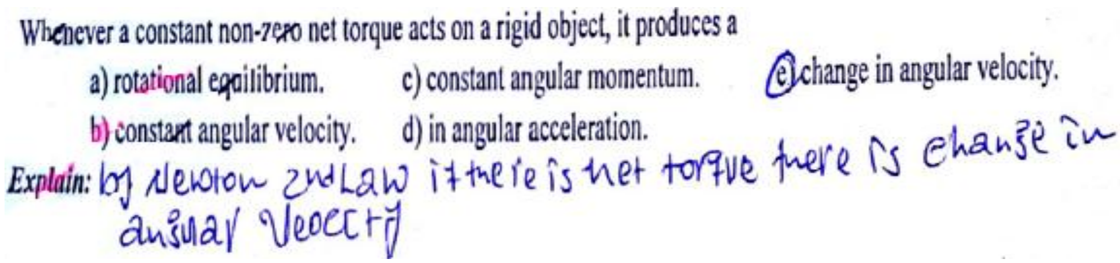
According to the adjusted post-test score results in the Bonferroni test, the adjusted post-CU mean scores of the treatment group students taught with the TI integrated with CBI (M_a = 8.35) was higher than both the groups with the REACT strategy of CBI (M_a = 7.69) and the traditional learning method (M_a = 4.77). In a similar manner, the post-test mean scores of the group taught with the REACT strategy of CBI was significantly larger than the group taught with the traditional instruction. Even though the groups taught with the traditional method integrated with the REACT strategy of CBI acquired better understanding of concepts than the groups taught with REACT strategy of CBI, a statistically significant difference was not observed between the performances of the students in the two treatment groups.

On the other hand, as it is indicated in table 14, the students grand post-CU score was below the average although it is better than those found in the comparison group. This is because students have encountered a problem in answering the conceptual items. When we closely look at the students performance in the understanding test with respect to the conception levels used for quantifying the scores, the percentage of students who are in the category of sound understanding was not that much satisfactory. Table 16 shows the percentage of students' conception levels across the groups on the rotational motion concepts.

Table 16: Percentage of students' conception levels across the groups

	Treatment group I	Treatment group II	Comparison group
No Understanding	29	27	35.5
Specific Misconception	23	22	30
Partial Understanding	28	24	32
Sound Understanding	20	26	1.5

Although it varies from item to item, on average, around 20% of treatment group I students and 26% of treatment group II students have a sound understanding on the rotational motion concepts. These numbers are bigger when compared to the percentage of students (1.5%) found in the comparison group who have a sound understanding. These are students who supported their correct response to the first-tier with right explanations as shown in figure 6.


Whenever a constant non-zero net torque acts on a rigid object, it produces a

a) rotational equilibrium. c) constant angular momentum. e) change in angular velocity.

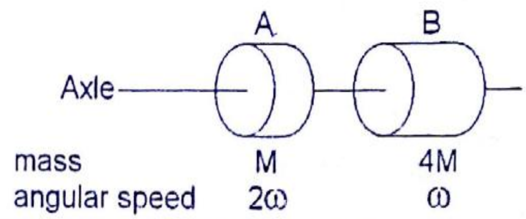
b) constant angular velocity. d) in angular acceleration.

Explain: by Newton 2nd Law if there is net torque there is change in angular Veocety

Figure 6: Sample student's response to item 2 of the CU test

On the other hand, students with partial understanding are those who answered the first-tier correctly without giving any explanations. This is evident in the following sample student's response.

Two copper disks (labeled "A" and "B") have the same radius but disk B is thicker with four times the mass of disk A. They spin on frictionless axles. If disk A is rotating twice as fast as disk B, which disk has more rotational kinetic energy?



a) The faster rotating disk A.
b) The thicker disk B.
c) It depends on the actual numerical values of the angular speeds of the disks.
d) Both disks have the same rotational kinetic energy.
e) None of the above.

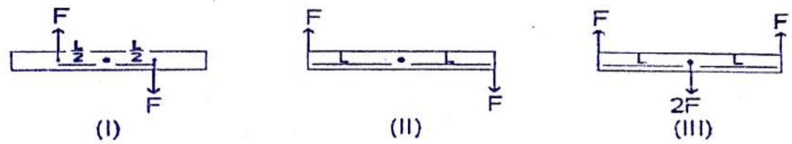
Explain:

Figure 7: Sample student's response to item 3 of the CU test

Those who answered the first-tier wrongly but with correct explanations are also categorized in this range. Almost one-third of the students are found in this range. Majority of the students which are found in this category are students who hesitate to support their answers to the first-tier with explanations. This could have a big effect in making the students grand post-CU score to become below the average. On the other hand, those students who responded the first-tier correctly but with a wrong reason are categorized under specific misconception.

A considerable number of students in the treatment groups as well comparison group had also responded to both tiers with wrong answers as shown in figure 8.

Rank order the three cases according to the angular acceleration of the rigid rod of length 2L about an axis passing through its center and perpendicular to the paper, largest first. All forces labeled F have the same magnitude.

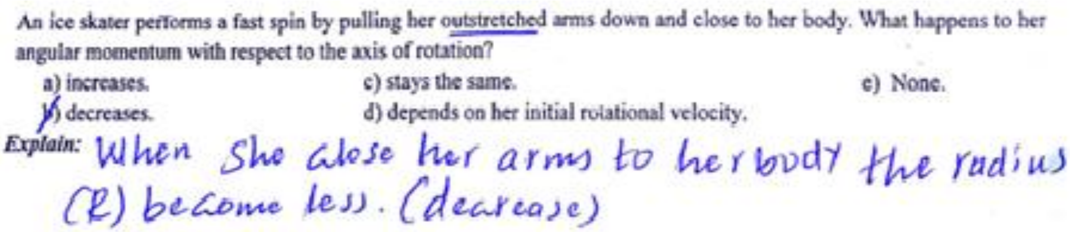


a) (I) = (II) > (III).
b) (I) > (II) > (III).
c) (II) > (I) > (III).
d) (II) > (III) > (I).
e) The angular acceleration is zero in all three cases.

Explain: b/c All are the same magnitude. there is no Velocit

Figure 8: Student's response to item 17 of the CU test

These are students that have poor understanding of the target rotational motion concepts. The students that gave no explanations for their wrong response to the first-tier were also found under this category. However, the percentage of students that fall in this category is bigger in the comparison group when compared to those found in the treatment groups. Majority of these students scored lower results in items which are related to the concepts of speed/velocity, rotational kinetic energy, torque, angular acceleration, friction and angular momentum. For instance, item 18 of the CU test asks students about the concept of an angular momentum for an ice skater that performed a speedy spin through pulling her extended arms down near to her body. If the students were asked to state the law of conservation of angular momentum, they can easily state it. They did this in the PSS test. However, these students fail to properly apply/use the theoretical knowledge they know to the conceptual problem given to them. This is evident in sample student's response shown below.



An ice skater performs a fast spin by pulling her outstretched arms down and close to her body. What happens to her angular momentum with respect to the axis of rotation?

a) increases. c) stays the same. e) None.

b) decreases. d) depends on her initial rotational velocity.

Explain: When she close her arms to her body the radius (R) become less. (decrease)

Figure 9: Student's response to item 18 of the CU test

The second research question was about the instructional approaches effect on students' gender. It is stated as:

> *RQ2: Would there be any differences among male and female students exposed to CBIAs in their acquisition of concepts?*

This question was answered through testing the following null hypothesis.

> ***H_{o2}:*** *There is no significant difference among male and female students exposed to CBIAs in their acquisition of concepts.*

The results of testing this hypothesis indicated that the effects of the instructional methods on gender was not statistically significant on students' CU aggregate mean scores when the students' prior CU scores effect are controlled (F (1,159) = .009, p = .923, *partial eta squared* = .000). Furthermore, the difference among male and female learners' was not statistically significant for each of the groups. According to Pallant (2011), plots are very useful for visually inspecting the relationship among the variables. The plot showed in figure 10 illustrates the results of ANCOVA for interaction effects of post-CU scores. It is apparent from the plot that the CBIAs contribute to both male and female students' post-CU scores better than their peers found in the comparison group. Thus, it can be stated that the CBIAs are valuable for both male and female students in terms of post-CU scores. As a result, hypothesis H_{o2} of the study was, thus, accepted as there was no significant difference was observed among male and female students taught with CBIAs in their rotational motion concepts acquisition. However, the students who have been taught with the integrated method had a better gain when compared to the students who have been taught with the purely CBI. Conversely, that much variation was not noticed on the performance of male students found in the two treatment groups.

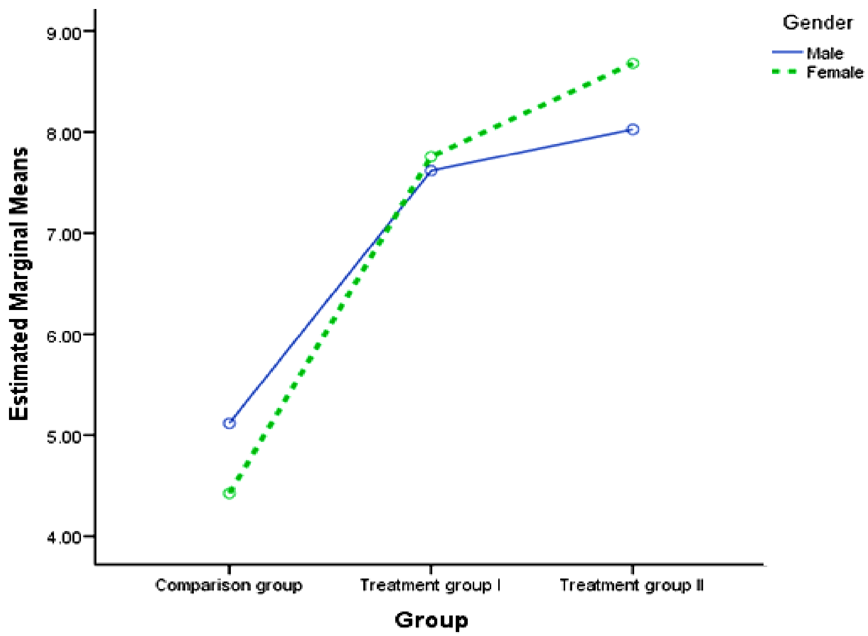


Figure 10: Interaction plot for post-CU score

As before, ANCOVA was again performed so as to analyze the effect of the instructional methods and gender on learners PSS scores when the effects of students' prior score was controlled. The result is presented in Table 17 below.

Table 17: ANCOVA results for post-PSS scores

Source	*df*	*F*	*p*	*Partial Eta squared*	*Observed power*
Corrected Model	6	7.72	.000	.226	1.000
Intercept	1	258.14	.000	.619	1.000
Pre-PSS	1	21.61	.000	.120	.996
Group	2	2.38	.096	.029	.476
Gender	1	6.23	.014	.038	.699
Group * Gender	2	2.40	.093	.029	.480

ANCOVA results shows that the interaction effect of the instructional methods with gender is not statistically significant (F (2,159) = 2.409, p = .093, *partial eta squared* = .029). The result indicated in the table can be used to answer research questions 3 shown below.

> *RQ3: Would there be any differences in the students' skills of solving problems related to rotational motion among the students taught with CBIAs and those taught with TI?*

This research question is tested through the use of null hypothesis H_{o3} below:

> ***H_{o3}:*** *There is no significant difference among students exposed to CBIAs and those exposed to TI in their skills of solving problems related to rotational motion.*

The result in Table 17 indicates that the difference among the post-PSS mean scores of grade 11 learners learning of rotational motion were not statistically significant when the effects of their prior PSS scores are controlled (F (2,159) = 2.38, p = .096, *partial eta squared* = 0.029). Nevertheless, the adjusted post-test mean scores of the two treatment groups (M_a = 8.7 and M_a = 9.24 for treatment group I and II students, respectively) were greater than the comparison group (M_a = 7.83) as it is indicated in Table 18.

Table 18: Cross-tabulation of gender versus groups on post-PSS scores

		Group											
		Treatment group I				Treatment group II				Comparison group			
		N	*M*	M_a	*SD*	*N*	*M*	M_a	*SD*	*N*	*M*	M_a	*SD*
Gender	M	31	9.83	8.99	3.89	28	9.92	9.48	4.37	35	8.87	9.33	3.02
	F	22	8.33	8.40	3.34	28	8.73	9.01	2.87	22	5.74	6.32	3.74
	Total	53	9.21	8.70	3.71	56	9.32	9.24	3.71	57	7.67	7.83	3.62

The value of the partial eta-squared found for this variable (0.029) corresponds to an effect size of small to medium (Cohen, 1988), and it signifies that only 2.9% of the variability in the dependent variable is elucidated by the independent variable, instructional method. On the contrary, the observed power (0.476) of the variable under investigation shows the slight significance of the instructional methods used. This signifies that, although it was not statistically significant, the students in the treatment groups had slightly benefitted from the treatments or the instructional methods as compared to the students in the comparison group. Thus, as compared to the TI groups, the groups who were learnt with CBIAs acquired comparatively better PSS skills. But, since it was not statistically significant, hypothesis H_{o3} was not rejected.

On the other hand, the PSS performance of the students who were taught with the traditional method integrated with the REACT strategy of CBI is somewhat better than the performance of the students who were taught with the REACT strategy of CBI. However, this difference was not again statistically significant.

When we closely look at the learners' post PSS mean scores, it can be observed that the learners in each groups have a trouble in properly exploiting the rubric used in this study so as to assess learners PSS. The post-test mean scores of the learners on the PSS rubric are shown in Table 19.

Table 19: Students post-test mean scores in PSS rubric

	Treatment group I	Treatment group II	Comparison group	Total mean
Useful Description	0.56	0.45	0.44	0.48
Physics Approach	0.19	0.24	0.11	0.18
Specific Application	0.7	0.67	0.64	0.67
Mathematical Procedures	0.57	0.63	0.51	0.57
Logical Progression	0.31	0.31	0.21	0.28

As it is indicated in Table 19, learners in each of the groups have a trouble in properly using every of the rubric levels. They are observed when performing the best in specific applications as well as mathematical procedures; and the lowest in the physics approach as well as logical progression part of the rubric. This shows that learners use arithmetical formulas and associated specific applications for solving problems related to rotational motion devoid of giving much attention to the useful description, physics approach and logical progression parts. These results have been published by the researcher and the supervisor.

On the other hand, students were also observed having intricacy in solving of problems that needs concepts besides manipulation of equation. This is because when learners are faced with simple problems like item 3 of the PSS test, they easily solve it using the traditional way of solving problems. Conversely, if the problem entails them to use some sort of concept rather than the direct use of the formula like item 4 of the PSS test which state that ‘A disk having mass m and radius R is rotating with angular speed of ω around an axis which passes through the rim of the disk that is at right angles to its plane. The value for the moment of inertia about the center of mass is $I_{CM} = mR^2/2$. What is its total kinetic energy?’, majority of the students specially those in the comparison group failed to solve it. The question is answered by making use of the concept of the parallel axis theorem. Nevertheless, majority of the students solved this problem as shown in the following sample example without using the concept of the parallel axis theorem.

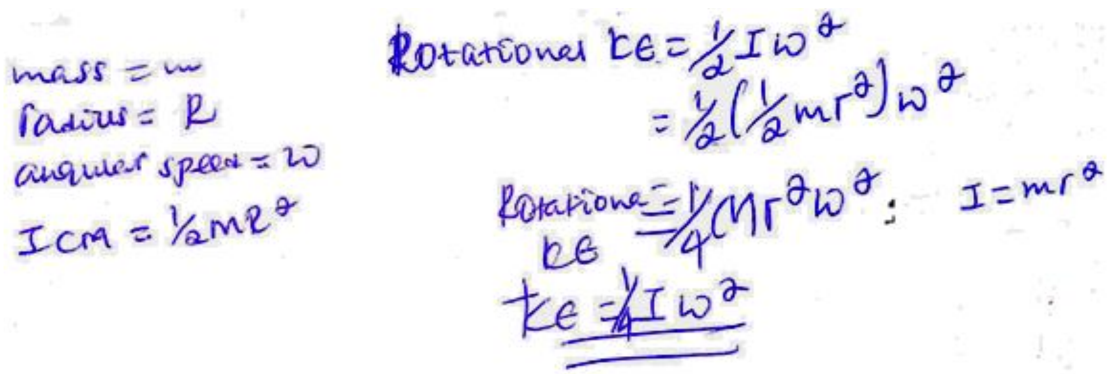


Figure 11: Student's solution to item 4 of PSS test

Similarly, in item 5 of the PSS test where the students were asked to solve the question ‘A skater is rotating at an angular speed of $32\,{rad}/{s}$ by outstretching her arms and legs outward. In this location, her moment of inertia about the vertical axis through which she is rotating is $45.6kgm^2$. When she pulls her arms and legs near to her body, the value for the moment of inertia changed to $17.5kgm^2$. What is her new angular velocity?’, there are students that tried to solve the problem using crisscross as shown in the sample example below instead of applying the law of conservation of angular momentum $(i.e., I_{initial}\omega_{initial} = I_{final}\omega_{final})$.

$$\frac{w_1 I_2}{I_2} = \frac{w_2 I_1}{I_1}$$

$$w_2 = \frac{w_1 I_2}{I_1} = \frac{32\,rad/s \times 17.5\,kgm^2}{45.6\,kgm^2}$$

$$= \frac{560}{45.6}\,rad/s = \underline{\underline{12.28\,rad/s}}$$

Or simply

$$32\,rad/s = 45.6\,kgm^2$$
$$w_f = 17.5\,kgm^2$$
$$w_f = \frac{32\,rad/s \times 17.5\,kgm^2}{45.6\,kgm^2}$$
$$= \underline{\underline{12.28\,rad/s}}$$

Figure 12: Student's solution to item 5 of PSS test

The fourth research question for which an answer was sought in the current study was about the effect of the approaches on students' gender. This is stated as:

> *RQ4: Would there be any differences among male and female students exposed to CBIAs in their skills of solving problems?*

The null hypothesis that is stated to answer the above research question is that:

> ***H_{o4}:*** *There is no significant difference between male and female students exposed to CBIAs in their skills of solving problems.*

The instructional methods effects on gender were statistically significant on students' post-PSS scores when the learners' prior PSS scores effects are controlled (F (1,159) =

6.234, *p* = 0.014, *partial eta squared* = .038). The closer inspection of the effects of the treatment or the instructional methods on gender on each of the three groups showed the existence of a statistically significant mean differences among male and female learners found in the comparison group only (F (1, 54) = 12.463, p = 0.001, partial eta squared = .188). The gap among male and female learners was, thus, larger in the comparison group favoring male learners in post-mean scores. On the contrary, an inspection of the post-PSS mean scores showed the significance of CBIAs to both male as well as female learners' even though the scores of the learners' are bigger in the second treatment group.

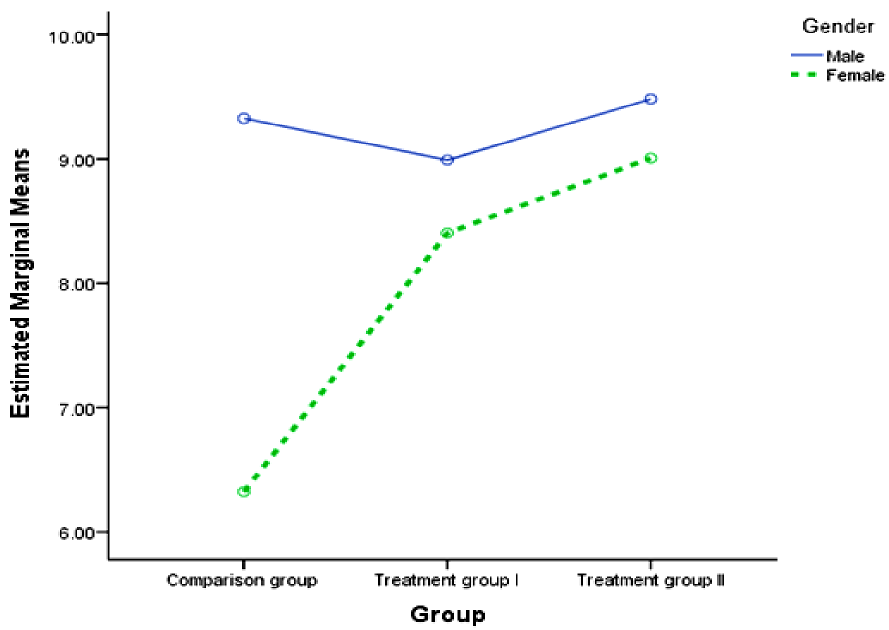


Figure 13: Interaction plot for post-PSS score

This is also clearly indicated in the plot shown in figure 13 displaying the results of ANCOVA for interaction effects of post-PSS scores. Consequently, hypothesis H_{o4} was not rejected as there was no significant differences was detected among male and female learners' who were taught with CBIAs in their problem solving skills, and thus it is possible to declare the significance of the approaches for both male as well as female students. This result has already been published by the researcher and the supervisor.

In addition to CU and PSS scores, follow-up ANCOVA was again performed in order to find out the effect of the instructional methods on post-affective scores of the students' when the effect of their prior-affection scores are controlled. One of the research questions that need to be addressed with regard to students' affection is that:

RQ5: Would there be any differences in the students' affections towards physics in general and rotational motion in particular among the students exposed to CBIAs and those exposed to TI?

This would be answered through testing the following null hypothesis:

Ho5: There is no significant difference between students exposed to CBIAs and those exposed to TI in their affections towards physics in general and rotational motion in particular.

As indicated in Table 20, it looks as if there is a slight mean difference on the interaction effect of the instructional methods and gender (F (2,159) = 3.296, p = .040, *partial eta squared* = .040), but that had not been statistically significant at the .017 level of significance. Hence, the result shown in table 20 could be safely interpreted. Thus, the result illustrates the existence of a statistically significant mean difference among the post-affective scores of the groups when the students' prior affection score effects were controlled (F (2,159) = 29.083, p = .000, *partial eta squared* = .268).

Table 20: ANCOVA results for post-affective scores

Source	*df*	*F*	*P*	*Partial Eta squared*	*Observed power*
Corrected Model	6	85.292	.000	.763	1.000
Intercept	1	36.184	.000	.185	1.000
Pre-affection	1	461.568	.000	.744	1.000
Group	2	29.083	.000	.268	1.000
Gender	1	2.917	.090	.018	.397
Group * Gender	2	3.296	.040	.040	.619

For the students' post-affections, the calculated value for the observed power is 1.0. This signifies that, for the present study, the likelihood of spotting a true effect when the effect presents is large enough. Moreover, the calculated value for the effect size was as 0.268 for students' affection and this corresponds to an effect size of large as described in Cohen (1998). This result has revealed the realistic importance of the study's outcomes as it has both the statistical as well as practical significance. When the students' adjusted means of the post-affective scores presented in Table 21 is investigated, it can be deduced that this variation is in favor of the two treatment groups.

Table 21: Cross-tabulation of groups versus gender on post-affective scores

		Group											
		Treatment group I				Treatment group II				Comparison group			
		N	*M*	M_a	*SD*	*N*	*M*	M_a	*SD*	*N*	*M*	M_a	*SD*
Gender	M	31	195.26	197.6	12.8	28	203.79	201.91	16.5	35	197.46	192.2	18.3
	F	22	194.55	199.13	21	28	197.18	200.36	20.1	22	186.14	184.95	16.4
	Total	53	194.96	198.37	16.6	56	200.48	201.13	18.6	57	193.09	188.58	18.3

Therefore, relative to the TI group, the group taught with the CBIAs had better affections towards physics in general and rotational motion in particular, and hence there is no sufficient data to accept hypothesis H_{o5} because of the existence of a significant difference between students taught with CBIAs and those taught with TI. So, it can be deduced that the learners who have been learnt through CBIAs generated a more positive affections towards physics than those learners who have been taught with the traditional method when the scores of the students previous affective were controlled.

The Bonferroni post hoc test result conducted for answering this research question shows that the adjusted post-test mean scores of the group with TI integrated with a CBI (M_a= 201.13) were higher than those of both the groups with the REACT strategy of CBI (M_a= 198.37) and the conventional learning method (M_a=188.58). Table 22 indicates the results of the Bonferroni test in accordance with the adjusted post-affective scores.

Table 22: Results of the Bonferroni test according to the adjusted post-affective scores

(I) Group	(J) Group	*Mean Difference (I-J)*	*Std. Error*	*p*
Comparison group	Treatment group I	-9.789	1.768	.000
	Treatment group II	-12.558	1.714	.000
Treatment group I	Treatment group II	-2.768	1.731	.335

As it is observed in the Table, the group which was taught with the traditional method integrated with the REACT strategy of CBI had better affections than group taught with the REACT strategy of CBI. But, this variation among the groups was not statistically significant. On the other hand, the post-test mean scores of the group taught with the REACT strategy of CBI was significantly larger than the mean scores of the TI learning group.

The other research question for which an answer was sought was about the approaches effect on students' gender in their affective scores:

RQ6: Would there be any differences among male and female students exposed to CBIAs in their affections towards physics in general and rotational motion in particular?

This question was answered through testing the following null hypothesis.

***H_{o6}*:** *There is no significant difference among male and female students exposed to CBIAs in their affections towards physics in general and rotational motion in particular.*

The results of testing this hypothesis indicates that the instructional methods effect on gender was not statistically significant on the population means of the post-affective scores of grade eleven students when their prior-affective scores effects are controlled (F (1,159) = 2.917, p = .090, *partial eta squared* = .018). However, a statistically significant mean difference was again observed among male and female students found in the comparison group (F (1, 54) = 8.364, p = .006, *partial eta squared* = .134). These differences are also evident in the post-affective scores plots shown in figure 14. The plot also shows the importance of CBIAs to both male and female students' post-affective scores even though the affective scores of the students are larger in the second treatment group. The descriptive statistics also showed that the mean gain scores of the post-affective scores are bigger for female students found in the treatment groups. However, female students' affective scores are higher in the first treatment group when compared to those found in the second treatment group. Generally speaking, it is possible to state that the CBIAs are effective for both genders in developing positive affection toward physics. Therefore, hypothesis H_{o6} was accepted as there was no significant difference between male and female students taught with CBIAs in their affections towards physics in general and rotational motion in particular.

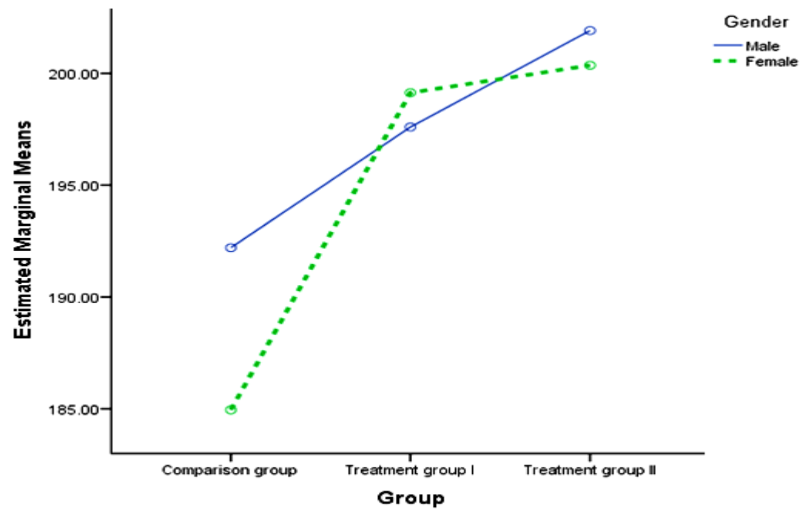


Figure 14: Interaction plot for post-affective score

As mentioned previously, the students' affection towards physics in general and rotational motion in particular was measured using ACQ. In the multidimensional model discussed in chapter 2, the affective characteristics are clustered under two separate latent variables of attitudinal and motivational variables. The attitudinal variable contains four constructs (i.e., situational interest, personal interest, asp. extra activities and importance of physics) while the motivational variable contains five constructs (i.e., self-efficacy, self-concept, achievement motivation, student motivation and anxiety).

To find out whether or not there was a significant mean difference among the groups and gender on the students' scores of these two sub-dependent variables (i.e., attitude and motivation), MANCOVA was performed after the preliminary testing of the assumptions showed no serious violations. The results are given in table 23.

Table 23: MANCOVA results for post-affective variable

Source	*Wilks' Lambda*	*F*	*Hypothesis df*	*Error df*	*P*	*Eta-Squared*	*Observed Power*
Pre-attitude	.635	45.087	2.000	157.000	.000	.365	1.000
Pre-motivation	.537	67.742	2.000	157.000	.000	.463	1.000
Group	.736	13.027	4.000	314.000	.000	.142	1.000
Gender	.979	1.724	2.000	157.000	.182	.021	0.358
Group * Gender	.949	2.100	4.000	314.000	.081	.026	0.621

By making through the use of a Bonferroni adjusted alpha value of 0.017, the results given in table 23 indicated the existence of a statistically significant mean differences among the groups based on the collective dependent variables of attitude and motivation, F (4, 314) = 13.027, p = .000; *Wilks' Lambda* = .736. This result signifies that students in the two treatment groups and comparison group had a statistically significant mean difference with regard to the variables of attitude and motivation following the treatments. To disclose the variable of affection which had significant difference, follow up ANCOVAs were conducted. Table 24 presents the ANCOVA regarding these sub-dependent variables.

Table 24: ANCOVA results for post-attitudinal and post-motivational scores

Variable	Source	*df*	*F*	*p*	*Partial Eta squared*	*Observed power*
	Corrected Model	6	40.732	.000	.606	1.000
	Intercept	1	55.214	.000	.258	1.000
Attitude	Pre-attitude	1	213.599	.000	.573	1.000
	Group	2	15.028	.000	.159	.999
	Gender	1	4.971	.027	.030	.601
	Group * Gender	2	.611	.544	.008	.151
	Corrected Model	6	49.498	.000	.651	1.000
	Intercept	1	35.446	.000	.182	1.000
Motivation	Pre-motivation	1	270.424	.000	.630	1.000
	Group	2	13.122	.000	.142	.997
	Gender	1	.452	.502	.003	.103
	Group * Gender	2	3.660	.028	.044	.668

This time, with the use of a Bonferroni adjusted alpha value of .025 (obtained by dividing the value of alpha by the dependent variables number), the follow-up ANCOVA results revealed that the instructional methods had a statistical significance effect on attitudinal (F (2, 159) = 15.028, p = .000) and motivational (F (2, 159) = 13.122, p = .000) variables as expected. The Bonferroni test conducted to see the source of the difference on the adjusted students' posttest scores is presented in table 25.

Table 25: Bonferroni test results post-attitudinal and post-motivational scores

Variable	(I) Group	(J) Group	*Mean Difference (I-J)*	*Std. Error*	*P*
Attitude	Comparison group	Treatment group I	-4.619	1.186	.000
		Treatment group II	-6.022	1.136	.000
	Treatment group I	Treatment group II	-1.403	1.152	.675
Motivation	Comparison group	Treatment group I	-4.309	1.244	.002
		Treatment group II	-6.091	1.218	.000
	Treatment group I	Treatment group II	-1.782	1.229	.448

Based on the adjusted post-affective score results in the Bonferroni test, the adjusted post-test mean scores of the group taught with the TI integrated with a CBI as well as the REACT strategy of CBI were significantly bigger than the group taught with the traditional instruction for each of the two variables. Thus, the treatment groups' learners' attitude and motivation to learn physics in general and rotational motion in particular had been positively affected as a statistically significant mean differences was detected among the two treatments and comparison groups with regard to the attitudinal and motivational variables. Additionally, when the attitudinal and motivational variables mean scores of male and female students are examined, both of them had not changed across gender in statistically significant ranges as a result of the effect of the instructions (F (2, 157) = 1.724, p = .182; *Wilks' Lambda* = .979).

4.4.3 Learners' and Teachers' Views about Context-Based Approaches

In this section, results regarding the students and teachers views about CBIAs are presented so as to have an in-depth outlook on the approaches that enhanced students learning of rotational motion. This was aimed for giving answer to the final research question which was stated as:

RQ7: How do learners' and teachers' perceive about the features of CBIAs?

In order to answer the research question, data were also collected from participating learners and teachers using focus group and one-to-one interviews, respectively. The aim of the focus groups and one-to-one interviews were to find out what students and teachers perceive about the CBIAs used in their classrooms. These interviews were conducted in each of the two treatment groups. Results were presented as follows.

4.4.3.1 Opinions Related to the REACT strategy of Context-Based Instruction

As it is discussed earlier, the REACT strategy of CBI was used to teach the first treatment group. To find out what students and teachers think about the REACT strategy of CBI, focus groups and one to one interviews were conducted with randomly selected groups of students and the teacher who taught the students. This is presented as follows.

4.4.3.1.1 Treatment group I learners' views

To find out what students perceive about the REACT strategy of context-based physics instruction, focus group interviews were conducted on five randomly selected 1 to 5 groups. Their responses were organized into the following themes.

a) Learners' views about the instructional methods used

The groups of students who participated in the focus groups from the first treatment group perceived as if learning the rotational motion topics through CBI was relevant to their lives. This observation is evident in these quotations.

> *"The study of rotational motion is good for us because it is related to our daily life. Some of the applications we used are apparent in our day to day activities."*

> *"The study of rotational motion helps us improve our daily lives, and it enabled us to understand most of the things that happened in our societies."*

> *"It was easy to understand the terms and ideas because we worked in groups, and we learned from each other."*

> *"What is good is that during the teaching and learning process, we have the opportunity to explain and emphasize those issues where we noted the misconceptions."*

The students viewed relevance of the study of the topic mostly in terms of applications to everyday issues as well as their wellbeing. The linkage of content with their daily life experiences, small group class discussions, the use of hands-on activities and frequent interactions among themselves and the teacher makes them to appreciate the teaching methods used. In usual classrooms, the students do not have such opportunities as it is evident in the following quotations.

> *"In usual classes, there is no interaction between us and the teachers, but here we are allowed to say what we think, even to argue with others or disagree with the teacher."*

The idea revealed from the interview protocol also revealed the ease of studying rotational motion with this kind of teaching method. Most of the students' ideas are almost similar as shown in the following two quotations.

> *"It is easy to learn because of its proper relation with our life."*

> *"The way our teacher taught us made it easy. We learnt the concepts by relating it to the things around us; so it was easy to understand."*

Furthermore, according to one of the groups, the difficulty or simplicity of learning a topic depends on the teacher's way of teaching. However, they mentioned that the method used was conducive to learn the topic. Although there are groups which need the teacher to do more examples and exercises, including entrance exam questions, they urged their teachers to use similar methods to the rest of the units.

b) Learners' performance in rotational motion

The focus group interview protocols showed that the treatment group students perceived as they understood the rotational motion topic better. They thought that they had performed well in the post-tests of the CU test as well as PSS tests as it is evident in the following quotations.

> *"When we took the pre-test, it was difficult, but after studying the topic, we felt more excited, and it became easy. We think that we passed in the second test (post-test)."*

> *"It was fun to learn rotational motion by using familiar experiences. It just makes us to learn the topic relatively in an easier manner. We, thus, expect to pass the test."*

However, some group of students also expressed that the CU test seems difficult as it is different in type with the types of tests that they are familiar.

c) Learners' interest to study rotational motion

The findings obtained from the focus group interview showed that majority of the learners expressed their interest to the REACT strategy of CBI used in the teaching of the rotational motion topic. This is what is seen in the following quotations.

> *"Learning about rotational motion topic was very interesting and fun. We used to look forward to the lessons."*

> *"The fact that we were dealing with things that happen in our lives made the study of rotational motion very interesting."*

Hence, the students liked the method used since the teacher taught the students by relating the topics to their daily life situations in addition to relating the topics with the translational motions that they have learnt previously.

4.4.3.1.2 Teacher's view on the Context-Based Instruction

The teacher who taught the first treatment group used the REACT strategy of CBI. Using this method, the teacher easily understood students' prior conceptions and addressed them at later stages of the instruction. As a result of the teaching and learning process, he observed a relatively good performance on his students' side when he tried to compare them with other sections he taught using the conventional teaching method as is was evident in the following quotations.

> *"Learners who were taught using the new method really understood the lessons. They performed better when I compare them with the other sections."*

> *"The use of real-life situations in the lessons helped learners to quickly understand topics learned, because they got the opportunity to relate the concepts to situations which they are familiar with."*

> *"Once you tell them what happens in real life, and then teach them the relevant concepts, it becomes easier for them to understand."*

He, thus, thinks that the teaching method he used gave students a chance to relate the topic with students' real-life scenarios that in turn produces a positive effect on their performance. Accordingly, he attributed his students' improved performance to the utilization of authentic activities throughout the instruction, students' ability to relate contents with contexts. According to the teacher, students have also got the opportunity to actively take part in the teaching and learning process that started through relating the content with the students' real-life scenarios. He signified that his students were keen to participate in class discussions through expressing their opinions. The teacher echoed his students' views in the ensuing statement obtained from the interviews:

> *"The involvement of learners in the lessons made them feel appreciated, because they felt that the little they knew from home was integrated in the lessons."*

It can also be said that the attitude of his learners towards the method he used in his classroom was also good. This was evidenced in this quotation.

> *"The teaching approach used in teaching the rotational motion unit turned out to be an exciting and interesting experience to learners. This is because situations and problems which relate to their everyday lives were used."*

Hence, the perceptions of students' towards the method as seen through the eyes of their teacher look nice as the strategies used in the class room enabled them to learn the concepts of the topic easily. On the other hand, the teacher mentioned the issue of time constraint as one factor hindering the implementation of student-centered teaching methods like the one used in this study. However, the teacher showed interest to use such kinds of methods in the remaining units. He also suggested the evaluation of the text book currently in use as they have some mistakes and also as it is not that much relevant to students' day to day life.

On the other hand, the teacher confessed that in the traditional or conventional methods to the teaching of rotational motion he used in the other sections, scientific concepts are not often clearly elucidated or related to everyday-life experiences. These allegations are obtained from teachers' annotations stated in the following quotation.

> *"What makes learners get lost during the study of rotational motion is the way teachers present the lessons as abstract concepts."*

To sum up, the comments from the students' as well as teacher's side show that learner who were taught with the REACT strategy of CBI liked the learning of rotational motion as they considered it to be pertinent to their lives. They were happy with the mode through which the rotational motion was taught since they obtained a chance to cross-examine their prior conceptions and appraise them in view of the new knowhow. As a result, they were happy to be taught with this type of instruction. Students were also somehow confident about their performance in rotational motion. However, some challenging problems such as content-load, students' much emphasis for solving problems rather than focusing on concepts, assessment techniques used in classrooms and national exams, unavailability of laboratory equipment and class size was mentioned by the classroom teacher as problems affecting the quality of classroom instruction. Additional problems which are related to the CBI raised are its more labor intense instruction when compared to the traditional one, and hence, it may not suit to the needs of all students. Many of these challenges were raised as a worry by the learners who participated in these focus groups as they are new to such kinds of instruction.

4.4.3.2 Opinions Related to the Traditional Method Integrated with Context-Based Instruction

In treatment group II, the traditional method which is integrated with the REACT strategy of CBI was used to teach the students. As before, focus groups and one to one interview was conducted in order to reveal what students and the teacher think about method of teaching.

4.4.3.2.1 Treatment group II learners' views

In this group, the focus group interviews was conducted with an intention to find out what learners dwell on the traditional method that is integrated with the REACT strategy of CBI. Their responses were organized into the themes discussed in the previous sub-section.

a) Learners' views about the method used

Since the teacher taught the students through relating the topics to their daily life situations in addition to relating the topics with the translational motions that they have learnt previously, the interview protocols revealed that learners who participated in the focus groups professed the learning of rotational motion as appropriate to their lives. This observation is evident in these quotations.

> *"It is related with our daily life. For example, when we go to school, we use different kinds of transports like bicycle and 'bajaj' which uses the applications of rotational motion."*

> *"We use the applications of rotational motion in our daily life. For example, pumps, pulleys and the like are few of rotational applications."*

> *"Yes, it has a relation with our daily life. For example, some objects in our house work using the principles of rotational motion."*

> *"The study of rotational motion relates to our daily life in many ways. Human lives have many relations to rotational motion. For example, for fetching water and riding a cycle, we use the concepts of rotational motion."*

> *"The discussions we made enable us to realize the myths which we had. By studying rotational motion, we tried to know the truth."*

Hence, the students viewed relevance of learning the topic mostly in relation to the importance to their day-to-day life and their wellbeing. The students was observed while appreciating the methods of teaching used, mentioning the utilization of practical activities, connection of content with everyday situations, small size classroom discussions and recurrent communications amongst one another and the teacher as the reasons for their appreciation. For instance, students' pleasure on the methods is implied in the following quotes as:

> *"The nice thing about the lessons was that we were talking about things that happen in our homes."*

> *"When we learned rotational motion, our teachers' allowed us to explain our views, but with the other classes, we are not given an opportunity to say what we think."*

According to another group, "we learnt the topic in a nice way. When we say that, the teacher teaches all of the portions in an interesting way by giving us real life examples that improve our knowledge." This enabled them to have a better knowledge in the topic they learnt. As a result, most of the students in focus groups want their teacher's to continue to use the method to the rest of the units but through supporting it with real experiments or videos in addition to the examples. One of the groups questioned about the clarity of the presentation of the topics on the student text book. According to them, the book has no enough examples and exercises. There is also a group which wants their teacher to do more problems that helps them to be well prepared for the national exams because of the much emphasis given to the quantitative problems in classroom as well as national exams.

b) Learners' performance

It was revealed from the interview protocol that the method makes students to be interested in the subject that in turn enabled students' to learn the topics easily. For instance, according to one of the groups, "we easily learnt this unit because it was related to our day to day life." Another group also expressed that, after learning through this method, the topic was not difficult as per our expectation. Hence, the method used helped them to work hard. Majority of the focus group participants feel as they had worked better in the post-tests of CU test as well as problem-solving skill test. According to them, the test created an opportunity to see their understanding level of the topic which in turn also prepares them for the national exams.

c) Learners' interest to study rotational motion

"We have gained a lot of knowledge about the rotational motion topic, and hence it was interesting" said one of the groups who participated in the discussion. The views of the other groups' students who participated in the focus group discussion were also similar. Hence, the students liked the methods used for teaching the rotational motion topic. This might be due to the proper integration of familiar contexts with the traditional teaching methods that they have been previously familiar.

4.4.3.2.2 Teacher's view on the combined Method

The teacher who taught treatment group II students through integration of the traditional method with a CBI expressed similar sentiment with the teacher who taught the 1st treatment group using real-life scenarios in the teaching of rotational motion:

> *"Learners who were taught using the new method really understood the lessons, because they were able to relate everything they did in class to what happens in real life."*

That means the learning process was linked with their daily life. The teacher was of the view that the method he used to the teaching of rotational motion was facilitative, stressing on the interactive nature of the approach and the association of content and contexts as some of the characteristics of the approach that may possibly improve the performance of the learners'. The teacher echoed his learners' views in the following statements:

> *"One outstanding aspect of the method is that the learners become very active during the lessons, and therefore the learners understood the lessons better."*

He also pointed out that he was capable of identifying his students' alternative conceptions, which he dealt with at later stages of the instruction as it is evident in the following quotation.

> *"What I liked is that, during the content introduction or relating phase, when you 'touch' on issues where learners had alternative conceptions, they would ask for clarification."*

Regarding the students' attitude and motivation towards the traditional method integrated with a CBI, the teacher witnessed that the learners' motivation during the teaching and learning process was changed well as the method is applied. Hence, students are observed being more satisfied. This is because previously the students learn the physics topics only through lecture method which emphasizes on mathematical calculations, but this time they got the opportunity to learn the rotational motion topic through connecting it to their daily lives as much as possible. So the teacher believed that his learners enjoyed learning the topic. He also showed that his students were excited to partake in classroom discussions and conveyed their viewpoints. Students' thinking related to considering physics as a difficult subject was also related to their previous belief.

On the other hand, the teacher confessed that in traditional methods of teaching the rotational motion that he used in the other sections, the concepts of science are infrequently associated and explained in relation to everyday-life scenarios. This affirmation is based on the teacher's comment mentioned in the quotation below.

> *"In traditional classrooms, we, do not usually link lessons to issues happening outside the classroom. We rush to finish the syllabus by just presenting theory. In the end, the learners do not understand the topic."*

Overall, the teacher believes that his students were attracted towards the learning of the topic, and he thinks that they had achieved well in the post-tests as a consequences of the method of teaching used. He ascribed his students' better performance to the usage of practical activities in classroom instructions and the linkage of content to contexts. However, according to him, it should be better if practical activities or videos are well incorporated in the teaching learning method implemented in the classroom. But, he deduced that the approach used may perhaps cause some challenges in schools pertaining to additional efforts required from teachers. However, unlike the other group, time constraint issues were not of concern in the implementation of the method.

In general, the annotations obtained from the students' illustrate that students who were learnt with this method found that the study of rotational motion as relevant to their lives. They enjoyed the method since the method used was in between the two extremes (i.e., between the traditional method with which they are familiar and the active learning method). As a result, they were happy with the approach used for teaching rotational motion as they interrogated their prior conceptions and amended it with regards to the new knowledge. The students were relatively confident about their performance, and they were very happy to be instructed with such type of instruction. On the other hand, just like the teacher who taught the first treatment group, issues like class size, assessment tools used in exams and lack of resources are mentioned as the problems affecting the quality of the teaching method used.

To conclude this section, the interview result agrees with the quantitative outcomes about the relative efficacy of the two interventions in improving learners' performance. The role played by CBIAs in enhancing students learning was acknowledged by learners in each of the two treatment groups' as it makes students' active in the teaching and learning process. Comments obtained from the treatment groups learners' and teachers' interviews also revealed the significance of giving students the opportunity to express their outlooks before teaching the scientific concepts or contents. On the other hand, teachers' who taught the treatment groups disclosed that in traditional methods of teaching the rotational motion topic that he used in the other sections, scientific concepts are not explained or related with real-life scenarios. Students' admiration of the instructional methods was also revealed in the quotes obtained from the two treatment groups' interview. The teacher also witnessed that the treatment groups' learners' motivation was changed well as the CBIAs are applied in the classrooms although it's slightly better in the integrated approach.

4.5 Discussion

In the previous sections, the quantitative as well as the qualitative results were presented. In this section, these two forms of data are triangulated together so as to have a sound understanding of the problem under investigation. When we look at the research questions raised earlier, the study showed the existence of statistically significant results concerning the effects of CBIAs on students' CU and affections towards physics although it had not been statistically significant on students' PSS. In the following sections, the effects of CBIAs on each of the variables are discussed one by one.

4.5.1 Context-Based Approaches and Students Conceptual Understanding

One of the foremost aims of the study was investigating the effectiveness of CBIAs on the students' CU. The detailed lesson plans used in the current study in every of the two treatment groups contributed for the proper implementation of the instructional approaches as it was evidenced in the classroom observations conducted in each classroom. The teachers of the treatment groups are also happy with the instructional methods used because of having the lesson plans that embeds contextual situations. The strategies used in the instructional methods offered a designed order of instruction; and since this order is explicit, it was confirmed that the teachers applied the instructional methods as anticipated in the lesson plans. As a result, when the study period is completed, it was realized that the CU scores of the students' showed increment from pre-test to the post-test in every of the groups. This rise in mean scores from earlier to the treatment to after the treatment has been statistically significant for each of the groups. The rise in mean scores of the learners from the pre-test to the post-test was an anticipated product of the study as learning had taken place. The point is that how the various groups mean scores differ.

The results of ANCOVA analysis conducted on students' post-CU scores shows the occurrence of a statistically significant mean difference among the groups adjusted according to the pre-CU scores. The value for the partial eta-squared obtained for this section of the study (0.345) pointed out that the instructional methods utilized had a considerable effect on the students CU mean scores of the two treatments groups and comparison group. As it was mentioned earlier, the calculated value for the observed power associated with the instructional methods is 1.000; demonstrating that the probability of spotting a real effect when the effect presents is big enough for this part of the study. Thus, the results of this part of the study have publicized the statistical and practical implication of the outcomes of the study.

The results of the Bonferroni test adjusted according to the pre-test mean scores point out that the two treatment groups CU scores was significantly larger than that of their peers in the comparison group. This finding showed that the utilization of CBIAs in teaching the rotational motion concepts is relatively more useful than the usual conventional/traditional method. Collectively, it is therefore possible to state that the

CBIAs are relatively effective ways of teaching and is capable of tackling the problems observed in physics education.

Furthermore, the adjusted post-test mean scores of the treatment group II students (traditional method integrated with a contextual instruction group) had been larger than that of the treatment group I students (REACT strategy of CBI group) as well as the comparison group students (conventional instruction group). In a similar manner, the CU scores of the REACT strategy of CBI group were also bigger than that of the conventional instruction (comparison) group. Although Rayner (2005) gave arguments about the risk of shifting a teaching method at a time, from a traditional non-contextualized approach to a completely contextualized approach as high, the researcher didn’t observe such risks. Instead, it was seen that the REACT strategy of CBI was effective on the CU of students than the conventional teaching method. In the literature, previous study results confirm that teaching through CBI has a positive effect on students CU scores (Bennett et al., 2006; Degirmencioglu, 2008; Ingram (2003); Kistack, 2014; Kruatong, 2007; Ozkan & Selcuk, 2015; Panprueksa, 2012; Ültay, 2012). Literature also emphasizes on the efficacy of CBI on student achievement (Campbell & Lubben, 2000; Glynn & Koballa, 2005; Murphy & Whitelegg, 2006; Wilkinson, 1999). According to Wilkinson (1999), one of the reasons that make a context-based instructional strategy to become superior when compared with the traditional method is that learners are observed to be more inspired when they got the opportunity to learn through the context-based learning atmosphere. Thus, in the context-based learning environment, it can be surmised that learners more actively participate in the activities offered to them as compared with the traditional learning atmosphere; and therefore, this is expected to enhance the students' conceptual understanding. Annotations obtained from the students and teachers who participated in the study imply that the variations among the two groups performance, after the intervention, are anticipated to have been derived from the teaching methods used in the teaching of the rotational motion topic. The two treatment groups' participants stressed that the utilization of well-known contexts that are familiar to the students, the use of practical activities of learning and the link of content and contexts were the potential determinants for their improved performance. The other facet of the instructional materials and approaches that might have improved students performance was revealing learners prior knowledge ahead of exposing students to content, relating content with contexts, and using the learnt content to new scenarios as it was recommended in Herbart' model for effective instruction. These instructional approaches persuade the instigation of lessons with the things that the students have been familiar and know. These rudiments had created opportunities for the students to argue, elucidate and discuss about everyday issues.

The importance of giving students the opportunity to convey their outlook prior to the introduction of contents or scientific concepts were also considered as another factor that could have enhanced their performance as revealed from the interview. Active involvement of the students in lessons might have assisted teachers to spot their students' alternative prior conceptions that have been addressed in the later phases of the instruction. Contemporary researches in cognitive science have publicized that uncovering students' earlier knowhow and experience is an essential element of the teaching and learning process (Eisenkraft, 2003). The mental engagement permitted students to scrutinize the suitability of their previous knowhow and idea or prior conceptions and enforced them to examine these prior conceptions alongside the content they had learnt. In accordance with the educational theorists like Dewey, Piaget and von Glasersfeld, this intellectual engagement is expected to augment the knowledge construction process (Abraham & Renner, 1986; Bybee et al., 2006; von Glasersfeld, 1989). This is in accordance with Rayner (2005) which showed that students exposed to CBIs have a superior admiration of the place of physics within their world and a deeper CU than those who have experienced traditional instructions. On the other hand, the result obtained is at odds with the results obtained by Tural (2013) that revealed no increase on students' academic achievement.

Furthermore, as explained earlier, the scores of students who were exposed to the traditional method that is integrated with the REACT strategy of CBI were higher than the pure REACT strategy of CBI. The reason why the scores of traditional method integrated with the CBI were higher than context-based learning instruction and conventional instruction could be that it can be used with optimum time efficiency, without being too slow (contextual) or too fast (traditional) as this method of teaching had integrated the REACT strategy of CBI properly with the traditional teaching method that the students have been familiar before. This is the view that was also supported by the students taught by the traditional method integrated with a CBI and their teacher in their interview protocol. They enjoyed the method since it was in between the two extremes (i.e., between the traditional method with which they are familiar and the active learning method). As it was revealed from the interview, the important part in this method was the exhaustive interaction between the teacher and the students. Such a student centered atmosphere offers chances for better participation. In doing so, it gives more chances for the students to obtain insight and self-efficacy, and thus, the students got the opportunity to learn and understand the topics (Balci, Cakiroglu, & Tekkaya, 2006). This may perhaps led the students to grasp the concepts in a meaningful way. In this fashion, the scores of the students in the group could have been relatively enhanced.

In the literature reviewed, it was reported that the utilization of the traditional method integrated with a contextual approach had effectiveness on the learners' achievement. In a study conducted by Peşman and Özdemir (2012), the traditional method integrated with the contextual approach was more efficient on students' physics achievement better than the 5E learning cycle. However, their study has given more emphasis on the need to distinguish between the teaching method and teaching approach through ignoring some specific teaching methods and approaches that cannot be treated separately. The REACT strategy of CBI used in this particular study is one of the examples for this. Although the results of this study related to the efficacy of traditional method with a contextual approach agrees with the results obtained by Peşman and Özdemir (2012), the researcher didn't agree on the distinction they made as there are specific CBIs like the REACT strategy that is designed to work only with the contextual approach or CBI. When the outcomes of other studies with related areas are scrutinized in literature, it is observed that a lot research was not carried out in the area. In this regard, the outcome attained in the current study is expected to contribute to the physics education literature. In contrast, there are study findings that reported the efficacy of combining traditional method with other active learning strategies. For instance, according to Ganyaupfu (2013), teacher-student interactive method was reported to be the most efficient method of teaching. This is followed by the active-learning method while the teacher-centered method of teaching was the least efficient one.

Nevertheless, even though the learners in both treatment groups achieved significantly better than those found in the comparison group, their grand post-test mean is below the expectation. This may be related to the assertions given by Duman et al. (2015) and Mashood and Singh (2015) that showed the conceptual richness and difficulty of rotational motion. Rotational motion is one theme in the complex domain of Mechanics. Students who participated in this study are observed to have a difficulty of understanding the concepts of rotational motion like angular acceleration, torque, angular velocity, angular momentum, moment of inertia and the like as it is evidenced in their CU test result. In simple arithmetical problems that did not contain that much concept like item 3 of the PSS test, most of the students easily solve the problems as the item only requires substitution of the given quantities into the formula for torque (i.e., $\tau = \vec{F} \times r = Fr\sin\theta$). However, in a similar conceptual item, majority of the students encountered a problem in answering the item. For instance, in items 6 and 9 of the CU test, students can answer the item using the formula for torque mentioned above but this time it requires them to think critically. But most of the students used the formula $\tau = I\alpha = mr^2$ where $I = mr^2$. By making use of this formula, students conclude as if the value of moment of inertia is greater for larger mass, which is wrong. In a similar manner, if they were asked to state the law of conservation of angular momentum, majority of them can easily answer it. However, when they are asked a concept oriented question like item 18 of the CU test, majority of them fail to properly apply/use the theoretical knowledge they know to the conceptual problem given to them. Hence, the findings obtained are in harmony with the findings reported by Klammer (1998), Pol et al. (2008) and Rimoldini and Singh (2005) that showed students difficulties in understanding the concepts of rotational motion.

Furthermore, the emphasis given to concepts was also not that much significant even in student textbook as the book simply starts the presentation of the topics through definitions rather than writing a statement enabling the students to think of the ideas that are there in their mind. Hence, the book was not prepared in a manner that makes learners enhance their reasoning skills. Textbooks, therefore, need to be revised by incorporating activities that enable students to practice the new knowledge through connecting it to what the learners' be familiar with. Activities ought to be authentic, set in a meaningful situation and connected to the actual world. They should not just engage the students in repeating facts again and again as this result in 'surface' learning. Thus, so as to help learners comprehend the concept they learnt, students' previous knowledge on the topic should have to be considered as the basis for the instructions. Since student's learning will contain mistakes, activities given to them should offer chances for assessing themselves, correction, discussion with peers, teacher feedback and other 'reality checks'. This is in agreement with the ideas raised by Derebssa (2006).

On the other hand, students in Ethiopia were usually assessed via the usual quantitative achievement tests in class exams as well as even in national exams. As a result, students are not that much familiar with two-tiered tests that are used for assessing students CU although two-tier tests had been widely used to analyze the students' science concepts understanding levels (Gurel et al., 2015; Treagust & Haslam, 1986; Wang, 2004). In the interview protocol, some groups of students in both treatment groups had also expressed about the difficulty of the CU test notifying their unfamiliarity with such types of tests.

Students' unfamiliarity with such types of conceptual questions might have a negative impact on their performance as the students were commonly assessed using the achievement test that focuses on equation manipulation rather than concepts. As a result, students face a problem when faced with two-tiered tests for the first time, and hence they hesitate to support their answers to the first-tier with reasons. The students' performances were superior only when the first-tier of the items was taken than when both tiers of the items were considered. This signifies that students may choose the right response for the content item through memorization without having the knowhow of the underlying reasons. This is in agreement with the finding obtained by Kılıç and Saglam (2009). This can have an impact on the treatment groups' students' CU items performance even though they had performed better than the learners in the comparison group.

According to Wang (2004), two-tier tests have been well thought-out as a immense enhancement over the earlier assessment tools given that these tests takes into account learners' reasoning or explanation for the answers they selected and associate their options to misunderstanding of the target concept. Hence, efforts should be made to make students familiar with such types of tests that due much emphasis on concepts rather than using the usual achievement test mostly based on equation manipulation. This is in line with the arguments given by Kılıç and Saglam (2009) that recommended the usage of two-tier tests that evaluate learners' understanding in a better manner without being difficult for scoring and applying.

On the other hand, since science or physics education curriculum materials and textbooks are highly overloaded with contents with the assumption for developing intellectual ability of learners, teachers and learners are expected to go over these materials and adopt them without question. As a result, the two teachers' who taught the treatment groups confessed that in traditional methods of teaching rotational motion they used in the other sections, the concepts of science are not often noticeably explained and related with everyday life experiences. Hence, the traditional method of teaching rotational motion, which normally comprise the transmission of abstract information and which seldom embrace practical activities could give an explanation for the comparison group's low performance in rotational motion. Regrettably, as it is explained by Taasoobshirazi and Carr (2008), so as to internalize curriculum materials and textbook information, many students focus on memorization of concepts devoid of understanding it in detail with the intention to pass exams. It was thus assumed that the outcomes of the study add novel evidence to the literature as the execution of a well-ordered usage of CBIAs enhances the students understanding of rotational motion concepts.

4.5.2 Context-Based Approaches and Students Problem-Solving Skills

In the present study, the effect of CBIAs on students' physics PSS was also examined. The adjusted post-PSS mean scores of the group that was taught with CBI (REACT strategy) was greater than the group that was taught with the traditional method of teaching. Hence, the usage of the REACT strategy of CBI had enhanced learners' PSS. The investigator, thus, didn't notice the trouble mentioned by Rayner (2005). The comments from the students' as well as teacher's side also shows that learners who were taught with the REACT strategy of CBI enjoy the study of rotational motion as they deemed it to be pertinent to their lives. They also obtained a chance to interrogate their prior conceptions and reconsider it with regards to the new-fangled knowhow.

Similarly, the adjusted mean of the group of learners' that were exposed to the TI integrated with a CBI were also a bit larger than the adjusted mean of their peers in the group taught with the REACT strategy of CBI. This result illustrates the comparative efficiency of the traditional instruction that is integrated with a CBI as compared with the traditional method as well as the REACT strategy of CBI in teaching the concepts of rotational motion. The finding of the study, thus, corroborates with Peşman and Özdemir (2012) outcome that reported the efficacy of integrating traditional instruction with a context-based approach on the learners' performance.

In general, the adjusted mean of the learners in every of the two treatment groups (i.e., 8.7 and 9.24, respectively for the 1st and 2nd treatment group learners) were to some extent larger than the scores of the comparison group students (7.83). However, this variation was found to be not statistically significant. Though the difference was not statistically significant, the role played by the CBIAs in enhancing students' performance was also acknowledged by the students who took part in the interview. Hence, the study result to some extent supports the outcomes obtained by other researchers that reported the enhancement of students' PSS through the use of active learning strategies (Herlina, 2014). The finding is also in line with the results obtained by other researchers through the use of other active learning methodologies (Awoke et al., 2016; Heller et al., 1992).

There might be hordes of reasons that made the finding to be not statistically significant. To mention some of them, primarily, the learners' post-PSS scores were examined with collective means. If the effect of the learners' achiever levels were investigated in the current study, it is actually possible to trace the factor that might have caused the result not to become significant. In the second place, rather than giving attention for both concepts and procedures, learners visualize physics learning as only solving of quantitative problems due to much attention given to quantitative problem solving in ordinary physics instructions. As a result of this, the traditional instruction or the conventional teaching method was also more or less good in enhancing learners quantitative PSS that do not entail that much concept albeit it was not that much efficient like the student-centered methods of teaching that is exercised in the present study. The study outcome supports the findings reported by Lea (1994) and Moelter, Hoellwarth, and Knight (2005) that demonstrated the scores of learners who were taught with TI as higher in quantitative problems when compared with learners who were taught by instructional methods giving due emphasis to concepts. This is thus considered as a causal factor that makes the learners' post-PSS scores not become significant. The other reason that makes the learners' PSS not to be significant is the rubric that is utilized to score the learners written answer to the PSS test. Since the learners were not familiar with the rubric that is exploited for marking their written responses, majority of the learners had not worked the post-PSS test in a better manner although they properly worked out the equation manipulation part of the rubric. This indicates that the learners solved the PSS test using the usual formula-centered mechanisms of problem solving although the learners' written responses was marked using the MAPS rubric. Consequently, the learners and even teachers do not give the physical meanings to the result they obtained. This is also apparent on the learners post mean scores of each of the five levels of the problem-solving assessment rubric utilized in the present study. This could have a remarkable impact in making the scores of each of the two treatment groups learners not to become significant.

Traditional physics instruction depends on the assumption of enhancing learners understanding of the concepts as well as the principles of physics via methodically and repetitively solving of comparatively easier problems (Leonard et al., 1996; McDermott, 1991). However, such traditional strategies of solving problems were found to be less efficient (Gerace & Beatty, 2005). For improving the physics teaching and learning processes at the high schools and upper levels, Gerace and Beatty pointed out how the methodology of teaching that comprised of the use of problem-solving should be re-conceptualized and reorganized. They also explained that the problems commonly exercised in traditional physics classrooms are typically goal-directed, narrow, detached and naive. When learners encounter with such kinds of problems, they show an unnecessary behaviors more willingly than spotlighting in intellectual activities that develop enviable intellectual growth. Moreover, it also makes the learners to construct an abstract depiction of the problem without having adequate understanding of concepts. This compels the learners to concentrate on finding the last answer. They, thus, commonly use means-ends analysis for finding out the lane of the solution by means of equation manipulation.

According to Docktor, Strand, Mestre, and Ross (2015), in the traditional strategies of solving problems, less weight was prone to the necessary concepts as well as principles while more stress was apt to formulas and arithmetical procedures. The appearances of typical textbooks of physics confirm this fact (Wilson & Buffa, 2002; Young, Freedmand, Dandin, & Lewis, 1999). This is because in typical physics books, formulas are given in terms of common symbols. After that it continues to explaining upon what those symbols means. On the other hand, little guidance is given for the learners concerning when to exploit that specific formula to a problem (Larkin, 1981). In Ethiopian context, learners are expected to learn solving the problems of physics using the traditional strategies of solving problems. In the presently in use student textbook, problems are solved using the traditional strategies of problem solving as indicated in the subsequent example that is directly copied from grade 11 physics textbook (Ministry of Education, 2010; p.136).

Worked example 6.13

A flywheel is rotating at 1000 revolutions per minute and has a moment of inertia of 50 kg m². What is its angular momentum?

Angular momentum = moment of inertia × angular velocity

$L = I\omega$

Angular velocity

$= \frac{1000 \times 2\pi}{60} = \frac{100\pi}{3}$ rad/s

$L = 50 \text{ kg m}^2 \times \frac{100\pi}{3}$ rad/s

$= 5233.3 \text{ kg m}^2/\text{s}$

Figure 15: Sample worked example in student textbook (Adopted from Ministry of Education, 2010, p. 136).

In the example shown above, attention was prone to the expression which is used for solving the problem and then insertion of the quantities given into the expression or the formula. There was thus no physical interpretation of the final answer requiring the CU of rotational motion. Physics teachers also pursue similar method when solving problems for their learners. As a result, the learners had worked out the best on the specific application as well as mathematical procedure of the rubric; and the minimum on the physics approach as well as logical progression part. Thus, after identifying the given quantities and equations that may or may not be suitable, many of the learners utilize a plug-and chug approach so as to solve problems in a way which is similar to the examples worked out in their textbooks. The learners’ attention was only on choosing an equation and substituting the given quantities into the equation so as to obtain the final answer. This shows the attentions given to arithmetical equations and related specific applications of physics devoid of giving due attention to useful description, physics approach as well as logical progression part of the rubric.

Although solving problems is very beneficial for physics teaching and learning process, students are observed while considering studying physics as finding the correct numerical answer (Ganina & Voolaid, 2009). Students identify the required quantity and then insert the given numbers into the formula so as to solve the problem. Thus, even though learners solved problems quantitatively by inserting values into equations, they may not have the capability that enables them to develop the required skills used to transfer their understanding to novel situations which in turn assist them to solve more complicated problems in the real world context. Hence, learners may not often relate the results to other, more intricate circumstances although they easily solve standard problems found in textbooks. This finding corroborates with the outcomes reported by other researchers (Ambrose, Shafer, Steinberg, & McDermott, 1999; Kim & Pak, 2002; Leonard, Dufresne, & Mestre, 1996; Mazur, 1992; 1997; McDermott, Rosenquist, & van Zee, 1987; Redish, 2005; Reif & Scott, 1999; Trowbridge & McDermott, 1981).

In addition, the finding also confirms that majority of the learners did not manage problem-solving in a designed or tactical way. Consequently, they do not develop an apt knowledge about the strategies that used in solving problems. Amongst the studies conducted in Ethiopia, Zemenu (2014) also showed that many physics learners had a trouble in properly using the strategies of problem-solving in physics problems as they consider attaining the final answer as their main goal. Learners just dash into arithmetical computations without properly understanding the idea of the problem under investigation. Consequently, once they completed the solution of the problem, majority of the learners didn't attempt to attach the quantitative result they obtained to the physical reality. Alternatively, they do not give meaning or interpret it as they did not relate their end result with everyday scenarios. Therefore, in finding out and reporting the solutions of physics problems, weaknesses are noticed on learners (Zemenu, 2014). This might have contributed something for the occurence of a not significant mean difference among the three groups. This agrees with the arguments given by Gerace and Beatty (2005) that showed about the ineffectiveness of the problem-solving ways that is used within the traditional physics classrooms. So problem-solving, as commonly employed, was not that much effective as expected. This is also in agreement with the outcomes obtained somewhere in the literature (Walsh, Howard, & Bowe, 2007).

Hence, traditional instructions are observed when heartening manipulation of expressions at the cost of CU even though physics teachers consider the integration of conceptual knowhow with problem-solving as a decisive goal of physics instruction (Docktor et al, 2015). Although some students can correctly solve problems via developing the aptitude of when to utilize a suitable expression used for solving problems, research outcomes have indicated that problem-solving alone do not produce a deeper understanding of concepts as well as principles (Bowden et al., 1992; Clement, 1982; McDermott, 1984, 1991). Thus, the traditional strategy of problem solving that is experienced in the classrooms of physics was not successful in helping out learners understanding of concepts (Gerace & Beatty, 2005).

Though numerous researchers have used divergent methods and drawn attention to different key issues so as to increase learners' PSS, it is essential to coach learners on the role of every of the levels used in problem solving (Yu, Fan, & Lin, 2014). Thus, if our longing is to enhance learners' skill of using concepts of physics to physical experiences and reason with them which in order allows them to solve different forms of problems, teachers as well as learners should have to be trained so as to make them to have a suitable knowhow on the strategies of problem-solving besides the use of student centered methods. The research carried out by Yu, Fan, and Lin (2014) revealed that learners' understanding of the levels and roles of the rubrics used for solving of problems would assist them to tackle complicated, hard and poorly structured problems in an appropriate manner in the future. If teachers only concentrate on the design process devoid of entailing learners to scrutinize and cautiously dwell on every level and give good reasons for their choice, nothing may be added to the learners' PSS from the overall process (McCormick, 1996). Even though problem-solving remain essential to classroom instructions, the means used in problem solving must be altered as one ingredient of a fundamental reorganization of the teaching and learning processes (Gerace & Beatty, 2005). To achieve this, consciousness needs to be first created on the learners' and teachers' concerning the rubrics that are used to mark learners' PSS. Hence, according to Gerace and Beatty (2005), the critical point here is that the manner through which we learn something should have to be learnt.

Although controversial, learners will face a difficulty of developing their PSS if they don't have the proper understanding of the target concepts (Hake, 1998; Knight, 2002). The finding obtained from the present study also confirms this fact. This is because when learners come across with easier problems, they are observed while solving the problems using the traditional techniques of problem solving without any difficulty. Conversely, if the problem entails them to apply the concept that they have learnt in addition to directly using the equation, most of the learners especially those in the comparison group failed to solve it. Thus, students were observed having a trouble when solving problems that needs concepts besides manipulation of equations as they fail to use the concept they learnt while solving the problem. Hence, the study's outcome support the importance of stressing on concepts which is used for solving problems so as to make learners not to consider physics problem solving as a search for formulas that are not recalled shortly after the class is over. This is in agreement with the findings reported by Docktor et al. (2015). Besides this, while using the problem-solving rubric, learners also shows weaknesses in using the concept they even familiar with. Thus, for developing both the conceptual knowhow as well as PSS, learners and teachers needs to be familiarized with the strategies used to solve problems as the strategies concentrate on the conceptual nature of the problems besides the mathematical computations. To summarize, the findings of the study evidently demonstrate that, without coaching learners about the strategies of problem-solving, the utilization of student-centered teaching methods (like CBIAs) alone did not bring a noticeable effect on learners' PSS.

On the other hand, according to Kneeland (2001), problem solving is considered as a process sooner than an end answer. Therefore, it is not right to come to a decision on the correctness or wrongness of the students worked solution by only considering the last product or solution (Armagan et al., 2009). This is because problem solving is the entire course of action throughout the problem-solving process (Blum & Niss, 1991). Finding out and assessing the type of efforts made by the learners and how the solution is obtained is awfully crucial for the reason that problem solving process start on through recognition of the problem. Accordingly, teachers should also consider the whole process that the students followed while scoring or evaluating the work of students rather than focusing only on the final solution or result. In general, CBIAs result in students' skills of solving problems at least as efficiently as in TI as it was also explained by Barber (2000).

4.5.3 Context-Based Approaches and Students Affection

The other main concern of the present study was the changes on learners' affection (attitudes and motivation) towards the learning of physics in general and rotational motion in particular after being taught with the CBIAs and TI. After the intervention, the adjusted means of the post-affective scores of the two treatment groups were bigger than the traditional learning group. Thus, the obtained results showed that the affections of the students in the two treatment groups were enhanced better than their peers found in the comparison group when their prior affection towards physics were controlled. The results obtained from the focus group interview also signified an increment in students' affection. So, it can be said that the students in both treatment groups had been motivated and interested by the approaches.

However, although not significant, as compared with the students found in the 1st treatment group, those found in the 2nd treatment group were more comfortable with the method they experienced. The reason for the better affections in the second treatment group students might be related to the students' familiarity with some of the components of the intervention as the intervention is the teaching method that was formed by properly integrating the REACT strategy of the CBI with the conventional/traditional method of teaching. This outcome indicates that students got pleasure when learning through an integrated method that comprised at least some component of the active learning method blended with the traditional method. The responses obtained from the interview protocol also support this argument. It, thus, confirms the importance of incorporating structured lecture on the stages of the active learning strategies used in the class. This is in line with the results obtained by Carpenter (2006). Furthermore, according to the study conducted by Qualters (2001), student-centered learning methods were not preferred by the students due to the in-class time spent on the activities, fear of not covering topics in the book and anxiety when shifting from traditional instruction expectations to the active ones. Thus, the combined method can make the students to feel free and have better affections to the topic they are learning.

In general, the primary causes for the positive outcomes of the CBIAs may strictly be related with the nature of the instructional approaches used in the study. In each of the two treatment groups, the instructional approaches encouraged the students to examine the existing knowledge that they have in mind through starting each of the lessons with an aspect of the context. In each step of the instructions used in every of the two groups, the emphasize given to the significance of the rotational motion concepts to what the learners' are familiar with it attracted the students towards the learning of physics in general and rotational motion in particular.

Based upon the nature of the lessons' content, the learners in both treatment groups dealt with different activities through frequently working with their colleagues. As a result, they got the opportunity to discover the concepts of the rotational motion and the relations between them rather than receiving the information inertly. All these events are expected to make physics more momentous to the learners' which in turn increases their interest towards the physics lessons. These circumstances are observed on student outcomes by a relatively greater understanding and better affections towards physics. The students' probable prejudgment on physics being just a collection of facts to be memorized easily shifted into the emotion that physics is all the things that surrounds us. Accordingly, the approaches made the students to vigorously take part in the lessons and study physics more eagerly. This is in accordance with the explanations given by Bennett and Lubben (2006) that showed the existence of a variety of learning activities in CBI which could engage learners in both mental and physical activities.

The results attained from focus group interviews also pointed out an increase in students' admiration and inspiration. The use of real-life scenarios could have made the significance of studying rotational motion more explicit to the learners and thereby enabling them to construct knowledge. It could also have improved learners' attitudes towards the study of rotational motion and made them want to learn more, and hence perform well in the topic. The teachers' who taught the two treatment groups witnessed that the treatment groups learners' motivation was changed well as the CBIAs are applied. Hence, students are observed to be more satisfied and enjoyed the study of rotational motion as they got the opportunity to learn by relating it to their daily life. This was clearly evidenced on the interviewees' transcripts. The teachers also indicated that their learners were eager to take part in class discussions and express their views.

In literature, more similarities were reported on the results of studies focusing on the effects of CBIAs on students' affective responses than those studies reporting cognitive findings. As it is discussed in the result section, the affective characteristic contains two separate latent variables of attitude and motivation which could have a significant effect on students' affection. As a result, majority of the studies treated the sub-affective variables separately. For example, the study carried out by Sözbilir, Sadi, Kutu, and Yıldırım (2007) showed that CBIAs not only enhances students' motivation and eagerness to study science but also raises their interest in science. Broman, Bernholt, and Parchmann (2015) also showed that CBIAs have the capability of increasing learners' interest in and knowhow on the subject of science. According to the review paper carried out by Bennett et al. (2006) on context-based and STS studies, it was confirmed that CBIAs can assist the students in developing a more positive feelings towards science in general. Glynn and Koballa (2005) also reported that when compared to TI, CBI is more valuable in enhancing the students' motivation. Besides this judgment, in substantial number of studies (Barber, 2000; Gutwill-Wise, 2001; Kaschalk, 2002; Parchmann et al., 2006; Ramsden, 1992, 1994, 1997; Rayner, 2005; Sutman & Bruce, 1992), students have developed better affective responses to the learning of science after the use of CBIAs. On the other hand, the study result is in contrast to the results obtained by Peşman and Özdemir (2012) that showed no evidence for claiming the existence of a significant mean difference on students' motivation in physics although the traditional instructional method had been observed when enhancing the effect of the contextual approach while the learning cycle reduced it.

4.5.4 Context-Based Approaches and Gender

The other main component that was examined in the present study is the CBIAs effect on gender related disparity. With regard to gender related discrepancy, the results of MANCOVA showed a statistically significant mean difference among male and female learners based on the adjusted alpha levels in the post-test scores. The following paragraphs show the discussion of the effects of the instructional approaches used on gender for every of the variables separately.

When we examine at the effects of the methods of instruction on students post-CU scores separately, a statistically significant mean difference among male and female learners was not observed on students' aggregate post-CU mean scores. Moreover, the difference among male and female learners was not statistically significant for each of the treatment groups as well as comparison group. In traditional classroom instruction, therefore, the students' performance in understanding test is low for both male and female learners. This is in line with the arguments given by Finkelstein (2005) and Taasoobshirazi and Carr (2008) that showed the ineffectiveness of traditional method in enhancing learners conceptual understanding. In contrast, the students found in the two treatment groups had performed in a better manner than those found in the comparison group as a statistically significant difference was obtained on learners' post-CU scores. When compared with the learners found in the comparison group, the positive role played by CBIAs to both male and female students' better enhancement of post-CU scores was clearly indicated on the plot shown in figure 10. Thus, CBIAs are valuable for both genders in enhancing students' post-CU scores. On the other hand, as discussed earlier, the students who have been taught with the integrated method had a relatively better gain as compared to the students that were learnt through the REACT strategy of CBI. The performance of female students is also better in the case of the integrated method even though that much difference was not observed on the performance of male students found in the two treatment groups. Thus, female students had benefitted more from CBIAs in terms of their CU scores as it is indicated on the plot shown in figure 10. This outcome is in agreement with the results obtained by Whitelegg and Edwards (2001) that showed the importance of CBIAs particularly for female students. According to Lubben et al. (2005), female learners enjoy materials based on context in a better manner if they got the opportunity to partake in non practical activities while male learners demonstrated better pleasure when engaged with practical work. This might had been the reason for the performance of female students to become better than their male counterparts in the post-CU test. Thus, hands on activities incorporated in the strategies of CBIAs had played a positive role in enhancing female students' conceptual understanding scores. This is again similar with the arguments given by Taasoobshirazi and Carr (2008). The review conducted by Lubben et al. (2005) also demonstrated equivalent performance of female students with their male peers in the same class on science CU tests.

On the other hand, after the intervention, a statistically significant mean difference was noticed among male and female learners' grand post-PSS scores when the learners' previous scores are controlled. Yet, from among the three groups, a significant difference was detected among male and female learners there in the comparison group only favoring male learners. Therefore, in PSS test, male learners found in the groups who were taught with the traditional method had performed in a better manner when compared with their female colleagues. This is in harmony with the findings obtained by Adigwe (1992), Awoniyi (2000) and Zhu (2007) that reported the occurrence of gender differences in arithmetical problem solving in favor of male learners. Consequently, Zhu recommended instructors to think about mechanisms which would help to enhance all female and male learners PSS through the use of suitable instructional methods. Using CBIAs, a significant rise on the female students' PSS mean scores was observed in each of the two treatment groups even if the learners' performance was again relatively better in treatment group II. Hence, the gap among male and female learners was not that much bigger in the treatment groups. However, male students in the treatment group I achieved smaller than their peers found in the comparison group. This might be caused by the due attention given to solving of problems in traditional classroom instructions.

With regard to students' post-affective grand mean scores, the instructional methods effect on gender was not statistically significant. Yet, as it is also evident in the plot shown in figure 14, a statistically significant mean difference was again detected among male and female learners there in the comparison group favoring male learners. On the other hand, the plot also showed the contribution of CBIAs for both male as well as female learners' post-affective scores. The study findings is thus in agreement with Lubben et al. (2005) finding that reported the usefulness of CBIAs to both male and female students in significantly developing their attitudes toward science as compared to their counterparts taught with the TI. However, the students' affective scores are bigger in treatment group II as before. In addition to this, as it is depicted in the plot shown in figure 14, male students are observed to benefit a bit more from the instructional method used in treatment group II while female students are observed to benefit a bit more from the instructions used in treatment group I on students' affection. The descriptive statistics also showed that the gain scores of the post-affective mean scores are bigger for female learners in the treatment groups. According to Lubben et al. (2005), when compared with male students, female students who were taught with CBIAs produced a considerably higher positive attitude for joining science fields. The result obtained from this study also supports this finding. Therefore, for developing positive affection toward physics, the study result showed the effectiveness of CBIAs for both genders.

Therefore, even though male and female learners reply in a different way to different instructional methods, the CBIAs had a capability to reduce the gender gap observed in physics education researches. This shows that the CBIAs are gender friendly. The study result is in consonant with the findings obtained elsewhere in literature (Lubben et al., 2005; Nentwig et al., 2007; Taasoobshirazi, 2007; Taasoobshirazi & Carr, 2008; Whitelegg & Edwards, 2001; Wilkinson, 1999). It seems that the group work that was indispensable for the realization of CBIAs had a positive role in minimizing the gender gap. Consequently, the results of the study match with Nieswandt's (2005) finding that underlined female learners inclination to group interaction with their colleagues during activities in the classroom although the reverse is true in a review paper carried out by Lubben et al. (2005) that report their leaning towards non-practical activities. Thus, the integration of a context which is familiar to majority of the students into the instructional activities is valuable for both genders as it enables them to take part in a range of activities of learning.

The relatively better performance of male and female students who have been learnt through the integrated or combined approach might arises from the students' familiarity with some of the components of the intervention as the intervention is the teaching method that was formed by properly integrating the advantages of both the REACT strategy of the CBI as well as the conventional/traditional teaching method. This finding is in harmony with the findings obtained by Ganyaupfu (2013) which reported the better efficacy of combined approach (i.e., combining both passive learning and active learning methods) in the teaching and learning process as it enable students to perform well when compared with the purely teacher centered as well as student-centered teaching methods. This in turn makes the performance of male as well as female students to become better as it is evidenced in the results obtained in this particular study. In general, it is possible to state that integration of a familiar context into the instructional methods and engaging them in a range of activities is useful for both male and female learners as it enhances students learning outcomes. Thus, CBIAs have the capability to lessen the gap observed among male and female learners' physics performances.

To conclude this chapter, the increasing possibility of schools being unrelated to what students learn and issues affecting students learning of physics should have to be the concern for all of us. Since the outcomes of the present study recommend that the utilization of contexts that are well-known and relevant to learners enhanced students' learning of rotational motion, a physics curriculum should therefore be relevant to the students' day to day life so as to make the teaching and learning process effective. This is the view that was also supported by Mansilla and Jackson (2011). Attention should be given so as to connect learning activities with the experiences of the students and real-world problems. According to the Partnership for 21^{st} Century Skills (2007), if students got the opportunity to understand the relation between what they are learning and familiar real world scenarios, their motivation for learning increases. Hence, the utilization of familiar contexts is a key element of the 21^{st} century teaching and learning process. This is because when teachers construct meaningful activities of learning that gives due attention on the resources, strategies and contexts that learners will face in adult life, the students' critical thinking skills as well as performance will be improved there by developing collaboration and communication skills (Partnership for 21^{st} Century Skills, 2007). A latest foresight study carried out by Redecker and Punie (2013) on the future of learning also showed the need of opening schools to the society through incorporating familiar experiences into teaching and learning process. Therefore, schools should encourage their teachers for using instructional methods that due much emphasis on contexts and students' prior knowledge.

CHAPTER FIVE: SUMMARY, CONCLUSION AND RECOMMENDATIONS

This mixed method study was aimed at investigating the effect of using context-based instructional approaches (CBIAs) on students' learning of rotational motion. The chapter starts by providing a summary of the entire study, followed by the discussion of the main conclusions that are drawn from the study findings. The chapter closes with a discussion of recommendations as well as limitations of the study.

5.1 Summary

The main objective of current study was to analyze the relative effectiveness of CBIAs on grade 11 students' learning of the concepts of rotational motion. The participants of the study are students who were found in Robe, Batu Terara and Ginnir preparatory schools (one section from each school) in Bale zone of Oromia regional state. For giving answers to the following specific research questions, the mixed method design employed was an embedded approach with a quasi- experimental design.

RQ1: Would there be any differences in the students' acquisition of rotational motion concepts among the students taught with CBIAs and those taught with TI?

RQ2: Would there be any differences among male and female students exposed to CBIAs in their acquisition of concepts?

RQ3: Would there be any differences in the students' skills of solving problems related to rotational motion among the students taught with CBIAs and those taught with TI?

RQ4: Would there be any differences among male and female students exposed to CBIAs in their skills of solving problems?

RQ5: Would there be any differences in the students' affections towards physics in general and rotational motion in particular among the students taught with CBIAs and those taught with TI?

RQ6: Would there be any differences among male and female students exposed to CBIAs in their affections towards physics in general and rotational motion in particular?

RQ7: How do learners' and teachers' perceive about the features of CBIAs?

Just before the treatment started, the students of the two treatment groups and comparison group have taken the CU test, PSS test and ACQ as a pre-test so as to look for whether a statistically significant variations within the groups exist or not. Then, during the study period, the 1st treatment group was learnt with the REACT strategy of CBI while the 2nd treatment group was learnt through the traditional method integrated with the REACT strategy of CBI. In contrast, the traditional method of teaching was used to teach the students in the comparison group. Subsequent to the intervention, the CU test, the PSS test as well as the ACQ was administered as post-test. The researcher also conducted classroom observation in every of the three groups during the intervention period that lasted for seven weeks, and it was evidenced that the teachers felt safe with the instructions because of having lesson plans which served as teacher guides. Thus, it was guaranteed that the teachers executed the interventions as anticipated by the researcher given that the strategies incorporated in the methods offers a planned and well-defined order of instruction. Furthermore, data was collected using focus group and one to one interview from the two treatment groups' students and teachers, respectively. The data's acquired from the classroom observation and interviews were hardened to support the results obtained through the tests and questionnaires.

Because of the existence of three dependent variables with a covariate, MANCOVA was used for running the inferential statistics in addition to the descriptive statistics. In MANCOVA, students' pre-CU, pre-PSS and pre-affective scores had been assigned as covariates; the instructional methods and gender were the independent variables whereas the students' post-CU, post-PSS and post-affective scores were the dependent variables. After running MANCOVA, follow-up ANCOVAs were computed to examine the instructional methods effect on every of the variables separately. Hence, the first six research questions were examined through testing null hypotheses. Furthermore, the data obtained from the observations and interviews were also analyzed. The data gathered from the learners and teachers' interviews in the two treatment groups were used to give response to the final research question.

The investigation of the study results demonstrated the existence of a statistically significant mean differences along with the three groups in terms of their post-CU and affective scores. The traditional method integrated with a CBI group's CU scores as well as affective scores was greater than those of the CBI (REACT strategy) group and the conventional instruction group. In addition to this, the CU and affective scores of the CBI group's were significantly greater than that of the traditional instruction group. Hence, it was found out that the performances of students in both the traditional method with a CBI and the purely CBI are far more effectual than the traditional method of teaching in terms of learners' CU and affective scores. In addition to these, the two variables of affection (i.e., attitude and motivation) have a significant impact on learners' affection.

On the other hand, the study additionally provides proof regarding the efficacy of CBIAs on students' PSS as the adjusted post-test mean scores of the two treatment groups was relatively greater than their peers in the comparison group. Here also, the integrated approach worked better than the REACT strategy of CBI. However, this mean difference was found to be not statistically significant. Furthermore, the learners had worked out the best on the specific application and mathematical procedure part of the rubric; and the slightest on the physics approach as well as logical progression part. This indicates that, the learners solve problems using the traditional techniques of problem solving just like the one used in their textbook. Hence, the traditional or usual techniques of solving problem that is practiced in the physics classroom is not as such effective in serving learners develop accurate knowledge since the teachers as well as the learners give attention only on choosing an apt formula and substituting the given quantities into it so as to obtain the last result. Consequently, learners and even their teachers do not have the appropriate knowhow of problem-solving strategies like the MAPS rubric utilized in this study for marking the learners' written response to a problem.

Associated with gender related differences, there was a statistically significant mean difference among male and females learners there in the comparison group in their PSS scores and affective scores. This difference is in favor of male students. Hence, the TI was not effective in enhancing students PSS as well as students affection. On the other side, no difference was observed among female and male learners in the comparison group in their CU scores showing female and male students' weak performance in understanding test. In contrast, no statistically significant difference was detected among male and female learners exposed to the CBIAs in each of the assessed dependent variables. Thus, CBIAs have the capability of minimizing the gap there in between male and female students' performances in the learning of rotational motion topic.

The annotations obtained from study participant learners and teachers indicate that the differences in the students' performances of the two groups, following the intervention is expected to have been obtained from the methods employed to teach the rotational motion topic. Participants from the two treatment groups assert that the usage of well-known contexts that the students could link, the use practical learning activities and the linkage of content and contexts are the possible factor that might have enhanced the performance of the treatment group students.

5.2 Conclusions

The subsequent conclusions had been drawn based on the analysis and findings of the study.

The CBIAs created a considerably better acquisition of concepts related to the rotational motion than the traditional method of instruction. The result obtained also showed that the traditional method integrated with a CBI was moderately better than the REACT strategy of CBI in enhancing students understanding of concepts. Hence, integrating traditional and active teaching learning strategies is relatively better than the purely contextualized instruction.

The study found that learners use arithmetical equations and related specific applications so as to learn the rotational motion topic devoid of giving due attention to useful description, physics approach as well as logical progression parts. The study also showed that the utilization of student centered teaching methods like the CBIAs did not have a significant effect on learners' PSS as majority of the students were solving problems using the traditional mechanisms of problem solving. So without training learners about the problem-solving strategies used to mark their written responses, the use of student centered learning strategies like the CBIAs alone did not have that much observable effect on learners' PSS. Hence, for developing learners' PSS better, we need to coach our students and train our teachers in appropriate problem-solving strategies to be used in the physics classroom besides the teaching methods used in order to shift learners away from their focus on equations and arithmetical procedures to problem-solving approaches rooted on the concepts of physics and principles besides using student centered teaching and learning strategies. The study results also showed that learners who have been taught using the TI scored on average superior in quantitative problems than conceptual problems. This part has already been published by the researcher and the supervisor.

The learners in the two treatment groups developed better affections towards physics in general and rotational motion in particular when compared with the learners found in the comparison group. Hence, CBIAs can also be utilized in the classroom teaching and learning process so as to please and encourage students towards physics subject in general and rotational motion in particular and develop better attitudes towards physics.

Although male and female students react differently to the various types of instructions, CBIAs had the capability to reduce the gender gap observed in physics education researches. Therefore, in terms of all the assessed dependent variables, it is possible to state that integrating a context which is common to the learners into the instructional methods and engaging them in a various learning activities is valuable for both male and female students.

5.3 Recommendations

Through showing the importance of physics to students' day to day lives, CBIAs promise positive student outcomes as this study showed the relative effectiveness of CBIAs in promoting students' CU and PSS to some extent. Thus, as a remedy to the problems faced the physics teaching and learning practices at schools, CBIAs can be considered as an alternative to teach rotational motion and other physics topics in order to have more competent and interested students towards the subject.

Considering the outcomes derived from this study and the conclusions drawn from them, the below listed recommendations were presented for policy and practice purpose.

- The results of this study present evidence which support the findings mentioned in literature by demonstrating that learners hold different conceptions on a range of rotational motion concepts. Through the use of appropriate teaching strategies, it is possible to obtain a significantly better acquisition of scientific conceptions. Hence, through trainings, teachers should be well informed about alternative instructional methods to traditional methods of teaching physics fostering student engagement like the CBIAs. Methods of teaching courses at teacher training institutes should also include CBIAs as an alternative to the traditional teaching method. Physics instructors ought to help pre-service teachers with the procedures of implementation of CBIAs and also assist them in accessing suitable context-based materials.
- CBIAs should be used as a basis for preparing new and innovative curriculums. Curriculum developers should also think of adopting school physics to fit with CBIAs so as to produce literate students. Besides, text book writers should also

give much emphasis to concepts through incorporating the students' misconceptions there in the literatures.

- Context based teaching and learning strategies can also be used with the conventional or traditional classroom instructions effectively. Since the result obtained in this particular study showed the relative effectiveness of the integrated approach (i.e., the traditional method integrated with a CBI), teachers are encouraged to try such types of integrated teaching methods in their classrooms.
- As two-tier tests consider students' reasons and explanation for their responses, they are considered as a valid and reliable tool for assessing the ideas of the student better. Thus, physics teachers are recommended to use two-tier tests for evaluating their students' conceptual understanding of the topic they are teaching. Furthermore, through the use of two-tiered or three-tiered tests, others are recommended to investigate the students understanding levels of the topic under investigation by taking manageable number of students and CU tests.
- For developing learners' skill of applying the concepts of physics to physical circumstances and reason with them and to solve various types of problems (including new ones that are not practiced in class), students and teachers should have knowledge of appropriate problem-solving strategies besides using student centered teaching and learning methodologies. Physics text book writers and curriculum developers should have to rethink about introducing various strategies of solving problems in the examples included in the students physics text books.

- Rather than only marking the final solution, physics teachers should also develop the habit of checking the steps used by the students while marking or scoring the work/ the solution of the students.
- The CBIAs used in this research were prepared in accordance with the 11th grade syllabus on rotational motion. Given that contextual teaching of physics is seen as advantageous at the high school level, comparable studies could be performed at different grade levels with different topics in longer periods of treatment so as to investigate the effectiveness of CBIAs.
- In future studies, the effectiveness of a similar learning approach on completely different outputs of learning like retention, science process skill, etc can be examined.
- In this study, the researcher used the extended version of the ACQ so as to evaluate the students' affection. Others are recommended to try the shortened version of the ACQ so as to evaluate their affection towards physics.

5.4 Essence of the study

The focus of the present study was to evaluate the effectiveness of CBIAs (i.e., REACT strategy of CBI and the TI integrated with a CBI) as compared to TI on students' learning outcomes that had not been previously investigated as such. It is revealed that learning with CBIAs helped students to notice the importance of physics and realizes that physics in their everyday life. Therefore, the present study finding shows evidence about the importance of using instructional methods that due much emphasis on contexts and students' prior knowledge so as to enhance learners' performance. The study thus adds insights in the significance of utilizing classroom practices that makes real-world contexts more central to the teaching of physics which in turn enhanced learners' understanding of concepts and their affection to learn physics. On the other hand, in earlier studies, the enhancement of students PSS through the use of active learning strategies was reported. However, for enhancing students' PSS to a maximum level, the findings of this study showed the merit of the simultaneous utilization of student centered method(s) of teaching and latest strategies used to solve problems in order to shift learners away from their focus on equations and arithmetical procedures towards the approaches of problem-solving that is anchored in physics concepts and principles. Furthermore, the integrated method was slightly better than the purely CBI. Hence, the study finding has a value in showing teachers to try such types of integrated teaching methods in their classrooms as one alternative method of teaching that can be used with optimum time efficiency without being too slow (contextual) or too fast (traditional). The study has thus played a crucial role in tackling the research gaps mentioned in the literature. Therefore, the present study is anticipated to contribute to the literature with its findings.

5.5 Limitations of the Study

The present study is not far from limitations. Therefore, acknowledging and recognizing these limitations is very essential so as to inform readers the way through which the outcomes of the present study are interpreted. The following is thus the discussion of the limitations that are identified and acknowledged in this study.

This study was conducted using a quasi-experimental design. The researcher takes non-interacting groups of students from different schools so as to increase the internal validity of the study. But this might produce another confounding variable which might affect the outcomes of the study. It was also better if the students' means across different groups such as achiever levels were investigated in addition to looking for aggregate ones. However, the achiever levels of the students were not investigated as it was difficult for the researcher to assign the students' into the different achiever levels. This is because the researcher faced difficulty to group the students into the different achiever levels as teachers in the selected schools, according to my observation, did not commonly mark students' assignments properly and hence they give them uniform marks so as to make their semester scores above 50%. This is a common practice in the preparatory schools of the country. This is done due to the fact that, after the students took the Ethiopian Higher Education Entrance examination, their grade 11 and 12 transcript scores were taken into consideration in the University field placement. On the other hand, formal training was not given to the students about the problem-solving strategy used to score their written solution although teachers were aware about the strategies and also used it in the classroom. The absence of the training enabled the students to solve problems using the usual traditional strategies of solving problems. It is also better if the learners' written response to a problem was marked by different raters. But due to different reasons, the students' written solution was marked by the researcher only. Furthermore, in classrooms, students were usually assessed using an achievement test. Hence, they encounter a problem when faced with two-tiered tests for the first time, and hence they hesitate to support their answers to the first-tier with reasons. This might have an impact on the students' CU scores or conceptual achievement. In addition to these, at the start of the study, the researcher did not have awareness about the existence of the shortened version of ACQ, and thus used the extended version of ACQ. But it would have been better if the shortened version was in use so as to make students not to be tired off while filling the questionnaires. In spite of these, the researcher tried to make the study as complete as possible.

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PUBLICATION

The problem solving part of this dissertation has been published in an accredited international journal.

Fikadu Eshetu & Shimeles Assefa (2019). Effects of Context-Based Instructional Approaches on Students' Problem-Solving Skills in Rotational Motion. *EURASIA Journal of Mathematics, Science and Technology Education*, *15*(2), 1-13. https://doi.org/10.29333/ejmste/102283

APPENDICES

Appendix I

Rotational Motion Conceptual Understanding Test

Instruction: Answer the following questions in the space provided in front of each questions. Provide an explanation for your choice under each question. All objects are homogeneous (made of the same material throughout) and perfectly rigid. Always ignore the retarding effects of air resistance.

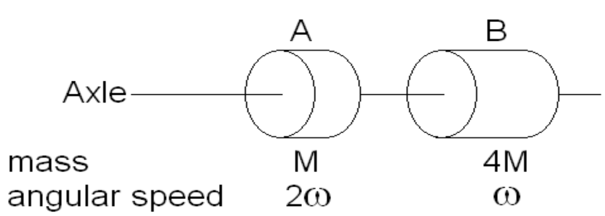
1. The moment of inertia of a rigid cylinder
   A. Does not depend on the radius of the cylinder.
   B. Does not depend on the mass of the cylinder.
   C. Depends on the choice of rotation axis.
   D. Depends on the angular acceleration of the cylinder
   E. Can be expressed in units of kg.

Explain:

2. Whenever a constant non-zero net torque acts on a rigid object, it produces a
   A. rotational equilibrium.
   B. constant angular velocity.
   C. constant angular momentum.
   D. change in angular acceleration.
   E. change in angular velocity.

Explain:

3. Two copper disks (labeled “A” and “B”) have the same radius but disk B is thicker with four times the mass of disk A. They spin on frictionless axles. If disk A is rotating twice as fast as disk B, which disk has more rotational kinetic energy?

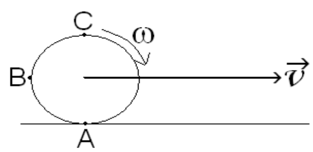


A. The faster rotating disk A.
B. The thicker disk B.
C. It depends on the actual numerical values of the angular speeds of the disks.
D. Both disks have the same rotational kinetic energy.
E. None of the above.

Explain:

• Setup for the next three questions

A rigid wheel of radius R rolls without slipping on a horizontal road. The linear velocity of the center of the wheel with respect to the road is $\vec{v}$ and the angular speed is ω.



4. The direction of the instantaneous velocity of point B (see the figure above) with respect to the road is roughly:
   A. $\searrow$
   B. $\nearrow$
   C. $\rightarrow$
   D. $\uparrow$
   E. There is no direction since the instantaneous speed of point B is zero with respect to the road.

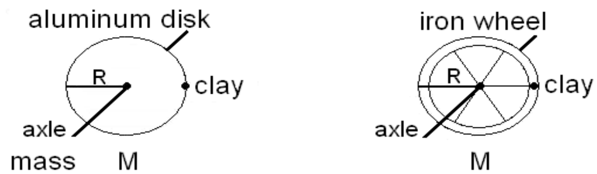
Explain:

5. Which one of the following statements is true about the speed of the points at the rim of the wheel with respect to the road (see the figure above)?
   A. It is larger for points at the bottom of the wheel than for points at the top of it.
   B. It is smaller for points at the bottom of the wheel than for points at the top of it.
   C. It is the same for all points, with $v = \omega R$.
   D. It is the same for all points, with $v = 2\omega R$.
   E. None of the above.

Explain:

• Setup for the next three questions

An aluminum disk and an iron wheel (with spokes of negligible mass) have the same radius R and mass M as shown in the figure. Each is free to rotate about its own fixed horizontal frictionless axle. Both objects are initially at rest. Identical small lumps of clay are attached to their rims as shown.



6. Consider the net torque acting on the disk + clay and wheel + clay systems, about a point on its own axle. Which one of the following statements is true?
   A. The net torque is greater for the disk + clay system.
   B. The net torque is greater for the wheel + clay system.
   C. Which system has a greater net torque depends on the actual numerical values of R and M.
   D. There is no net torque on either system.
   E. The net torques on both systems is equal and non-zero.

Explain:

7. Which one of the following statements about their angular accelerations is true?
   A. The angular acceleration is greater for the disk + clay system.
   B. The angular acceleration is greater for the wheel + clay system.
   C. Which system has a greater angular acceleration depends on the actual numerical values of R and M.
   D. There is no angular acceleration for either system.
   E. The angular accelerations of both systems are equal and non-zero.

Explain:

8. Which one of the following statements about their maximum angular velocities is true?
   A. The maximum angular velocity is greater for the disk + clay system.

B. The maximum angular velocity is greater for the wheel + clay system.

C. Which object has a greater maximum angular velocity is determined by the actual numerical values of R & M.

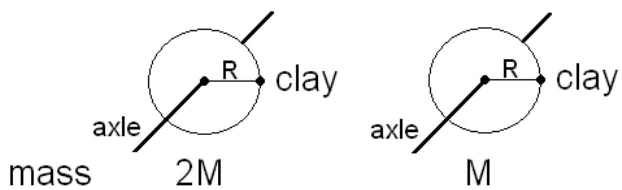
D. The maximum angular velocities of both systems are equal and non-zero.

E. There is no angular velocity for either system so the question of a maximum value does not arise.

Explain:

• Setup for the next two questions

Two copper disks of different thicknesses have the same radius but different masses as shown in the figure. Each disk is free to rotate about its own fixed horizontal frictionless axle. Both disks are initially at rest. Identical small lumps of clay are attached to their rims as shown.



9. Consider the net torque acting on each disk + clay system, about a point on its own axle. Which one of the following statements is true?
   A. The net torque is greater for the system in which the disk has larger mass.
   B. The net torque is greater for the system in which the disk has smaller mass.
   C. Which system has a greater net torque depends on the actual numerical values of their masses.
   D. There is no net torque on either system.
   E. The net torques on both systems is equal and non-zero.

Explain:

10. Which one of the following statements about their angular accelerations is true?
    A. The angular acceleration is greater for the system in which the disk has larger mass.
    B. The angular acceleration is greater for the system in which the disk has smaller mass.

C. Which system has a greater angular acceleration depends on the actual numerical values of their masses.

D. There is no angular acceleration for either system.

E. The angular accelerations of both systems are equal and non-zero.

Explain:

11. Two identical rigid marbles roll without slipping across rigid horizontal floors. One rolls on a stone floor with coefficient of static friction $\mu_S = 0.8$, and the other rolls on a glass floor with $\mu_S = 0.4$. Which marble is slowed down more by friction, and why? Ignore air-resistance.

    A. Both marbles are slowed equally because the marbles themselves are identical.

    B. Neither marble is slowed by friction because both roll without slipping.

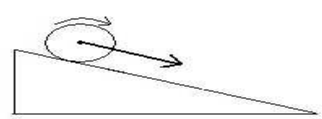
    C. The marble rolling on stone is slowed more, because the greater μ_S makes the force of friction on it greater.

    D. The marble rolling on glass is slowed more, because the slippery nature of the glass impedes rolling.

    E. It is impossible to answer without knowing the coefficient of kinetic friction μ_K because the marbles are moving.

Explain:

12. If a rigid spherical ball is rolling without slipping down on a stationary inclined plane, then



    A. the coefficient of friction between the ball and the plane is precisely equal to 1.

    B. the ball has a negligible angular acceleration.

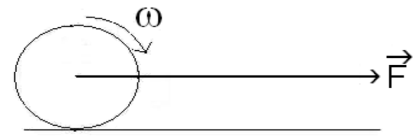
    C. the ball has a negligible moment of inertia.

    D. the plane slopes steeply, at more than 45^0 to the horizontal.

    E. the static friction between the ball and the plane is not negligible.

Explain:

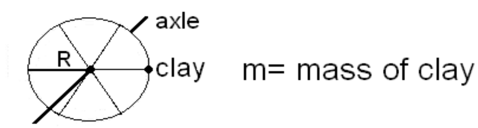
13. You apply a horizontal force, $\vec{F}$, to the center of a rigid wheel which is initially at rest on a horizontal floor. If the wheel starts rolling without slipping, then:



A. All of its kinetic energy is in rotational form.
B. The coefficient of static friction between the wheel and the floor must be precisely equal to 1.
C. It will roll better on a frictionless floor.
D. The coefficient of static friction between the wheel and the floor cannot be zero.
E. None of the above.

Explain:

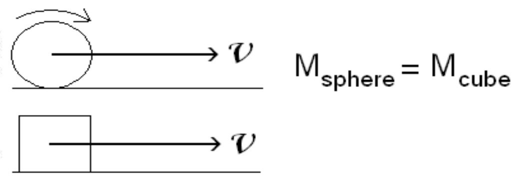
14. A wheel of mass M and radius R is free to rotate about a fixed horizontal axle. A small lump of clay of mass m is attached to its rim as shown in the figure. Consider the magnitude of the net torque τ acting on the wheel + clay system about a point on the axle shown in the figure, and let g be the magnitude of the acceleration due to gravity. Which one of the following statements is true?



A. $\tau = mgR$.
B. $\tau = (m+M)gR$.
C. $\tau = (m+M/2)gR$.
D. $\tau = (m+M)g/R$.
E. None of the above.

Explain:

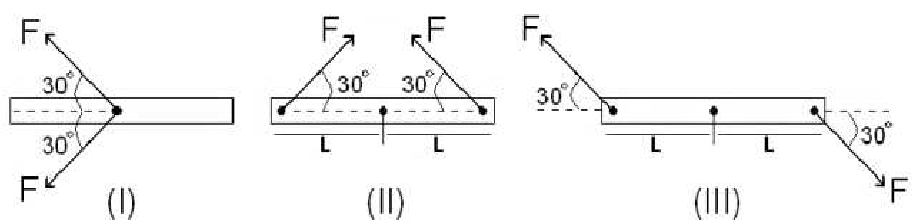
15. On a horizontal floor, a rigid sphere rolls without slipping and a rigid cube slides without rotating. Both objects have the same mass M. At a certain instant, the points at the center of mass of the sphere and the cube have the same speed v relative to the floor. Which one of the following statements is necessarily true at that instant?



A. The cube and the sphere have the same total kinetic energy.
B. The cube has a smaller total kinetic energy than the sphere.
C. The work required to stop the cube is greater than that required to stop the sphere.
D. Which object has a larger total kinetic energy depends on the actual numerical value of the mass M.
E. None of the above.

Explain:

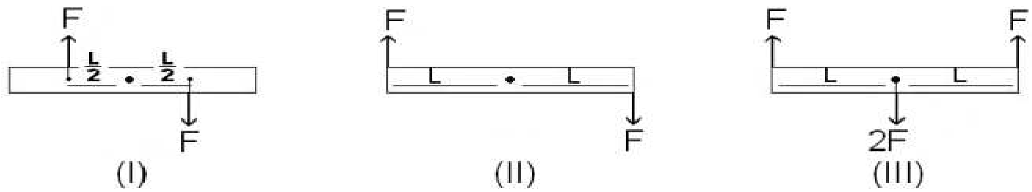
16. The figure shows 3 cases in which a rigid rod of length 2L is acted upon by some forces. All forces labeled F have the same magnitude. Which cases have non-zero net torque acting on the rod about its center?



A. (I) only.
B. (II) only.
C. (III) only.
D. (I) and (II) only.
E. The net torque is zero in all cases.

Explain:

17. Rank order the three cases according to the angular acceleration of the rigid rod of length 2L about an axis passing through its center and perpendicular to the paper, largest first. All forces labeled F have the same magnitude.



A. (I) = (II) > (III).

B. (I) > (II) > (III).

C. (II) > (I) > (III).

D. (II) > (III) > (I).

E. The angular acceleration is zero in all three cases.

Explain:

18. An ice skater performs a fast spin by pulling her outstretched arms down and close to her body. What happens to her angular momentum with respect to the axis of rotation?

A. increases.

B. decreases.

C. stays the same.

D. depends on her initial rotational velocity.

E. None.

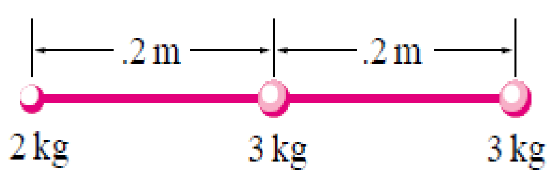
Explain

Appendix II

Rotational Motion Problem-solving Skill Test

Instruction: Answer all the following questions by showing all the necessary steps.

1. In an isolated system, the moment of inertia of a rotating object is doubled. What happens to the angular velocity of the object?
2. A flywheel is rotating with an angular velocity of $1.4\, {rad}/{s}$ and is acted on by an acceleration of $0.6\, {rad}/{s^2}$. What angular velocity will it have attained after 3 complete turns? How long will it take to do those 3 turns?
3. A door knob is placed in the center of a 75cm door. If a force of 4.45 N is exerted perpendicular to the door at the knob, what torque is produced to open the door?
4. A disk with mass m and radius R is spinning with angular speed ω about an axis that passes through the rim of the disk perpendicular to its plane. The moment of inertia about center of mass (*CM*) is $I_{CM} = \frac{1}{2} mR^2$. What is its total kinetic energy?
5. A skater is spinning at $32\, {rad}/{s}$ with her arms and legs extended outward. In this position her moment of inertia with respect to the vertical axis about which she is spinning is $45.6 kgm^2$. She pulls her arms and legs in close to her body changing her moment of inertia to $17.5 kgm^2$. What is her new angular velocity?
6. Three particles (point masses) of mass 2 kg, 3 kg, and 3 kg, are welded to a straight mass less rod as shown in the figure. Find the location of the center of mass of the assembly.



Appendix III

Affective Characteristics Questionnaire

The purpose of this questionnaire is to collect information about your attitudes and motivation towards the learning of physics. The information to be obtained through the questionnaire is going to be used only for the research purpose. Therefore, your cooperation by giving genuine information is highly valuable for the completion of the study.

Thank you in advance for your cooperation.

Direction

Dear students, please indicate your choice by marking a cross (x) under the option which you think best represents your feelings about the statement given below.

S. No	Factors	Absolutely I agree	I agree	Undecided	I do not agree	I definitely do not agree
1	Our physics class is fun.					
2	I find the physics course interesting.					
3	I actually look forward to going to physics class.					
4	Our physics class is dull / boring.					
5	I think physics helps to develop mind.					
6	I think everyone should learn about physics.					
7	I think what we learn in physics courses makes life easier.					
8	I think physics is an area which will become increasingly important in the future.					
9	I think physics is important for the career I would like to follow.					
10	The stuff we learn in the physics class will not be used in real life.					
11	I will not use the info that we learn in physics class; so I don’t need it.					
12	I think physics subject will be useful for further study.					
13	I think what we learn in physics subject is useful in daily living.					
14	Physics subject is boring.					
15	I have good feelings toward physics subject.					
16	Physics subject is enjoyable to me.					
17	I enjoy studying physics in school.					

18	I like physics subject.					
19	I want to develop my physics skills.					
20	I am interested in acquiring further knowledge of physics.					
21	I want to take more physics than I have to.					
22	I plan to take as much physics as I can during my education.					
23	I like reading magazine articles about physics.					
24	I would like to belong to the physics club.					
25	I would like to be given a physics book or a piece of physics equipment as a present.					
26	I like reading books about physics or technology.					
27	I like watching television broadcasts on physics or technology.					
28	I like talking about physics or technological matters with friends.					
29	I like consulting a textbook, encyclopedia, and so on if a question concerning physics or technology arises.					
30	Thinking about an upcoming physics test makes me anxious.					
31	Taking an exam in a physics course makes me anxious.					
32	A physics test would scare me.					
33	Studying for a physics test makes me anxious.					
34	Physics tests make me nervous.					
35	I feel nervous in physics class.					
36	Walking into a physics class makes me anxious.					
37	Physics usually makes me feel uncomfortable and nervous.					
38	Physics makes me feel uneasy and confused.					
39	I dread having to do physics.					
40	I am capable of obtaining good marks in physics subject.					
41	I am proud of my ability in physics subject.					
42	I feel good about my work in physics subject.					
43	I am proud of my achievements in physics subject.					
44	I am feeling as good as the other people in my class in physics.					
45	I try hard to do well in physics.					
46	I try to do my best in school.					
47	I try hard, no matter how difficult the work is.					
48	When I fail in physics subject that make me try that much harder.					
49	If I have enough time, I can do even the hardest problems in physics.					
50	I am sure that I can learn physics.					
51	I think I can handle more difficult physics problems.					
52	I know I can do well in physics subject.					
53	I am sure I could do advanced work in physics.					

Appendix IV

Interview Questions

Thank you for agreeing to participate in this discussion. The discussion is needed to explore your views and experiences on context-based instructional approaches in relation to the dissertation entitled ‘Context-based instructional approaches on preparatory school students learning of rotational motion’. In this discussion, there are no wrong or right answers. Everything you say will be treated in confidence and is used for research purpose only. Your views will remain anonymous, and will not be used against you in any way. You are therefore requested to feel free to say what you really think and how you really feel. You may decline from participating in the discussion at any time, and there will be no consequences for you. The discussion will take approximately 20 to 30 minutes, and it will be audio-recorded so that I may be able to listen to the discussion at a later stage, to make sure that I capture your views correctly. The materials on the tape will not be reproduced or used anywhere else. Do you have any questions or comments before we start?

I. For teachers

1. How would you describe learners’ performance in the rotational motion topic that you just taught?
2. In your opinion, what do you think could be the reason for this performance?
3. Tell me about learners’ attitude and motivation towards the study of rotational motion and physics as a subject?
4. What do you think is the cause of this attitude and motivation?
5. According to your experience, how would you describe learners’ perception of rotational motion in relation to its relevance to their daily lives?
6. In your opinion, what do you think should be modified on the teaching method that you have used to have a better result in the teaching of rotational motion topic?
7. Is there anything else that you would like to add?

II. For Students

1. Let’s talk about your experience of the study of rotational motion, did you like it or not? Tell me why you feel that way.
2. In your opinion, do you think the study of rotational motion relates to your daily life? Why do you say so?
3. How do you feel about the way rotational motion was taught? Would you have liked it to be taught in a different way? Tell me more.
4. Tell me what you think about the study of rotational motion? Do you consider the study of rotational motion to be easy or difficult to learn? Tell me why you think so.
5. After studying rotational motion, you have taken a test to assess your understanding and problem-solving skill of the topic. Tell me what you think of your performance in the test?
6. Imagine that someone has asked you to make suggestions on how you would like rotational motion to be taught. What would you say to him/her?
7. Is there anything else regarding the study of rotational motion that you would like to share with us?

Appendix V

Classroom Observation Checklist

School:-________________________ Date:-______________________
Section:-_______________________ Time:-_______________________

i. REACT Strategy

Questions	Yes	Partially	No
Did the teacher start teaching the concept in an interesting context?			
Does the context fit the topic to be addressed?			
Did the teacher ask the students questions about the context?			
Did the teacher revealed the ideas and thoughts that students have about the topic?			
Did the teacher give answers to the questions asked?			
Did the teacher provide a suitable learning environment in which the students can compare the target concept with their own experience?			
Did the teacher give students exclusive learning activities to gain experience related to the target concept?			
Did the teacher make the students to learn by themselves instead of directly teaching the course?			
Did the teacher ask the students for deliberate questions in order to redirect students' to learn through themselves?			
Did the teacher give them enough time to investigate?			
Has the teacher acted like a guide and counselor for students?			
Did the target concept be constructed and connected with real life?			
Are new concepts presented in contexts and experiences that are familiar to the students?			
Do lessons and activities encourage the student to apply concepts and information in useful contexts?			
Did the teacher demand evidence from the students for the explanations?			
Did the teacher make scientific explanations using observations and findings of students?			
Did the students participated regularly in interactive groups where sharing, communicating, and responding to the important concepts and decision-making occur?			
Did the teacher provide another application that allows students to use their new knowledge?			
Did the teacher encourage students to use scientific explanations in new situations?			
Did the teacher provide an environment where the students are required to show how they transfer their knowledge to real life or technology?			
Did the teacher answer the questions in the new application?			
Do students handle the new knowledge in the context presented at the beginning of the lesson?			

ii. Traditional method with a context based instruction

Questions	Yes	Partially	No
Did the teacher revealed the ideas and thoughts that students have about the topic?			
Did the teacher start teaching in an interesting context?			
Does the context fit the issue to be addressed?			
Did the teacher lecture the topic to the students?			
Are new concepts presented in contexts and experiences that are familiar to the students?			
Was the transition from context to context appropriate?			
Did the teacher solve sample questions about the topic?			
Do lessons and activities encourage the student to apply concepts and information in useful contexts?			
Is there an opportunity for students to participate in solving sample questions?			
Was the topic addressed in the context given at the beginning of the lesson?			
Did the teacher provide an environment where the students are required to show how they transfer their knowledge to real life or technology?			
Did the teacher provide another application that allows students to use their new knowledge?			
Did the teacher evaluated students understanding of concepts?			
Did the students participated regularly in interactive groups where sharing, communicating, and responding to the important concepts and decision-making occur?			

iii. Traditional Method

Questions	Yes	Partially	No
Did the teacher solve sample questions about the topic?			
Is there an opportunity for students to participate in solving sample questions?			
Was the course teacher-centered?			
Is the course done in a traditional way?			

Appendix VI

The five categories of the MAPS rubric

	5	4	3	2	1	0	NA(problem)	NA(solver)
USEFUL DESCRIPTION	The description is useful, appropriate, and complete.	The description is useful but contains minor omissions	Parts of the description are not useful, missing, and/or contain errors.	Most of the description is not useful, missing, and/or contains errors.	The entire description is not useful and/or contains errors	The solution does not include a description and it is necessary for this problem /solver.	A description is not necessary for this problem. (i.e., it is given in the problem statement)	A description is not necessary for this solver.
PHYSICS APPROACH	The physics approach is appropriate and complete.	The physics approach contains minor omissions or errors.	Some concepts and principles of the physics approach are missing and/or inappropriate.	Most of the physics approach is missing and/or inappropriate.	All of the chosen concepts and principles are inappropriate.	The solution does not indicate an approach, and it is necessary for this problem/ solver.	An explicit physics approach is not necessary for this problem. (i.e., it is given in the problem)	An explicit physics approach is not necessary for this solver.
SPECIFIC APPLICATION OF PHYSICS	The specific application of physics is appropriate and complete.	The specific application of physics contains minor omissions or errors.	Parts of the specific application of physics are missing and/or contain errors.	Most of the specific application of physics is missing and/or contains errors.	The entire specific application is inappropriate and/or contains errors.	The solution does not indicate an application of physics and it is necessary.	Specific application of physics is not necessary for this problem.	Specific application of physics is not necessary for this solver.
MATHEMATICAL PROCEDURES	The mathematical procedures are appropriate and complete.	Appropriate mathematical procedures are used with minor omissions or errors.	Parts of the mathematical procedures are missing and/or contain errors.	Most of the mathematical procedures are missing and/or contain errors.	All mathematical procedures are inappropriate and/or contain errors.	There is no evidence of mathematical procedures, and they are necessary.	Mathematical procedures are not necessary for this problem or are very simple.	Mathematical procedures are not necessary for this solver.
LOGICAL PROGRESSION	The entire problem solution is clear, focused, and logically connected.	The solution is clear and focused with minor inconsistencies	Parts of the solution are unclear, unfocused, and/ or inconsistent.	Most of the solution parts are unclear, unfocused, and/ or inconsistent.	The entire solution is unclear, unfocused, and/ or inconsistent.	There is no evidence of logical progression, and it is necessary.	Logical progression is not necessary for this problem. (i.e., one-step)	Logical progression is not necessary for this solver.

Appendix VII

Syntax for Homogeneity of Regression

```
MANOVA Post-CU, Post-PSS, Post-affection, Pre-CU, Pre-PSS, Pre-affection
BY Group(0,2) Gender (1,2)
/PRINT=SIGNIF(BRIEF)
/ANALYSIS=Post-CU, Post-PSS, Post-affection
/DESIGN= Pre-CU, Pre-PSS, Pre-affection, Group, Gender, Group BY Gender
POOL(Pre-CU, Pre-PSS, Pre-affection)BY Group +
POOL(Pre-CU, Pre-PSS, Pre-affection)BY Gender +
POOL(Pre-CU, Pre-PSS, Pre-affection)BY Group BY Gender
/ANALYSIS=Post-CU
/DESIGN= Pre-CU, Pre-PSS, Pre-affection, Group, Gender, Group BY Gender
POOL(Pre-CU, Pre-PSS, Pre- affection)BY Group +
POOL(Pre-CU, Pre-PSS, Pre- affection)BY Gender +
POOL(Pre-CU, Pre-PSS, Pre- affection)BY Group BY Gender
/ANALYSIS=Post-PSS
/DESIGN= Pre-CU, Pre-PSS, Pre- affection, Group, Gender, Group BY Gender
POOL(Pre-CU, Pre-PSS, Pre- affection)BY Group +
POOL(Pre-CU, Pre-PSS, Pre- affection)BY Gender +
POOL(Pre-CU, Pre-PSS, Pre- affection)BY Group BY Gender
/ANALYSIS=Post- affection
/DESIGN= Pre-CU, Pre-PSS, Pre- affection, Group, Gender, Group BY Gender
POOL(Pre-CU, Pre-PSS, Pre- affection)BY Group +
POOL(Pre-CU, Pre-PSS, Pre- affection)BY Gender +
POOL(Pre-CU, Pre-PSS, Pre- affection)BY Group BY Gender.
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Appendix VIII

Sample instructional method used for teaching Treatment group I students in the form of daily Lesson Plan

Teacher`s Name: - _____________ **Duration**: - 40 min
Grade & Section: - 11C **Subject**: - Physics
Unit 6: - Rotational Motion

Objectives: - At the end of this lesson, students will be able to:

- ✓ Explain the concept of rotational KE
- ✓ Apply the concepts of rotational KE to solve problems.

Date	Topic	Stages of the method	Teachers activity	Students activity	Remark
07/07/09 E.C.	Rotational Kinetic Energy	Relating	• Start the lesson through reminding the previous lesson. • Then introducing the lesson of the day. To do this, first mention some rotating objects they encounter everyday such as wheels (of bicycles, buses, cars and trains), potter's wheel, spinning tops, rotating hands of a clock, merry-go-rounds, grinding stones, etc. You could point out to them that we live on a rotating object, the earth. Ask them to mention some natural phenomena that occur due to its rotation (e.g., the occurrence of day and night). Encourage your students to name a few more which you could add to the list. Then, introduce the day's lesson (i.e., the rotational KE) and encourage them to give you examples of energy's that is associated with rotation • Then reveal students preexisting knowledge about the rotational KE through linking the concept with something that the students knows, for instance by relating translational KE with rotational KE. The teacher needs to identify his learners' misconception about the topic.	• Listening • Participation ✓Asking ✓Answering	
		Experiencing	• Providing a suitable learning environment for the students to compare the concepts with their experience. The learners are thus provided with hands on activities that enable them to learn the concept of rotational motion. Since any moving object has kinetic energy, an example of a very energetic rotating body like an electric grindstone propelled by a motor was provided to them. Sparks are flying, and noise and vibration are generated as the grindstone does its work. This system has considerable energy, some of it in the form of heat, light, sound, and vibration. However, most of this energy is in the form of rotational kinetic energy. • Rotational kinetic energy has important effects. Flywheels, for example, can be used to store large amounts of rotational kinetic energy in a vehicle. Experimental vehicles, such as bus, have been constructed in which rotational kinetic energy is stored in a large flywheel. When the bus goes down a hill, its transmission converts its gravitational potential energy into KE rot. It can also convert translational kinetic energy, when the bus stops, into KE rot. The flywheel's energy can then be used to accelerate, to go up another hill, or to keep the bus from going against friction. • Helicopter pilots are quite familiar with rotational kinetic energy. Helicopters store large amounts of rotational kinetic energy in their blades. This energy must be put into the blades	• Participation • Group discussion	

			before takeoff and maintained until the end of the flight. The engines do not have enough power to simultaneously provide lift and put significant rotational energy into the blades. • To emphasize the analogy, roll a basketball across the floor and ask students to describe the energy of the basketball and what happens to that energy as the ball rolls to a stop. • Based on such kinds of hands on activity, the learners discover the new knowledge related to rotational KE.		
		Applying	• The students are provided with examples like the ones shown below to enable them to apply the new concepts to get a feeling for the energy associated with a few rotating objects. 1. A typical small rescue helicopter has four blades: Each is 4m long and has a mass of 50kg. The blades can be approximated as thin rods that rotate about one end of an axis perpendicular to their length. The helicopter has a total loaded mass of 1000 kg. (a) Calculate the rotational kinetic energy in the blades when they rotate at 300 rpm. (b) Calculate the translational kinetic energy of the helicopter when it flies at 20m/s, and compare it with the rotational energy in the blades. 2. Calculate the rotational kinetic energy of the Earth. As the Earth has a period of about 23.93 hours, it has an angular velocity of 7.29×10^{-5} rad/s. The Earth has a moment of inertia, $I = 8.04\times10^{37}\ kg\cdot m^2$. Therefore, it has a rotational kinetic energy of 2.138×10^{29} J. 3. Consider a person who spins a large grindstone by placing her hand on its edge and exerting a force through part of a revolution. (a) How much work is done if she exerts a force of 200 N through a rotation of 1.0rad? The force is kept perpendicular to the grindstone's 0.32m radius at the point of application, and the effects of friction are negligible. (b) What is the final angular velocity if the grindstone has a mass of 85kg? (c) What is the final rotational kinetic energy? • After solving the problems, the learners are required to interpret their results and create concepts by connecting it with real life or context	• Applying the new knowledge to real world situations • Participation & discussion	
		Cooperating	• The students are given time to think about and discuss in groups through sharing, communicating and responding to the important concepts and decision-making process	• Participation • Group discussion	
		Transferring	• Here the teacher encourages his students to use explanations in new situations, i.e., by providing another application allowing students to use their new knowledge. For instance, they may give them a problem like the one shown below allowing students to use the concept of rotational KE in a new situation. ○ What do you think is the difference between rotational and translational kinetic energy is that translational is straight line motion while rotational is not. ○ Explain the kinetic and translational kinetic energy found in a bike tire while being ridden down a bike path.	• Participation ✓Asking ✓Answering ✓Doing class work and homework	

Teacher`s Name: -                    Dep`t head Name:-_________   Vice Director name:_______

Signature:-_________   Signature:-_________   Signature:-_______

Date:-   Date:-   Date:-

Sample instructional method used for teaching Treatment group II students in the form of daily Lesson Plan

Teacher`s Name: - _____________
Duration: - 40 min
Grade & Section: - 11B
Subject: - Physics
Unit 6: - Rotational Motion

Objectives: - At the end of this lesson, students will be able to:

- ✓ Explain the concept of rotational KE
- ✓ Apply the concepts of rotational KE to solve problems.

Date	Topic	Stages of the method	Teachers activity	Students activity	Remark
07/07/09 E.C.	Rotational Kinetic Energy	Relating	• Start the lesson through reminding the previous lesson. • Then introducing the lesson of the day. To do this, first mention some rotating objects they encounter everyday such as wheels (of bicycles, buses, cars and trains), potter's wheel, spinning tops, rotating hands of a clock, merry-go-rounds, grinding stones, etc. You could point out to them that we live on a rotating object, the earth. Ask them to mention some natural phenomena that occur due to its rotation (e.g., the occurrence of day and night). Encourage your students to name a few more which you could add to the list. Then, introduce the day's lesson (i.e., the rotational KE) and encourage them to give you examples of energy's that is associated with rotation • Then reveal students preexisting knowledge about the rotational KE through linking the concept with something that the students knows, for instance by relating translational KE with rotational KE. The teacher needs to identify his learners' misconception about the topic.	• Listening • Participation ✓Asking ✓Answering	
		Presentation	• Presenting the concept of rotational motion to the students through lecturing ✓ Teachers explanation allowing students to discover new knowledge	• Listening • Taking notes	
		Applying	• Linking the new concepts with students' real life or context through experiencing the learners with the rotational energy associated with grindstone, flywheel, helicopters, rolling a ball on the floor, etc just in a similar manner used with treatment group I students. • The students are provided with examples that enables them to apply the new concepts to get a feeling for the energy associated with a few rotating objects like the one shown below: 1. A typical small rescue helicopter has four blades: Each is 4m long and has a mass of 50kg. The blades can be approximated as thin rods that rotate about one end of an axis perpendicular to their length. The helicopter has a total loaded mass of 1000 kg. (a) Calculate the rotational kinetic energy in the blades when they rotate at 300 rpm. (b) Calculate the translational kinetic energy of the helicopter when it flies at 20m/s, and compare it with the rotational energy in the blades.	• Applying the new knowledge to real world situations • Participation • Discussion	

			2. Calculate the rotational kinetic energy of the Earth. As the Earth has a period of about 23.93 hours, it has an angular velocity of 7.29×10^{-5} rad/s. The Earth has a moment of inertia, I = 8.04×10^{37} kg·m^2. Therefore, it has a rotational kinetic energy of 2.138×10^{29} J. • After solving the problems, the learners are required to interpret their results and create concepts by connecting it with real life or context		
		Transferring	• Here, the teacher encourages his students to use explanations in new situations, i.e, by providing another application allowing students to use their new knowledge. For instance, they may give them a problem like the one shown below allowing students to use the concept of rotational KE in a new situation. o What do you think is the difference between rotational and translational kinetic energy is that translational is straight line motion while rotational is not. o Explain the kinetic and translational kinetic energy found in a bike tire while being ridden down a bike path.	• Participation • Group discussion	
		Evaluating	• Measuring whether the students understood the new information correctly ✓ Oral questions, class work, etc. As homework, a problem like the one shown below is given to them. 1. Consider a person who spins a large grindstone by placing her hand on its edge and exerting a force through part of a revolution. (a) How much work is done if she exerts a force of 200 N through a rotation of 1.0rad? The force is kept perpendicular to the grindstone's 0.32m radius at the point of application, and the effects of friction are negligible. (b) What is the final angular velocity if the grindstone has a mass of 85kg? (c) What is the final rotational kinetic energy?	• Participation ✓Asking ✓Answering ✓Doing class work and homework	

Teacher`s Name: -
Signature:-_____________
Date:- _____________

Dep`t head Name:-__________
Signature:-__________
Date:- _____________

Vice Director name:________
Signature:-_________
Date:-

Sample instructional method used for teaching Comparison group students in the form of daily Lesson Plan

Teacher`s Name: - _____________ **Duration**: - 40 min
Grade & Section: - 11B **Subject**: - Physics
Unit 6: - Rotational Motion

Objectives: - At the end of this lesson, students will be able to:

- ✓ Explain the concept of rotational KE
- ✓ Apply the concepts of rotational KE to solve problems.

Date	Topic	Stages of the method	Teachers activity	Students activity	Remark
07/07/09 E.C.	Rotational Kinetic Energy	Introduction	• Start the lesson through reminding the previous lesson. • Then introducing the lesson of the day.	• Listening • Participation through giving answers	
		Presentation	• Giving lectures about the rotational motion topics • Solving problems related to rotational motion like those found in their text book	• Listening • Taking notes	
		Summarization	• Summarizing the main points of the lesson	• Listening • Participation to some extent	
		Evaluation	• Measuring whether the students understood the new information correctly • Oral questions, class work, homework, etc	• Participation ✓Asking ✓Answering ✓Doing class work and homework	

Teacher`s Name: -
Signature:-____________
Date:- ____________

Dep`t head Name:-_________
Signature:-_________
Date:- ____________

Vice Director name:_______
Signature:-________
Date:- _________

Appendix IX
Cooperation Letter

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Addis Ababa University
College of Education and Behavioral Studies
Department of Science & Mathematics Education
Addis Ababa, Ethiopia

Date: February 01, 2017
Ref. No.: SMED/074/2009-17

To: Robe Town Education Office
Robe
Goba Town Education Office
Goba
Ginnir Town Education Office
Ginnir

Subject: **requesting cooperation for research work**

Mr. Fekadu Eshetu is a PhD candidate at the department of science and mathematics education. He has requested the department to write him an official letter to collect data from your schools in your catchment.

The department has ratified his research entitled "**Context based instructional approach on Preparatory school students' Learning of Rotational Motion**" for the fulfillment of PhD degree. This is therefore; to kindly request your usual cooperation for Mr. Fekadu Eshetu in permitting him to collect the necessary data from students and physics teachers of the selected schools.

With Regards,

College of Education & Behavioral Studies
Natural Sciences Educ. Program Unit (GSE)
Addis Ababa University

Kassa Micheal (PhD)
Chairman, Department of Science and Mathematics Education

C.C.
Mr. Fekadu Eshetu

☎ 011 1 22 07 67 ✉ 1176

Addis Ababa University

College of Education and Behavioral Studies

Department of Science and Mathematics Education

Dissertation Approval Form

The PhD Dissertation entitled: "*Context-Based Instructional Approaches and Preparatory School Students' Learning of Rotational Motion*" has been completed under my supervision and submitted for examination with my approval.

Supervisor's Name: Shimeles Assefa (Assoc. Prof.)

Signature: ____________________

Date: 17/12/18