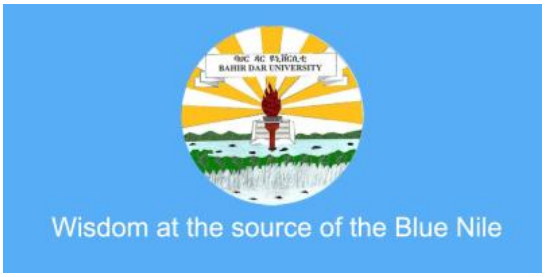

Making Science and Mathematics Teaching and Learning Impactful

International conference on Science and Mathematics Education

College of Education and Behavioral Sciences

Bahir Dar University, Bahir Dar, Ethiopia

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(Organized by the BDU-NORHED Project Office)

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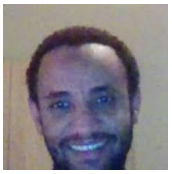

Introduction

Learning science and mathematics in schools is important to help students develop problem-solving skills, become better aware about technology, and better know and manage their surrounding environment. For students to get the best out of their learning experiences, the way they learn science and mathematics need to be meaningful. In schools, particularly in developing countries, science and mathematics are taught as mere facts to remember and as heuristic procedures to follow for solving problems. The new science of learning promotes that children should *learn* science and mathematics rather than *learning about* science and mathematics. A wider impact to this end can be possibly created by intervening on the way science and mathematics teacher educators are prepared which will subsequently influence the way school science and mathematics teachers are prepared. To this end, the BDU-NORHED project is designed in 2016 with the objectives of producing more and better qualified graduates in the area of mathematics and science education. The project is a 5-year institutional partnership project among Bahir Dar University (BDU), Norwegian University of Science and Technology (NTNU), and University of Juba (UJ). Beyond producing qualified graduates, the project has aimed at enhancing the gender responsive teaching practices and mathematics and science pedagogical skills of school teachers through short term STEM pedagogy training, producing more and better research by establishing collaborations among the north and south partners, schools and teacher education colleges and strengthening the capacity of the STEM center particularly at Bahir Dar University.

One of the tasks planned in the project is creating platform in which researchers, teachers, experts and policy makers involved in science and mathematics education come together and share experiences. Hence, the project office at the College of Education and Behavioral Sciences, Bahir Dar University organized this conference with the theme of *Making Science and Mathematics Teaching and Learning Impactful.* The conference is one of a few of its kind in higher learning institutions in Ethiopia in general and at BDU in particular to specifically focus on the teaching and learning of science and mathematics. Attempt is made to select papers which tend to provide empirical and/or theoretical arguments on how to make science and mathematics teaching and learning impactful. Two keynote speeches from notable mathematics (Professor Paul Ernest) and science (Dr. Temechegn Engida) education experts and twenty three papers will be presented in the conference. It is the belief of the organizers that the conference will inspire educators and researchers for more work on the issues of science and mathematics teaching and learning.

Keynote Speakers

Professor Paul Ernest

Paul Ernest is currently emeritus professor of the philosophy of mathematics education at Exeter University, UK. Originally a student of mathematics and philosophy up to PhD level he became interested in educational issues through teaching school mathematics in London during the 1970s. His main research interests concern fundamental questions about the nature of mathematics and how it relates to teaching, learning and society. He has developed a semiotic theory of mathematics and education. He is best known for his work on philosophical aspects of mathematics education and his contributions to developing a social constructivist philosophy of mathematics. *(Source: Wikipedia).* Professor Paul Ernest sole authored seven books which mainly focus on philosophy and theories of mathematics education, authored more than 120 book chapters and more than 140 journal articles. Besides, he edited 11 collections which focus on issues of teaching and learning of mathematics as well as mathematics education. He also worked as a series editor of the book *Studies in Mathematics Education* and editor of *Philosophy of Mathematics Education Journal.* His talk in the present conference is about *mistakes in mathematics and learning.*

Mistakes in Mathematics and Learning

Abstract

Mistakes and errors are common in mathematics and its learning. Errors can rob theorems and proofs of their correctness. Nevertheless, how errors are viewed is very important. Are maths errors seen as bad mistakes always to be avoided or even as sins? If so, one can make students fear taking risks in trying to solve problems, damaging their confidence and attitudes. Errors and mistakes are a necessary part of formative assessment, showing teachers what students understand and what they can perform. Constructivist learning theory depends on errors demonstrating students' personal knowledge construction. Social constructivist learning theory posits that learner capabilities are shaped by dialogues in which guidance, feedback and correction by teacher or capable other is essential. Dialogical interaction is the key mechanism behind individual knowledge growth, as well as culture maintenance and the transmission of ethics. Supportive correction is necessary, with errors treated positively: yes to acceptance, and no to fear of errors. Children should see the maths classroom as open, active and creative – where risk taking is encouraged, supported by teacher guidance.

Dr. Temechegn Engida

Temechegn Engida is a holder of PhD in science education and had been an instructor in the Addis Ababa University (AAU) teaching both undergraduate and postgraduate (MA and PhD) students of science education/curriculum and instruction as well as researching and advising research works through face-to-face and distance modes. He served as the Associate Dean for Research and Postgraduate Programs of the Faculty of Education in the AAU. He is the founding President of the Federation of African Societies of Chemistry and is serving as Editor-in-Chief of the African Journal of Chemical Education. He is also the Chairperson of the Committee on Chemistry Education in Africa (CCEA) that is the responsible body of FASC for ACRICE (African Conference on Research in Chemistry Education). He has published over 35 research articles and book chapters. Dr. Temechegn currently works for the UNESCO International Institute for Capacity Building in Africa (IICBA) as the Program Officer for ICT and STEM Education. In this capacity he has been building the capacities of STEM teacher educators and teachers in over 30 African countries in areas such as eLearning content development, ICT-enhanced teacher development, contextualizing STEM curricula and instruction. His talk in the present conference is about *issues and trends in science education*

Science Education: Issues and Trends

Abstract

Science education has gone through various stages of development, each time raising issues that pertinent to national as well as global concerns. As science educators, we should understand, get insight and up-to-date issues and trends in science education research which will lead us to come up with new research questions. This speech, therefore, raises the main issues in science education and tries to propose future directions both for research and practice.

A Political Ecological Perspective on Environmental Education

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Background. Environmental education is often given a normative justification based on the environmental challenges the world is facing with. That sometimes makes environmental issues to a question about right and wrong, almost moral statements. But looking closer at environmental issues, they, in most cases, include distribution of costs and benefits between social groups. Then we are into politics and power struggles in society. Then, political ecology becomes important because it focuses on both the environmental challenges in society and the political context they are embedded into.

Sample and Method. This presentation is a theoretical reasoning based on the tradition of political ecology as well as perspectives in environmental education. The paper tries to combine these two perspectives.

Results. The combination of those different theoretical perspectives on environmental education indicates that one has to change how one teach about environmental issues. One must look more on how those are articulated in society, and how the perceptions of those issues vary between social groups, as well as who the beneficiaries and losers are from different ways to handle those issues. Further, the livelihoods of the students and their families as well as the local community are included.

Conclusions. A combination of political ecology and environmental education would make an education closer to the perceptions of people giving students the insight that handling environmental issues would help with narrowing mismatches in perceptions. Students have to learn that in the realm of environmental issues, one has to understand who the beneficiaries are when it comes to environmental policies.

Implications. Teaching on environmental education should involve problematization of environmental issues that one has to look on environmental issues from different angles identifying how different social actors are related with specific problems. Further, the approach has a potential to make education closer to the real life experiences of the students, and not with abstract problems that the students come across.

Science and Mathematics Achievement in Primary Schools of South Gondar Zone, Amhara, Ethiopia

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Background. In the present technology dominated world, a modern country needs as many students as possible specializing in math, science, and technology. Mathematics and science are among the crucial subjects of the school curricula in terms of preparing educated human power for the overall development. It is essential to increase attention to mathematics and science and cultivate a generation of scientists. Therefore, it is evident that education with science and mathematics is the major component that contributes to the level of prosperity, welfare, and security of a nation. In this sense, science and mathematics education is believed to serve as the foundation of technological development, and it is a key factor to economic growth. For instance, China stood second in the world in the proportion of science, technology, engineering and mathematics (STEM) degrees awarded with 52.1%, next to Japan with 64.0% (UNESCO, 2007 and Oli Negassa, 2014). Although science and mathematics are in every aspect of our life, international studies show that success in science and mathematics education is lower than success in other disciplines (Pravica, 2005, cited in Genene, 2014). Even though the trends of mathematics and science scores show a decreasing trend, there is a growing recognition of their importance in developing countries.

Sample and Method. A multistage stratified sampling method followed by simple random sampling techniques was employed. Schools were selected randomly through the lottery method. Students were then proportionally sampled from the schools selected randomly. Using this method, a total of 384 students were selected from three towns and three schools.

Results. The result of the study indicated that there is a decreasing achievement trend in mathematics and science subjects. A statistically significant, but a very low, relationship was observed between the mathematics and science achievement score ($r = 0.200$; $p < 0.01$).An independent samples t-test indicated that a statistically significant difference was not observed between male and female students ($t(368) = -.500$, $p > .05$) in the their achievement score where the males' score in mathematics and science ($M = 64.92$, $SD = 10.82$, $N = 370$) was only slightly lower than females' ($M = 66.20$, $SD = 32.36$), but the location of residence was found to be significant as a factor in students achievement of mathematics and science achievement scores, $F(2, 367) = 3.520$, $P < 0.05$. There were however significant differences between zones ($M=67.15$, $SD=10.24$.) and wereda towns ($M=63.35$, $SD= 32.59$).

Conclusions. Mathematics and science achievement scores among the primary school of south Gondar Zone show a decreasing trend. The achievement score suggested that mathematics correlated significantly with science achievement score of the students. Sex did not have any effect on students' on the mathematics and science achievement score. Location of the schools had a significant effect on mathematics and science achievement scores.

Implications. The Ministry of Education and universities shall design and conduct large scale research to find out the underlying reasons for the decreasing achievement trends in science and mathematics.Large scale research undertaking shall be carried out to see the relationships between mother tongue, language of instruction and mathematics and science achievement scores.

The Effect of Blended Learning on Mathematical Achievement and Anxiety: A Context-Based Technology Integration for Meaningful Learning

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Background. Ethiopia has envisioned to become a middle-income country by the year 2030. To achieve this vision, several initiatives including the ESDP (I-V), GQIP, and currently the education development Roadmap have been undertaken to improve the quality of education. Apart from those initiatives, it is equally important to rethink of a pedagogical approach that suits the contemporary technological advancement. It is no longer viable to rely on one-size-fits-all curriculum. Students' achievement in mathematics is declining from time to time (NEAEA, 2014). This unsatisfactory result may be attribed to many factors including fear of mathematics learning(Melesse, 2014; Shishigu, 2018) which could be due to the reason that the teaching learning system does not suit or motivate learners to take it at ease (Melesse, 2014) and the pedagogical approach used (Eshetu, Dilamo, Ayele, & Zinabu, 2009). Thus, there is a need for new pedagogical approaches which are up to students' expectations and technological advancement. So far, the impact of instructional technology on students' learning is not consistent and lacks specific context of students' environment. This indicates the need for intensive investigation to come up with a dynamic model of technology integration. As a result, this study aimed to restructure the existing mathematics course in Ethiopian higher education so as to produce a pedagogically enhanced learning environment.

Sample and Method. To achieve the goal of this study, an interrupted time series research approach was used; it is used to understand causality within the process. Thus, the design is different from the one sample pretest-posttest design. In an interrupted time series design, there is a repeated measurement which the pretest-posttest design does not possess. In this research, a total of four measurements were taken throughout the intervention period in order to provide sufficient number of data points to conduct a statistical analysis to evaluate the effects of the intervention. To better examine the role of blended learning, the course level blending model was used. Based on the nature of students (novice to computers), the instruction was given on a face-to-face manner, which takes about 67% of the semester contact hour. Hence, the blended learning model in this study was designed to be a supplemental model which was implemented at three stages. Participants included 25 second year students enrolled in the department of mathematics.

Results. The repeated measures ANOVA show a significant difference between students' mean scores of course achievement measured before, during and after the intervention ($F(2.182, 52.358) = 8.354$, $p < .05$, $\eta 2 = .258$). The multiple comparison test further shows a significant improvement of students' course achievement. It was also found that when technology is used as a tool to enhance students learning, it can overcome the math anxiety caused by the cognitive failure.

Conclusions. The supplemental blended learning approach produced a positive effect on mathematics achievement. The improvement on achievement of students can be attributed to the vast learning opportunity students got as a result of the intervention. It was found that blended learning, as one of an emerging pedagogical approach, has a promise of overcoming a difficulty like mathematics anxiety.

Implications. It is recommended that the Ministry of Education and higher education institutions need to be cognizant of the benefits of blended approach in the current digital age and particular local contexts. Additional studies should be conducted in different courses to see the effectiveness of the method in other dimensions.

Pupil's Algebraic Thinking Development on Addition and Subtraction Using Compensation in Grade Three

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Background. This study aimed to investigate pupils' algebraic thinking development on addition and subtraction through the use of two principles of compensation-compensation principle for addition and compensation principle for subtraction in grade three**.** The properties of these two operations, addition and subtraction ease the pupils' algebraic thinking development in lower primary grades and it would be easy for pupils to identify the relationship of numbers especially. Some researchers point out that subtraction of numbers is difficult compared to addition of numbers, and they suggest algebraic thinking development as a tool to ease difficulties in addition and subtraction (Duncan, 2015; Russell and Schifter, 2011; Britt and Irwin, 2005). Also, Subramanian and Banerjee suggest arithmetic need to be linked to algebra through pedagogical tools which will give children chances of thinking mathematically. However, research in the South Sudan is dearth.

Sample and Method. Case study with a qualitative approach was used in this study. The study dealt with how pupils got the concept of compensation strategy especially in compensation principle for addition and compensation principle for subtraction. Test, interview, and observation were used as data collection instruments. Aclass of fifty (50) third graders were sampled. Simple random sampling was employed for selecting the target number of pupils. The pupils selected participated by answering some numbers in the test questions on addition and subtraction. Not only that five (5) pupils (3 boys and 2 girls based on their performance in test (low and high performers) were also selected out of fifty (50) pupils for interviews, with the help of their mathematics.

Results. The finding for this study revealed that pupils understood the compensation principle for addition very well compared to their subtraction knowledge. Pupils performed very well in the test when they added numbers using compensation principle for addition than subtraction where they performed poorly in the test. It is supported by Irwin and Britt (2005) that students performed very well in addition questions "compensation in addition continued to be the easiest operation, while compensation in subtraction was the most difficult" (p. 49). Therefore, the findings revealed that pupils could develop their algebraic thinking on addition using compensation principle for addition easily compare to compensation principle for subtraction.

Conclusions. The purpose of this study was to investigate how pupils could develop algebraic thinking on addition and subtraction using compensation strategy, and to what extent have they got concept of compensation strategy in term of adjusting numbers to be added or subtracted. Findings for this study revealed pupils have developed conceptual understanding about compensation strategy. Also, pupils have known the directions of compensation strategy. Therefore, the finding for study indicated that pupils can develop their algebraic thinking in addition to easily using compensation. However, findings for this study indicated that it is gradual for pupils to develop their algebraic thinking in subtraction using compensation because pupils mixed up compensation principle for addition with compensation principle for subtraction. Thus, compensation strategy is found to be the foundation of algebraic thinking in lower primary grades. Hence, compensation

strategy is reliable and valid for the development of pupils' algebraic thinking in addition and subtraction in lower primary grades based on how they approached problem of addition and subtraction of numbers using this new strategy.

Implications. Compensation strategy is the best method for developing algebraic thinking in lower primary grades but it needs flexibility because it is part of mental method. Furthermore, introducing algebraic thinking in lower primary grades informs of compensation strategy, and incorporation of it in mathematics curriculum is vital to open up the mind of pupils in primary for algebra in secondary school. Moreover, compensation strategy increases the pupils' creativity in adjusting numbers. However, algebraic thinking and compensation strategy are a bit complicated for pupils of low understanding and slow learners.

The Status of Problem-Solving Approach in the Teaching of Mathematics in Some Selected Universities of Southern Regional State, Ethiopia

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Background. The status of problem-solving approach (PSA) in the teaching of mathematics at university level was investigated in this paper. The study was conducted at four sampled universities in Southern regional state or SNNPR, Ethiopia. There are three approaches for teaching mathematics problem solving. Teaching for problem solving, teaching about problem solving and teaching through problem solving. In teaching for problem solving (problem solving as a skill), the emphasis is placed on learning mathematics for the main purpose of applying it to solve problems in a wide range of situations once students have learnt a particular topic related to the same content area. In order to solve problems students need to make meaningful connections between the new problems with what they already know. Teaching about problem solving (problem solving as a context) includes guidance about problem solving process and instruction about a variety of problem-solving strategies. It particularly teaches thinking skills and problem solving heuristics and the emphasis is on using heuristic strategies to approach and solve unfamiliar problems that are usually not domain-specific to any topics in the syllabus. Teaching through problem solving treats problem solving as a process of inquiry, while both teaching for and about problem solving treat problem solving as an object of inquiry. Teaching mathematics through problem solving or the PSA starts with a problem. Teacher pose problems to challenge students' knowledge and thinking, thus providing a need for the students to organize their understanding in order to resolve the problem and this approach makes problem solving a means rather than an end. Teaching through problem solving is a vehicle for students to construct, evaluate and refine their own theories about mathematics and the theories of others. It is a means of developing mathematical thinking as a tool for daily living, and that problem-solving ability lies at the heart of mathematics. Teachers, in most cases, tend to avoid teaching mathematics through problem solving. Problem-solving approach expected to implement in mathematics classrooms at all education levels in the country. In particular, it is important at university where students learn independently, because any problem and misunderstanding at this stage may affect individuals in their world of work. Students' later life largely affected by the way they taught at university. This implies the status of the practice of problem-solving approach assessed continuously. In Ethiopia, mathematics curricula devised to give students with the mathematical facts and skills to promote problem solving and to make decision for everyday use. The mathematics curriculum at university also seeks to encourage noble values and love for the nation by developing the mathematical skills needed in modeling and solving practical problems.

Sample and Method. Purposive sampling technique was used to select four universities in the southern regional state Ethiopia, and 92 participant mathematics lecturers in this particular study. The explanatory sequential mixed method design, which entails descriptive survey and exploratory design, was employed. Data was collected from lecturers using questionnaires, classroom

observation protocol / field notes and interview guides. All the instruments had their validity and reliability determined. Quantitative data gathered was analyzed using descriptive statistics, while qualitative follow-up data gathered from lecturers using classroom observation protocol/field notes and interview guides was analyzed in order to explain the results of quantitative results.

Results. The implementation of the PSA in mathematics instruction at different stages of the instructional process was considered low. The results obtained from the questionnaire and classroom observation revealed that lecturers, in general, did not employ a wide variety of instructional methods that incorporate the PSA to engage students in the entire teaching-learning activity. Different factors were given for the poor implementation of this method, such as poor motivation of lecturers, negative attitude of both students and lecturers, shortage of appropriate teaching resources, bulky curriculum and inflexible schedule, poor student problem-solving experience, lack of support and large class sizes.

Conclusions. The study has provided insights into the use of teaching mathematics through problem solving and the extent to which this instructional approach was used in the selected Ethiopian universities. Firstly, the study shows that teaching in Ethiopian universities was dominated by lecturer-talk while students sat passively, listening to the lecturer, and taking down notes written on the board. This is despite efforts by the Ethiopian government to increase access to quality higher education and require of universities to provide quality education and produce graduates who can model and solve real-life problems, reason logically and think critically. Secondly, the lecturers who supposed to adopt the much more effective instructional approach such as teaching through problem solving not provided with necessary training and necessary materials. This adversely affected teaching and the lecturers' morale. Thirdly, students prefer given knowledge rather than develop their own knowledge. It is for this reason when lecturers tried to get them actively involved in the lectures students did not respond as expected. Lastly, the seating arrangement in lecture rooms was not conducive to teaching through problem solving. The study shows lack of harmony between what decided by authorities and what exists or is happening on the ground. It thus concluded that for the changes successfully effected there is a need to take heed of what exists and whether there are measures in place to accommodate what newly introduced.

Implications. The study has provided further insights into teaching through problem solving. Firstly, the theoretical background spelt out what PSA entails and what it does not entail. By so doing, it distinguished PSA from 'teaching for problem solving' and 'teaching about problem solving'. Secondly, noting the lecturers' views about PSA and the way the lecturers went about thinking they were teaching through problem solving show the lecturers' conception of PSA. This implies that PSA used the way it has been conceptualized or understood. Thirdly, the successful use of PSA depends significantly on the type of questions or tasks given to students during learning. Questions or tasks should be thought provoking and stimulate critical and creative thinking. Lastly, the challenges that adversely affect the use of PSA as documented in this study add further dimension to efforts or shed more light into the intricacies surrounding the use of PSA.

Review of the Effectiveness of Advance Organizer Teaching Model on Students' Academic Achievement and Motivation in Science and Mathematics

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Background. Advance organizer is an instructional strategy used to promote students' learning and retention. Teachers use advance organizer to help their learners make a link between what they know and what is to be learnt. Advance organizer is a useful tool that helps students have better understanding and retention of new learning materials. Researchers have investigated the effect of advance organizers on achievement and motivation of students in science and mathematics subjects. However, review of existing studies on the effectiveness of using advance organizers in teaching science and mathematics is limited. . Hence this study is designed to analyze the role of advance organizer on secondary and senior secondary schools students' academic achievement and motivation in science and mathematics subjects.

Sample and Method. To investigate the effectiveness of advance organizer as a teaching model on students' academic achievement and motivation in science and mathematics subjects, 60 peer-reviewed journals, 10 books, and 17 additional full publications were reviewed and analyzed. The process consisted of identification of the problem; literature search; evaluation and selection of the literature; analysis and presentation of data.

Results. The results of the literature analysis showed that during pre-test, no significant difference was noted in the performances of students in the experimental and control groups. However, during the post-test, students' achievement in the experimental group was found to be significantly better than that of the control group. Furthermore, it is found that advance organizers facilitated students' motivation and retention in science and mathematics subject.

Conclusions. Research on the role of advance organizers as facilitators of students' learning in science and mathematics subjects appears to be nebulous and inconclusive. The review indicated that Advance Organizer as a teaching strategy significantly influenced students' academic performance and motivation in science and mathematics. The analysis also showed that no significant difference was observed in achievement of students by age and gender.

Implications. The findings of the literature review have implication for science and mathematics teachers, curriculum developers and educational researchers. The review indicates that studies examining the effects of advance organizers on students' achievement and motivation in science and mathematics are inadequate. Future studies that examine the effect at a broader scope are required.

Improving the Learning of Optics: Analysis of Elementary Students' Conceptual status

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Background. Over the past three decades, Physics education researchers have unanimously found that the concept of optics remains conceptually and semantically difficult to teach and learn. Investigations by these researchers have examined conceptions of optical phenomena held before, during and after instruction and these studies revealed that students' conceptions are often perceptually dominated, undifferentiated, and are driven by everyday language and commonsense knowledge which is different from the formal scientific knowledge. Students' conceptions are inappropriately applied to situations by using knowledge from previous learning which is inconsistent with the principles taught in physics class. Students are also resistant to change in spite of instruction. In the Ethiopian context, although studies that confirm international experience are non- existent, the universal nature of students' conceptions about optics is somewhat similar. One prominent trend found in science teaching in the Ethiopian education system is the conventional teaching methods. Studies have shown that conceptual learning in optics is more or less independent of the conventional teaching methodswhere the teaching relies on such traditional approaches to teaching. As a result, physics teaching that engages students, relating physics to real-world situations, and generally focusing more on students' learning should be promoted to overcome those misconceptions and to bring about functional conceptual change. This study was targeted to examine guided inquiry as a teaching strategy for the conceptual understanding of elementary optics among eighth-grade students .The study explored and quantified students' conceptions of elementary optics before and after instructions.

Sample and Method. The design employed in the study was quasi-experimental. Two groups: experimental and control groups (40 students in the experimental and 39 students in control group) were formed. Atse Tsetse Dingle Primary School was selected purposely based on its convenience on the number of classrooms and random assignment of students After pretest, two classrooms were randomly selected and students were assigned as experimental and control group. Guided inquiry was employed for the experimental group; whereas, conventional instruction was applied to the control group students for two months. Data were collected through open-ended conceptual test and simple drawings and analyzed with the facet- scheme hierarchical organization, abundance and gain of it to determine and quantify students' conceptions.

Results. Before intervention, students assigned in both the experimental and control group showed nonscientific conceptions which is described as nonscientific facets and schemes of knowledge. These nonscientific facets and schemes of knowledge were very naïve and holistic in nature. After intervention, students taught by conventional instruction, showed little alteration on each facet and scheme of knowledge. However, those students who were taught with guided inquiry showed a considerable shift and alteration of each facet and scheme of knowledge than the conventional

group. The experimental group magnificently overcame their nonscientific facets and schemes of knowledge and built scientific concepts. Based on the experiment, guided inquiry was found to result in better students' conceptual understanding of elementary optics.

Conclusion. As noted by other researchers, students' nonscientific conceptions are almost identical with other context learners' nonscientific conceptions. This indicates the universal nature of students' nonscientific conceptions. Nonscientific conceptions in elementary optics are very stubborn to surmount easily with teaching by telling. This is because, the concepts, they got from their experience of the real world is more plausible than the new concepts told by the teacher. This implies that new activity which could challenge their existing nonscientific conceptions with the plausible model is required.

Implications. The study confirmed that guided inquiry is an effective teaching strategy to surmount students' nonscientific conceptions and to boost their understanding in elementary optics. This approach provides a possibility to test students' nonscientific conceptions and challenge it with discrepant activities. It also allows the students' to practice hand on activities and do physics as physicists. In addition, guided inquiry enriches the students with explaining, inferring and reasoning abilities. This might be helpful for physics teaching since most concepts in physics are misunderstood and need the aforementioned principles.

Inquiry Based Science Education and Teacher Professional Development

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Background. Inquiry as pedagogical strategy has been introduced to science teaching and learning 100 years ago (e.g. Barrow, 2006). Historically, there has been a development in the conceptualization of inquiry. It has been shown that inquiry represents a shift from the traditional orientation in terms of teachers' role, students' role and student work (e.g. Anderson, 2002). In general, students have to be active in acquiring knowledge of science concepts and learn about nature of science. In the absence of an agreed up on definition, today inquiry is seen to be multifaceted and encompasses the content, the teaching and the learning aspects (e.g. Crawford, 2014). Within these dimensions, teachers' beliefs about the subjects, the outcome valued, classroom culture and pedagogical approach play important roles in the implementation of inquiry (Maaß, Swan, & Aldorf, 2017). Despite the recommendations from policy makers and science educators, classroom implementations of inquiry in Europe was (or still is not?) as wide spread as expected. Teachers need support. In the efforts to train teachers and popularize the implementation of inquiry approach, European Union (EU) has funded several projects. Among others PRIMAS and Mascil in which the Maths and science team of our Department of Teacher Education, NTNU has participated are to be mentioned. In this paper, we share the teacher professional development (TPD) model that our team employed and the experiences while working with these projects.

Context and Method. In Norway and within the projects PRIMAS and mascil, we developed and conducted TPD based on research literature. We trained ordinary in-service teachers to become facilitators who in turn would train their colleagues. In training the facilitators, we followed the Müller's model (Müller, 2003) which describes the education of facilitators as a process consisting of three parts: learning off job (seminars with teacher educators/didacticians), learning by job (running PDs with support) and learning on job (action research). The seminars focused on the topics: Inquiry-based learning, beliefs, how to tackle unstructured tasks, task analysis, formative assessment, lesson study, training other colleagues. The facilitator education lasted for about one year, and the facilitators started to conduct workshops with their teacher colleagues during the last six months of this period. We did case studies (Yin, 1984) in two schools (School P and School S). We visited the facilitators' workshop (one in each school), observed some of the teacher colleagues' lessons, and conducted pre- post interviews with facilitators and three teachers from each case school.

Results, Discussion and Possible Implications. In Norway, a systemic support in the form of allocated time within ordinary working hours was a prerequisite for in-service teachers' participation in the project. Overall, the chosen PD model has resulted on facilitators and teachers growth. The workshop observations showed that all facilitators had acquired a good understanding of inquiry as indicated by how they lead their colleagues in discussing IBL concepts, tasks and

teacher' roles (Febri, Sikko, Dahl & Staberg, 2016). The interviews suggested that the facilitators' role seemed to be crucial for the teacher growth. Teachers were empowered to create their own inquiry lessons and tasks.

Preservice Elementary Physics Teachers' Epistemic Knowledge: Development and Validation of a Test in Electricity and Magnetism

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Background. The primary concern of science education is to create a scientifically literate society. Accordingly, assessments need to align with this science education goal. However, existing conceptual tests to assess scientific knowledge did not evaluate students' scientific literacy adequately. The competencies in scientific literacy require the three forms of scientific knowledge, namely, content, procedural and epistemic knowledge. Teaching and assessments in science should therefore promote all forms of scientific knowledge and introduce students with the established way of thinking in science to make citizens scientifically literate (OECD, 2013). A review of physics education research studies revealed that relatively few studies are conducted to assess students' epistemic knowledge. The majority of these studies are focused on the personal aspects of epistemology and deal with beliefs about the nature of knowledge and knowing in science (Berland, et al., 2016). In contrast, other studies that focus on scientific reasoning disregarded the complexity of scientific knowledge. Recently science educators claim that scientific reasoning requires content, procedural, and epistemic knowledge (Osborne, Rafanelli, & Kind, 2018; Kind & Osborne, 2017). Kind and Osborne (2017) argue that scientific reasoning has its own unique "entities, procedures, and epistemic constructs" (p.10). Since scientific reasoning depends on epistemic knowledge, there is a paucity of valid and reliable test instruments that can uncover students' epistemic knowledge in physics. Moreover, the construct of epistemic knowledge has not been addressed enough. This study is guided by the following research questions: (1) How effectively do the developed test items measure preservice physics teachers' epistemic knowledge? (2) Do these test items measure epistemic knowledge as a unidimensional construct?

Sample and Method. This study followed the Styles of Scientific Reasoning (SSR) framework (Kind & Osborne, 2017) to conceptualize the construct epistemic knowledge and for the development of test items. SSR provides a theoretical foundation for its categorization of scientific reasoning into six distinct features based on the cognitive history of science. Then, we identified epistemically challenging concepts from the electricity and magnetism course. The test was then developed in a constructed-response format since forced-choice items are inefficient in assessing epistemic knowledge of students. The Epistemic Knowledge Test of Electricity and Magnetism (EKTEM) evolved through various iterations. Efforts were also made to mirror the structure of TIMSS and PISA items. Eventually, the revised version that consisted of 20 constructed-response items was administered to twenty graduating pre-service physics teachers. The data were analyzed using Winsteps Software (Linacre, 2012).

Results. Based on five randomly selected EKTEM test results which were scored by two different raters using similar scoring rubrics, the average of the scores of the two raters were found to be highly reliable (within the interval of 0.84 to 0.94). The results proved the objectivity of scores, hence, comparing students' epistemic knowledge on an item by item basis or overall test-wise make sense. The Cronbach alpha coefficient of EKTEM was found to be 0.84, i.e., the test has internal consistency. The average discrimination index for EKTEM is 0.24. The Rasch analysis of EKTEM data suggested that some items were predicted to be among the most difficult for the test takers. Besides, few items were found to be redundant from the perspectives of measurement. The Wright Map of EKTEM suggests the need for items to fill measurement gaps between Item 14 and 11 as well as Items 11 and 1. Apart from this, the gaps between items in the regions of the epistemic knowledge construct seem acceptable. Furthermore, the mean values of infit MNSQ and infit ZNSD of EKTEM were .99 and -.10 respectively. The mean values of outfit MNSQ and outfit ZNSD of EKTEM were 1.01 and .00 respectively which implies that difficult items were not correctly answered by a significant number of low performing students and easy items were correctly answered by a significant number of students who do well in EKTEM. EKTEM test items are in an acceptable infit and outfit range with the model. This implies that those better performing students took the test seriously and do not make careless mistakes and random guesses in answering the questions (Bond & Fox., 2015). The qualitative analysis of students' response revealed that students built a very poor argument. Some students failed to present their claim and evidence as a distinct epistemic entity, to explain their evidence using theoretical conceptions, and to reason out the relevance of their evidence to support their claims.

Conclusions. In response to the lack of domain-specific epistemic knowledge test in physics, a test that can assess useful elements of epistemic knowledge in electricity and magnetism was systematically developed and validated. Analysis of quantitative and qualitative data provides sufficient evidence to claim the good basis for measuring epistemic knowledge. Core epistemic knowledge related practices were identified through a systematic review of existing epistemology of science studies. The EKTEM test tried to mirror PISA's epistemic knowledge test items. A panel of experts was also involved in reviewing items for clarity and capacity to elicit the expected domain-specific epistemic knowledge outcomes. The quantitative analysis showed that EKTEM produced a satisfactory inter-rater agreement while the reliability is slightly above the accepted alpha coefficient. Many reasons accounted for the small value of the alpha coefficient. The first reason may be the multifaceted nature of cognitive processes demanded to respond to each item. The second reason arose from the cohort composition and number of test-takers. Students found EKTEM test items as unusual and were too difficult. To construct and evaluate EKTEM test items, this study followed the procedure commonly recommended to prepare constructed-response items. The item development and validation procedures were in line with the acceptable guidelines of previous researches.

Implications. This study promotes the measurement of domain-specific epistemic knowledge skills using written tests rather than surveying a wide range of epistemic beliefs of students. On the one hand, EKTEM test can serve to evaluate instructional interventions aimed at the acquisition of domain-specific epistemic knowledge skills. On the other hand, EKTEM can be used to relate domain-specific epistemic knowledge with students' epistemic beliefs.

Nature of Classroom Culture of Physics Teaching and Learning: A Socio-Cultural Analysis of Teacher-Student Interaction

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Background. Educational innovations are invaluable to improve students' learning outcomes and the quality of education provision (OECD, 2016). Dialogical teaching (Vygotsky, 1978) as pedagogical innovation has been proposed by educators as a teaching approach since it involves students in active discussion rather than simply accepting ideas as truth (Alexander, 2000). Since 2015, an attempt has been made to introduce the dialogical teaching approach in the Ethiopian education system by the "Transforming the Pedagogy of STEM Subjects" (TPSS) project. The TPSS project implemented Dialogical Teaching (TD) in the teaching and learning of physics in second cycle primary schools (grade 5 to 8) and teacher education colleges. Prior to the TPSS project, two PhD dissertation studies which employed dialogical teaching were also undertaken (Mekbib, 2015; Mesfin, 2017). The finding from TPSS project and dissertation studies indicate that even if students who were taught by the dialogical approach performed better than those taught by the 'traditional' method their improvement was not satisfactory to the expected level (Mekbib, 2015; Mesfin, 2017; Alemu, Kind, Bashah, Michael, Atinafu & Rajab, 2019). The recognition of dialogic approaches to teaching and learning and their potential for raising students' performance is getting popular in the literatures. However, the establishment of these approaches to classroom culture or environment is not easy. This study aims to analyze the student-teacher interaction and characterize the nature of classroom culture of physics teaching and learning in Ethiopia and determine the aspects of the classroom culture that could affect the implementation of dialogical teaching.

Sample and Methods. The study is an ethnographic case study. All classroom communications and interaction between a 7^{th} grade physics teacher and his students were video recorded. The data were then transcribed and translated into English. Analysis was made based on the interaction between students and the teacher and emerging themes from the data were categorized and interpreted.

Results. Analysis was made based on five features: purposes of teaching, contents of interaction, communicative approach, patterns of discourse and teacher intervention.

Purposes of Teaching. While introducing the new lessons, the teacher asked students questions from the previous lesson. The purpose of the questions seemed to be relating the new lesson with students' previous knowledge. In the second phase, students were given tasks to be done in groups. During the group work, the teacher was involved in the discussion by asking oral questions that focus on procedures of solving numerical problems. In the third session, while the groups shared the results of their discussion to the class and the teacher, he solved the problem together with the students. The teacher also asked some questions that seemed to check their understandings.

Content of interaction. This feature of student-teacher interaction is concerned with the contents addressed by the teacher and students while communicating each other with respect to the lesson being taught. This focused on three dimensions: Everyday-scientific; Description-explanation-generalization and Empirical-theoretical dimensions. In the introduction session of the lesson, the teacher was asking students to define physics terms and posed questions that require brief answers. As those questions were requiring students to recite from either the previous lesson or from the textbook, students' responses were to the everyday-scientific dimension. The analysis in general showed that both students and the teacher were mostly involved in describing factual knowledge found in the curriculum in the form of definitions and relationship between concepts.

Communicative approach. This feature of student-teacher interaction is concerned with the extent to which the classroom interaction involves students and treats different perspectives on topics under consideration. The analysis was made based on two dimensions: Interactive/non-interactive and dialogical/authoritative dimensions. Authoritative nature of interaction was reflected in the questions asked by the teacher and the teacher's reaction to students' responses. Both oral and written questions used in the classroom were not purposefully designed to elicit different viewpoints. Students' responses to the oral questions were brief and their discussion on the group task was cantered on the final numerical answer rather than the logic behind the computation. At this point, the teacher was also authoritative because he ignored some of the students' responses and looked for another response or he immediately provided the answer after one or two student attempts.

Patterns of discourse. This refers to the distinctive pattern of teacher-student interaction observed in the lessons. Two distinctive patterns were observed in all lessons. The first pattern was an Initiation-Response- Evaluation (I-R-E) type in which the teacher posed oral question, the student provides response and the teacher evaluates the responses and the second pattern is an Initiation-Discussion/computation-Response-Evaluation (I-D/C-R-E) pattern which was initiated by the written questions given to students to be done in groups.

Teacher interventions. Teacher intervention refers to the various ways in which the teacher intervenes in the development of concepts and meaning making. The teacher's intervention was limited to only sharing of ideas, questioning and reviewing. The sharing of ideas was observed when the groups reflect the result of their discussion to the class Even if the teacher was unable to show the explicit relationship between previous and new knowledge, he reviewed what the students have learnt in the previous lesson. Questioning was the dominant type of the teacher's intervention which was observed throughout the whole sessions

Conclusions. From findings of the study, it is concluded that the culture of physics teaching and learning in Ethiopian classrooms is characterized by reminding of concepts/contents from previous lessons with an intention of connecting it to the new lesson, explaining concepts, emphasizing on solving numerical problems and describing relationship between physical quantities in the form of equations. The student-teacher interaction was mainly facilitated by asking oral questions which are simple, recalling. It hardly encourages students to critical and higher order thinking .The classroom is characterized by Initiation-Response-Evaluation (I-R-E) and Initiation-Discussion/computation-Response-Evaluation (I-D/C-R-E) type of interaction. The classroom is also featured by defining and describing contents in the curriculum rather than working on the diverse views of students.

Implications. In order to improve students' learning outcomes, the findings of the study imply that the teacher should focus on higher order and demanding questions than lower order questions and provide conducive classroom environment to create and entertain multiple views of students. He/she needs to give attention for conceptual aspects of contents and make his/her reactions to students' response encouraging for different perspectives than guiding their responses. With respect to implementing dialogical teaching approach in the classrooms, the findings imply that the nature of student-teacher interaction, the quality of teacher's question, the manner of teacher's reaction to students' responses and the type of intervention strategies used by the teacher seemed to affect the implementation of dialogical teaching in physics classroom.

Misalignment in Data Use Processes: Lessons for Capacity Building Efforts

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Background: Professional collaboration in schools has changed from focusing on narrow goals to embracing the many purposes of learning and human development (Datnow & Park, 2019; Hargreaves & O'Connor, 2018). However, national curricula vary in the support they provide to teachers in understanding and using standards. Furthermore, psychometric perspectives do not address differences in educational purposes and values across national contexts (Baird & Opposs, 2018). Successful implementation of data use innovations is therefore contingent on contextual factors such as teachers' knowledge, skills, and attitudes; quality assessments; curriculum and assessment alignment; leadership support; (Kippers, Wolterinck, Schildkamp, Poortman, & Visscher, 2018), and teachers' sense making processes (Bertrand & Marsh, 2015; Vanlommel & Schildkamp, 2019).The purpose of this paper is to explore how misalignment affects data use practices in schools. Alignment research allows researchers to study the different components of an educational system to compare their content and make judgments about their agreement (Martone & Sireci, 2009). Coburn, Hill, and Spillane (2016) have encouraged research into the alignment of standards with professional development, curriculum materials, and teacher evaluation, arguing for theory building about the conditions that encourage or discourage instructional change. This case study first zooms in (Nicolini, 2009) on contextual factors affecting data use practices before zooming out on issues related to misalignment in data use.

Sample and Method. I conducted four hour-long group interviews, observed two data discussion meetings, and wrote field notes in a Norwegian lower secondary school participating in a literacy development project. Guided by the research question: How are data use processes affected by alignment issues? Using open coding (Corbin & Strauss, 2008), I constructed descriptors and developed themes until they seemed saturated. Ethical approval was obtained from the Norwegian Centre for Research Data.

Results. Practitioners envisioned data use as a "carrier rocket" – a way to engage in collective capacity building. However, their ability to achieve this goal was limited due to the misalignment of several factors. There was misalignment between data literacy, professional values, knowledge of assessment constructs, the affordances of data management technologies, and curriculum documents. For example, technologies afforded attention to aggregated results and cut scores, leading practitioners to focus more on averages and less on sense making about disaggregated results. Furthermore, national curriculum documents represented standards through descriptions of disciplinary skills and knowledge. Misalignment between curriculum constructs and the data used to draw inferences about students was commonplace. Finally, previous experiences with collaboration on developing shared values hindered critical discussions about the meaning of data. This impacted the capacity to use data constructively for instructional change.

Conclusions. Misalignment of components such as standards, data, and professional development affects the capacity for data use. Given the cost and expertise involved in conventional alignment studies (Martone & Sireci, 2009), building local capacity for evaluating data sets is important.

Implications. While data literacy may be a key component in capacity building, data use efforts should also consider the potential misalignment of contextual factors. Moreover, professional development efforts should be sensitive of teachers' existing purposes and values.

The Periodic Table and the Nature of Science in Science Teaching: An Analysis of Secondary School Textbooks in Norway and Spain

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Background. The United Nations General Assembly and UNESCO have proclaimed 2019 as the International Year of the Periodic Table of Chemical Elements (IYPT). In popular accounts, the Russian chemist Dmitri I. Mendeleev (1834-1907) is featured as the "father of the periodic table". However, the history of the periodic table is more than just the story of its discovery by Mendeleev. Time and again, historians of science have pointed out that the history of the periodic table goes beyond one man, one date and one place. Chemistry textbooks have, however, neglected the results of science history research. Thus, this paper aims to analyze how the historical narratives on the classification of the chemical elements in secondary science textbooks provide students with a misrepresentation of the nature of science. Reviewing the history of science in teaching materials is one way of evaluating what current narratives in textbooks convey about the Nature of Science (NOS). Science educators have consolidated the critical study of the history of science in education as a fruitful line of research for the last decades.

Sample and Method. Content analysis of chemistry textbooks has been considered as an appropriate methodological approach to understand how science is shown in the teaching context. For our historical content analysis, the historical narratives in the textbooks are studied in relation to established historical research on the development of the periodic table, and assessed against selected characteristics of NOS. Thirty-one widely used science and chemistry textbooks from Spain and Norway have been selected for this study. The analysis is based on the SOURCE framework, where each letter in SOURCE represents an element from the history of science and corresponding attributes of NOS.

Results. Our comparative analysis reveals large differences in the role of history of chemistry between the Spanish and Norwegian teaching contexts, and similar differences in their inclusion of historical aspects in curricula and textbooks. Overall, the history of the periodic table is presented as a strike of genius by one man or as a linear development from early attempts to the current version of the periodic system. No textbooks include circular or helical versions of the periodic system, which continued to be developed after Mendeleev's table was presented. Also, references to failures in science and to the contributions of women are lacking.

Conclusions. We argue that the lack of references to women, to errors and to failures in the history of the periodic system represents missed opportunities to discuss chemistry as a tentative, collective and socio-cultural enterprise.

Implications. The textbooks in this sample tend to present the history of the periodic table as a "story of success" of a single man. Including nuanced and inclusive stories from the history of science is one way of balancing this simplified image.

Women and the Periodic System: A Lesson from the History of Science

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Background. Textbooks and popular accounts on the history of the periodic system often offer a simplified and anecdotal presentation and credit one man, Dmitri Mendeleev as discoverer. It is, however, generally accepted that there were six independent discoverers of the system. Less communicated is the fact that behind the discoveries of elements and of the different representations of the periodic system and the knowledge upon which it is built are a range of people, from technicians and unpaid assistants to full-fledged researchers, professors and leaders of laboratories. Many of these contributors were women. In a recently published volume, Women in their Elements: Selected Women's Contributions to the Periodic System (eds. Lykknes and Van Tiggelen, World Scientific, 2019), we offer 38 richly illustrated chapters on women, their work on elements and their contributions to the building and understanding of the periodic system. The aim of the volume is to shed light on the complex and multifaceted work of science by highlighting the work of many women in different roles. By offering stories which are scholarly informed, yet accessible in style, we give teachers and young people the opportunity to learn more about the history of the periodic system and the nature of scientific knowledge.

Sample and Method. While some volumes about women in the fields of chemistry and radioactivity have appeared in the last twenty years, to date no collection exists of women's work on the elements and the periodic system. Our main aim was, however, not to celebrate individual heroines or to restrict the knowledge of the elements to mere discoveries or isolations of elements; rather we wanted to shed light on the multifaceted character of scientific work centred on elements, on collaboration, and on the articulation of crucial steps within the greater scientific endeavour. As for the selection of women, the chapters include pre-periodic table contributions as well as recent discoveries, unknown stories as well as more famous ones. The main emphasis is on work conducted in the late 19th century and early 20th century. Furthermore, the book includes elements from different groups in the periodic table, so as to represent a variety of chemical contexts.

Results. The book is organised into eight parts: An extended introduction on the history of chemistry and women's role in it, followed by 38 stories of women and their work on elements and the periodic system under the following headings: Old and new understandings of elements; The glory of analytical chemistry: The elements multiply: New fields and instrumental methods; Clusters of women in radioactivity; Manufacturing elements: From artificial radioactivity to Big Science; Instrumental revolution and interface between chemistry and industry; and Social activism, sisters in arms.

Conclusions. It has been argued that studying science in its historical context may contribute to the understanding of science as a human endeavor, as a dynamical process rather than a static set of theories and laws, as multifaceted in its nature, dependent on intuition as well as logic. History of science may also provide effective illustrations of science-society interactions. By spotlighting

women's work on elements and the periodic system, we have aimed to reveal a fuller picture of the nature of science and all the people involved in the scientific enterprise, from unpaid assistants and technicians to full professors and leaders of laboratories.

Implications. We believe that these stories of female input will contribute to the understanding of the nature of science, of collaboration as opposed to the traditional depiction of the lone genius. The stories also offer a way of presenting an inclusive and nuanced history of the periodic system to students and their teachers.

Analysis of Grade 7 Chemistry Student Textbook Contents Vis-À-Vis Bloom's Revised Taxonomy

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Background. Textbook is a key for the promotion of a particular vision of a curriculum as well as teaching and learning process (Okeeffe, 2016; Dalim & Yusof, 2013). As teaching in science has moved from teacher-centered to student-centered approach, the role of textbook has to also change (Mergo, 2012; Khine, 2013; Ahtineva, 2015).Therefore, as chemistry is a branch of science, analysis of the textbook for the pedagogical shift is worth seeking. Bloom's revised taxonomy (BRT) is very important criteria to analyze contents of textbooks (Anderson, 2016; Rahpeyma Ayoub, 2015; Zewdie, 2014). According to the revised syllabus of MOE, (2013), teaching chemistry is important in that the student acquires factual knowledge, and skills such as application, analysis, synthesis and evaluation. Since chemistry is an experimental science, experimental and investigative skills should be also acquired in a sufficient way in order to make students much more familiar with advanced chemistry laboratories in their future endeavor. Therefore, this study has focused on the analysis of textbook contents. The researcher had a look at the textbook arrangements and organization from his primary school teaching and learning experience and during his graduate course work-study in 2018-second semester.

Sample and Method. Quantitative approach content analysis design was applied. From the current Ethiopian curriculum textbooks, the researchers selected Grade 7 chemistry student textbook written in English language and published in 2013 G.C. The reason that the researchers focused on Grade 7 chemistry was to suggest possible corrections or improvements for student textbook (MOE, 2013) and to determine the status of the student textbook from the grass root levels, since chemistry is given as a sole linear subject starting from Grade 7. All the learning objectives, experiments and activities of the textbook were included in the analysis.

Results. From 99 learning objectives 93 (93.939%) were categorized under lower levels of BRT of which, 51 (51.51%) were remember, 28 (28.28%) understand, and 14 (14.14%) apply while six (6.061%) were categorized under higher levels of which, five (5.05%) were Analyze, and one (1.01%) Evaluate. From 13 experiments examined, four (30.769%) were categorized under lower levels of BRT of which two (15.38%) were Understand and two (15.38%) Apply while nine (69.231%) were categorized under higher level-Analyze. In addition, from 137 activities 132 (96.350%) were categorized under lower levels of BRT of which 72 (52.55%) were Remember, 58 (42.34%) Understand and two (1.46%) Apply) while five (3.649%) were categorized under higher levels of BRT cognitive process dimension specifically Analyze. The chi-square test result showed that, the difference in proportion between lower and higher BRT level in learning objectives and activities was statistically significant no difference was observed in the experiments.

Conclusions. Learning objectives and activities of the textbook mainly focus on Lower Order Thinking Skill of BRT and which is statistically significant difference between the lower and higher

levels of BRT cognitive process dimension in the textbook. On the other hand, experiments involved proportionately similar number of lower and higher levels of BRT.

Implications. Although the Grades 7 chemistry student textbook incorporated both thinking levels, the lower levels thinking skills (remember, understand and apply) take the lion's share, while the higher-level thinking skills (analyze, evaluate and create) were not properly represented in learning objectives and activities, as some were totally absent or nearly neglected. This implies that, the learning objectives and activities of the textbook do not encourage students to exercise higher cognitive thinking skills. Therefore, the objectives and activities of each chapter in the textbook should be improved and revised. The results with respect to the experiments suggest that, students engage in higher order thinking when the do the experiments indicated in the textbook.

Status of students' mathematical affect, mathematics teachers' awareness and concern about and their effort to cultivate it: In case of Debre Tabor town administration

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Background. Learning of Mathematics subject occurs in an ocean of different mathematical affects (Marzano et al. 1992 cited in Brown, 1995). In the real world students come to Mathematics classroom with different negative mathematical affect mentality such as unconstructive beliefs about themselves in relation to the learning of mathematical issues, Math anxiety, poor mathematical self –concept, ,low mathematical self efficacy, poor motivation to be engaged in mathematical task, negative attitude towards Mathematics, fear about taking Math tests and beliefs about the irrelevance of Mathematics for their future life (Gal & Ginsburg ,1994).These social realities are also probably prevalent in Ethiopian actual mathematics classrooms at all levels of education. This was confirmed by researcher's personal experiences and local researches conducted by Johannes, (2007), Mulugeta and Tesfu (2016) and Solomon and Genene (2014).However, boys and girls might not be found in the same scenario. For instance, boys reported a stronger mathematics self-concept than girls (Bofah, 2016). No student can be successful in his /her mathematical life if he or she lacks positive mathematical affectionate mentality about self regarding Mathematics, Mathematics teacher, Mathematics learning and the value of mathematical learning tasks that make up the lesson (Marzano et al., 1992). Davidson (2015) asserted that to make our students successful in their mathematical life, we must spend more time, energy and money to explicitly cultivate their Mathematical affections at all levels of education. To carry out this scholarly recommendation, the status of students' mathematical affect and teachers' awareness and concern about students' mathematical affect and their effort investment to cultivate this affective dispositional quality should be carefully explored, articulated and documented. However, these issues are not addressed by previous researchers at both international and national levels. This is because most of the previous researches were targeted at exploring the relationship between students' mathematical affects and achievement but not about the specific variables explored in this study. The present s research was carried out to fill these gaps with the purpose of surveying the overall status of grade eight students' mathematical affect and Mathematics teachers' awareness, concern and effort investment in cultivating students' mathematical affect.

Methodology. In carrying out this study, mixed research approach and **QUAL.+qual.** design was used. The target populations of the study were grade eight students and Mathematics teachers teaching at second cycle primary schools. To select student samples, first three schools were selected by lottery method. Then, using stratified proportional random sampling technique five sections and 166 (83male & 83female) students were selected. Using comprehensive sampling 17 teachers were selected. To collect the needed data about the four variables of the study a 5 point Likert Scale questionnaires were used. The total number of items in the students' mathematical affect questionnaire was 48 whereas in teachers' questionnaire it was 58. Semi-structured interview was also employed for students for triangulation purposes. The questionnaires were validated using

different techniques and their reliability was checked using pilot testing. To analyze the collected data descriptive statistics (mean and standard deviation) and inferential statistics like one sample t-test and independent sample t-test were used. To examine the level of teachers' awareness, concern, effort and status of students' overall mathematical affect and its specific dimensions like attitude, belief, value and emotion one sample t-test was applied. To examine gender differences in Mathematical affect independent samples t-test was used The quantitative results were triangulated with the qualitative data obtained through interview.

Results. The results revealed that grade eight students' overall and specific mathematical affect status were found good .The findings also demonstrated non-significant gender difference in students' overall and specific mathematical affect when completing grade eight. Mathematics teachers were also found having better level of awareness and concern about students' mathematical affect and effort investment in cultivating students' mathematical affect.

Conclusion. Based on quantitative and qualitative results of the study it is concluded that grade eight students in Debre Tabor town are in good status in possessing positive Mathematical affectionate mentality, they have also a positive belief, attitude, emotion, and value regarding mathematics without any gender difference. Second cycle primary school mathematics teachers have a better level of awareness and concern about students' mathematical affect. They also have better level of effort investment in cultivating their students' mathematical affect.

Implications. The findings have an implication for different bodies. For instance, they remind primary school second cycle mathematics teachers to strengthen their current awareness and concern about the state of students' mathematical affect and maximize the effort they invest to cultivate students' desirable mathematical affects by being responsive to the hidden curriculum, to adapt the official curriculum as a potential source to cultivate students' mathematical affect, to be aware about the absence of significant gender difference with respect to students' mathematical affect and to communicate the mathematical affect status of students to their parents. The results can also inform primary school completer students to sustain the positive mathematical affectionate mentality they developed during their primary school life throughout their future secondary schools, colleges, and university life .The findings have also an implication for secondary school mathematics teachers to be aware and concerned about and invest much effort to sustain the positive mathematical affect mentality that primary school completers possessed when joining secondary schools and be cognizant that boys and girls are likely to have the same status of mathematical affect when completing primary schooling.

Practices in Teaching and Learning Electrochemistry at High Schools informed by chemical education research (CER): A Mini Review

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Background: Science educators strongly argue that the practice of teaching science should be informed based on contemporary learning theories, research and evidence-based practices instead of mere anecdotes, practitioner wisdom and 'gut instinct' for effective instruction to become possible in classrooms. Students need to earn robust understanding and sophisticated knowledge, scientific process skills and methods, and attitudes and values. By making use of scientific inquiry and related active learning instructions, there is high chance of shifting the learning objective from the need to teach 'mastery of scientific knowledge' to the 'enhancement of students' scientific literacy'. Electrochemistry is known to be one of the difficult topics to both teachers and students in high school. A lot of studies reported on the challenges and opportunities of electrochemistry. Electrochemistry is one of the most studied topics at high schools all over the world. It either generates electrical energy from redox chemical processes or consumes electrical energy to drive chemical reactions. However, to the best of my knowledge the multi-faceted features of this topic are not documented well. Thus, this review is believed to fill this research gap and provide relevant information on the practices of teaching and learning electrochemistry in high schools. This aimed at exploring the inherent learning difficulties in teaching and learning practices of high school students and the possible instructional strategies that improve electrochemistry learning. To guide my discussion, an attempt was made to answer the following research questions:

- What challenges are associated with the teaching and learning practices of electrochemistry in high school chemistry classrooms?
- How can students' learning difficulties and challenges related to learning electrochemistry in high school chemistry classrooms be rectified?

Sample and Method: Articles were searched from leading chemical education research journals which are indexed in Web of Science. After reading 165 journals, 70 of them were reviewed so as to answer two research questions, namely: (1) what challenges are associated with the teaching and learning practices of electrochemistry in high school chemistry classrooms? (2) How can students' learning difficulties and challenges related to learning electrochemistry in high school chemistry classrooms be rectified? The author of this review who has had years of experience in teaching electrochemistry in university and high school identified the articles. The search terms such as "electrochemistry", "learning difficulties", "misconceptions", "high school", "teaching and learning practice", "history and philosophy of science" and "chemical education research" were used. The research samples were classified in three sub-categories: high school (grade 9-12), high school students, and teachers while the learning domain was Chemistry (Electrochemistry: galvanic cell, electrolytic cell and redox reactions).

Results: The findings of this review indicated that high school students all over the world experience challenges and learning difficulties in electrochemistry. The students' limitation in understanding the particulate nature of matter, rote application of algorithms, lack of ability to integrate big or core ideas with structure-property relationships, poor background knowledge, absence of teaching aids and use of multiple definitions and models were found to be the main factors for the recurrent challenges. Students held misconceptions such as "The anode electrode mass increases over time", "No reactions will occur at the surface of inert electrodes", "The electric current produces ions", "Electrons move in a solution", etc. In addition, the results revealed that inquiry-based laboratory instruction, and simple and low-cost experiments, perspectives in history and philosophy of science and multiple representations and making use of various modes of argumentation helped students' to comprehend concepts of, and improve attitudes towards, electrochemistry. According to the results of this review, cooperative and constructivist teaching instructions outranked the direct teaching methods with regard to knowledge construction, enhancing scientific methods and process skills of students and improving their attitudes towards electrochemistry in particular and chemistry in general. The active learning instructions were: guided inquiry laboratory instruction, multiple representations, conceptual change teaching, case-based teaching, problem-based teaching, project-based teaching, contextual-based teaching, predict-observe-explain (POE) strategy and animated concept mapping teaching.

Conclusions: The aim of this paper was to examine the practices of teaching and learning of electrochemistry in high school classrooms elsewhere. Findings revealed that difficulties in learning electrochemistry topic in high schools are prevalent all over the world. Furthermore, results suggested that inquiry-based laboratory instruction, history of science experiments and philosophy of science, multiple representations (macro-sub-micro-symbolic),conceptual change teaching, case-based teaching, problem-based teaching, project-based teaching, contextual-based teaching, predict-observe-explain (POE) strategy and animated concept mapping teaching are very much helpful to improve students' electrochemistry learning.

Implications: The findings of this review have implications for future research and for planning instructions of electrochemistry in high school classrooms. Experiences of high school students towards electrochemistry teaching around the world revealed that an active learner-centered instructional strategies and history and philosophy of science greatly enhanced comprehension of concepts as well as improved students' attitudes. The results of this study are informative for teachers, textbook writers and policy makers in planning instructions, learning activities and assessments. Moreover, the triplet relationship between representational instruction and perspectives in history and philosophy of science have implications for teaching electrochemistry since they can offer students an expert-like knowledge and are very intriguing for students and teachers to develop 'a genuine experience of open-ended scientific inquiry' and learn the essence of original research work. For future work, I recommend that reviews of literature on challenges of implementation of the practices in teaching and learning electrochemistry in high school and universities are very helpful to understand the many features of electrochemistry.

Addressing Cross Cutting Issues using Statistics in Secondary Mathematics Education: From Modeling Problems to Extended Projects.

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Background. Although Ethiopian education policy and documents on mathematical curriculum recommend that there should be relevant problem solving activities on socio-cultural issues (TGE,1994), researchers have indicated that covering the text book is the most common teaching practice in Ethiopia instead of engaging students with rich problem-solving tasks (Asgedom, 2009; Micheal & O'Connell, 2014). This may lead teachers to use simple textbooks problems, and as a result students cannot develop cognitive abilities to solve socio-cultural problems in novel situations. A study by Asgedom (2009) has found that the practice of Ethiopian Education mostly focuses on knowledge acquisition, or what UNESCO calls "learning to know," to the detriment of other useful purposes, learning to do, learning to be and learning to live together which could enhance students' sympathetic or critical understanding on cross cutting issues.

Sample and Method. From the two high schools located in Dire Dawa, 80 students taken from two grade 9 sections participated in this study. Two teachers and two classes were selected from the two schools using purposive sampling to make teaching intervention on a unit of descriptive statistics using Modeling Approach. There were major decisions made by the researcher in revising and improving the intervention in the pilot test. Students were not accustomed to modeling and the researcher, based on modeling processes cycle, developed a worksheet for each Model eliciting Activity (MEA) that could help the teacher to scaffold students' modeling of real world problems. On the project, the students wrote four homework assignments describing their work going through statistical investigation processes such as (1) formulating a question; (2) collecting data; (3) analyzing the data and interpreting the results; and (4) writing and presenting the final project report. These four components provided the students a scaffolding structure to do the project to develop statistical thinking (Franklin et al., 2007).

Results. Content analysis of the text showed that non-routine statistical problem solving tasks were almost non-existent in the text. Based on quality assurance guide, team of students were at level two and three which is good considering students being novice for modeling process. The findings also revealed that students found the MEAs relevant to their life and they were 'hard fun' activities to address cross cutting issues of a society. Students were able to go through the modeling process and they were able to think 'outside of the subject box' in multidisciplinary areas. Students got used to the statistical inquiry cycle doing MEAs and projects. Further, the findings showed students could benefit more when they completed extended open-ended projects to experience statistical investigative processes by addressing cross cutting issues of a society.

Conclusions. Students elicit their models by externalizing their thinking through representation systems working on MEAs and they can develop their own models by testing, revising and refining iteratively in an engineering way. Students gain modeling experiences. The findings of this study suggest that Modeling Approach along with extended projects more likely enhances students' critical understanding of statistics by solving problems on topical issues of a society.

Implications. The finding of the study can be generalized to similar school setting, but needs further efficacy study at different school settings and populations; it also needs large scale effectiveness study to meet the interest of stakeholders in an education system. This study has shed light on how students can learn statistics or STEM subjects for addressing cross cutting issues of a society using modeling approach. For future research it has implications on how to teach students STEM literacy in a technological environment in an integrated way.

Discussion Points for Reform in Mathematics Education in Ethiopia

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Background. In recent years, many countries have undergone reform in mathematics education. The cause of the reform may not be uniform. For instance, there was educational reform that took place in USA, after the former Soviet Union launched the Sputnik satellite 62 years ago. This is what is called "the sputnik driven reform." The Americans were shaken and awaken for reform in science and engineering education driven by politicians by funding for education at all levels. The reform in mathematics in the sixties was called the "New Math" movement. This reform was masterminded by mathematicians, and it over-emphasized on sets, abstractions and rigid formalism. Due to its limitation, this movement gave way to another one in the seventies called "Back to the Basics." Another example is what is called, the PISA-shock driven reform movement. PISA is the OECD's Program for International Student Assessment. Every three years it tests 15-year-old students from all over the world in reading, mathematics, and science. German students' scores in reading, mathematics, and science were lower than the OECD average. And this created shock among teachers, educators, policy makers and parents. Since then Germany and many other western nations have undergone reforms in mathematics education. This article provides rationale why reform in mathematics education is needed in Ethiopia too.

Sample and Method. The rationale for reform is presented based on the recent developments in the teaching and learning of mathematics. Theory, research and pragmatic experiences are used to address the issue of reform in mathematics education. Data gathered via document analysis, interviews and observation were among the different qualitative research methods used in the article.

Results. The discussion points for reform include the philosophy of mathematics education, learning theories, curriculum revision, knowledge for teaching, indigenous mathematics, quality of education via professional development and digital literacy. The absolutist paradigm dominates the philosophical view of most mathematics educators, instead of fallibilism view. In Ethiopia behavioral theory is more common than constructive and sociocultural paradigm of learning theory in mathematics education in the country. Ethiopian mathematics curriculum seems to be old compared to modern curriculum in other countries. This is evidenced by textbook research via document analysis method. With respect to understanding domains of mathematics, teacher knowledge for teaching (MKT) seems limited right now in Ethiopia as compared to the current developments in the field in the wide world. Further, indigenous mathematical knowledge is not yet fully integrated in the curriculum and in the instruction. In addition, professional development for quality of education and digital literacy for the teaching and learning of mathematics are emphasized. Two reform cases, from USA and Singapore, show that these issues raised in the article are vital for a meaningful and fruitful mathematics education reform. The how-to reform is not dealt in depth, but it is implicated via the why-to reform argument.

Conclusions. Calling reform in mathematics education in the country may be offending to some individuals who are keenly engaged in the field for some time independently or within the governmental structures. The intention is not that! However, it is done deliberately, since there is no meaningful reform in a significant way in a country of more than 100 million inhabitants, while many African countries with less population have achieved to organize and set their country professionals on the right path, at least. It is time to go deep into the issues mentioned above and other relevant topics for meaningful and fruitful reform in mathematics education.

Implications. If meaningful mathematics education reform takes place, then philosophy of mathematics education and learning theories will inform policymakers, educators and teachers to choose effective ways and strategies in the teaching and learning of mathematics so that student learning is boosted. The research around teacher knowledge can shape the design of the teacher education programs at all levels, for both pre-service and in-service programs. Educational reform is usually coupled with curriculum reform, all the intended, implemented and attained curriculum changes. In this article an evidence of ethno-mathematics activity, that has curriculum and instructional implication, for preparing culturally responsive mathematics education program is also given. Modern mathematics education reform has to also focus on collaborative professional development coupled with digital literacy. Hence it should be the agenda of policy makers at all level.

Mathematics and its Roles

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Background. Nowadays, no nation can make any significant economic development without having technological advancements. On top of this, adequate supply of young people with strong mathematical skill, talent and creativity is needed to effectively understand and exploit advances in science, technology and industry. Many of the global challenges and the needs for civilization are multi-disciplinary. Overcoming these challenges and satisfying the needs through scientific discoveries and technological advancements require mathematicians to collaborate with other professionals. Mathematics is one of the great achievements of humankind to give innovative solutions to many of our current and future challenges. It provides people with powerful theoretical and computational skills to capture complexity of real-life problems which are very essential for individuals and countries to gain competitive advantages in many areas of today's knowledge-based global economy. However, many of us are not able to comprehend the roles of mathematics beyond calculating numbers and practicing rules. Moreover, as mathematics has been taught in schools no effort has been made to show its real significance in our social civilization. This leads students to build negative attitude towards the subject and to demonstrate declining performance in mathematics. As a nation, without having interested and competent individuals in mathematics, it is impossible to produce scientists and engineers that will contribute in the advancements of science and technology in Ethiopia. Thus, this article reviewed different sources of information relevant to discuss the general roles and contributions that mathematics had played and will continue to play in the development of human personality and in the advancements of science and technology. In particular, efforts have been made to briefly explain how mathematics is one of the most efficient and sometimes the only mechanism to precisely examine behaviours of real problems and to point out appropriate ways of making decisions.

Implications. This paper will help the public, the stakeholders and policy makers to better recognize the practical relevance of mathematics in our community development efforts. This in turn will lead them to examine whether mathematics curriculum is developed and being implemented in a way that encourages students' active learning and problem-solving skills. Moreover, mathematicians will also be more aware of their course delivery and research activities to expose their students to a variety of mathematical modes of thinking and problem-solving skills. Realizing the importance of mathematics will inspire students to learn further mathematics and its applications in real life problems.

Effects of Conceptual Change Instructional Approach on Conceptual Understanding of Pre-Service Chemistry Teachers in Aliphatic Hydrocarbon Concepts

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Background. Research endeavors (Hassana, Hill, & Reida, 2004; Nash, Liotta & Bravaco, 2000) indicated that students' understanding of organic chemistry concepts is shallow and with alternative conceptions. Duffy (2006) suggested that instructors should go beyond stating the disadvantages of memorization and teach towards conceptual understanding. Also, Sendur (2012), in her study on alkene concept, made a call to make understanding related studies through investigating learners' understanding levels and misconceptions using teaching strategies like conceptual change texts (CCTs). The clear meaning of conceptual understanding and the approaches to be followed in this line are open to debate (Holme, Luxford & Brandriet, 2015) as there are diverse approaches to address students' conception problems. However, until now conceptual change is a prevailing agenda in science education literature. Traditional science texts are tricky for students to learn meaningfully because most are full of technical terms, which are very difficult to comprehend (Graesser, Leon & Otero, 2002). This is associated with the problem of text book writers (Graesser et al., 2002). Choosing the right strategy such as the use of CCT is suggested in science education literature (Başer & Geban, 2007; Özkan & Selçuk, 2012; Sendur, 2012; She, 2003; Sendur & Toprak, 2013). Preferring the right strategy to be used in the organic chemistry courses at college level may require applying the constructivist approach to bringing conceptual understanding. This entails using texts, which can make learning more meaningful and discuss alternative conceptions overtly. Conceptual change instruction can be of assistance for students to conquer misconceptions and learn intricate concepts in all subjects (Devis, 2001). As many organic chemistry concepts are generally abstract to students (Graulich, 2015), the problem starts with functionality chemistry which encompasses aliphatic hydrocarbon concepts. In different studies (Duis, 2011; O' Dwyer, 2012) it has been reported that aliphatic hydrocarbon concepts are among key areas of worry for students. However, there is little research work focusing on aliphatic hydrocarbons (Sendur & Toprak, 2013) through the use of conceptual change approach (using conceptual change texts). Therefore, effects of CCT- based instruction on understanding aliphatic hydrocarbons needs investigation.

Sample and Method. This research was conducted in Arbaminch College in SNNPRS, Ethiopia, with an enrollment of 3,500 regular Diploma pre-service teachers. The participants in this study were a convenience sample of 87 pre-service chemistry teachers aged 18 to 24 years (Mage=20.01, SD=1.28) enrolled in Introductory Organic Chemistry I in the same college in regular Program. All the 87 pre-service chemistry teachers provided data for the study. The study utilized quantitative data. Quantitative method with Pretest-Posttest Nonequivalent-Groups quasi-experimental Design was employed in this study.

Results. Independent samples t-test analysis showed that prior to intervention the differences in Aliphatic Hydrocarbon Diagnostic Test (AHDT) mean scores of the experimental and the comparison groups were not significant (M_{EG} =4.18, SD_{EG} =2.49, N_{EG} =44 and M_{CG}= 3.77, SD_{CG} =1.29, N_{CG} = 43; t(85)= .978, p>0.05). It was also observed that, compared to the pretest scores the comparison and Experimental group post test scores for understanding test were found to be higher (p<0.01 for CG and P<0.001 for CG). This lends evidence to prove change in the mean scores after implementation of Conventional Instructional Approach (CIA) and Conceptual Change Instructional Approach (CCIA). However, this does not confirm that the CCIA is better than CIA since the two treatments resulted in significant mean scored difference using paired samples t-test. To check if a significant difference existed in scores of understanding test independent samples t-test was employed on post test scores of groups. Independent samples t-test of post intervention data showed that the differences between the AHDT mean scores of the experimental and the comparison groups was significant in favor the experimental group (M_{EG} =6.43, SD_{EG} =2.31, N_{EG} =44 and M_{CG}= 4.93, SD_{CG} =2.13, N_{CG} = 43; t(85)= 3.15, p<0.01). The effect size for treatment obtained for Post-AHDT was, d=0.68, which is of medium effect size (Cohen, 1988).

Conclusions. The principal purpose of this study was to investigate effects of conceptual change instructional approach on conceptual understanding of pre-service chemistry teachers' in aliphatic hydrocarbon concepts. In this quantitative study, after intervention, data was gathered using the AHDT.. Analysis of the data revealed that the experimental group outperformed the comparison group in AHDT with medium effect size. The result confirmed the preeminence of CCIA over CIA.

Implications. Curricular materials used in science education, such as the modules in teacher education, do not facilitate meaningful learning with conceptual understanding. Such materials encourage memorization and are blamed like standard references in chemistry. Thus, curriculum materials that are based up on conceptual change approaches (e.g. presenting students' prior knowledge in textual part before presenting canonical views) need to be designed. Teachers in all the ladders of education should be empowered in the form of continuous professional development activities to come up with this research work like this that should be brought to every day practice at classroom level. Chemistry contents such as aliphatic hydrocarbon concepts in organic chemistry can be internalized well when teachers start the lessons based on students' prior knowledge with proper scaffolding. The research effort exerted in other specific domains can be christened little. Although this research work demonstrated the supremacy of CCIA in organic chemistry/aliphatic hydrocarbon concepts, there are several potential areas in chemistry for further research including inorganic, analytic chemistry and physical chemistry.

Mathematics Education in Ethiopia: A Systematic Review of Twenty Years of Discourses on the Discipline

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Background. Mathematics Education stems from disciplines ranging from mathematics up to post-modernism; and thus, it has plenty areas of research focus and practice. Globally, it is a well established domain of knowledge and research area. There are lots of dedicated conferences/workshops, articles/journals, academic programs, institutions and people. The most reputable and comprehensive conference is the International Congress on Mathematical Education (ICME), launched in 1969, which happens every four years. The purpose of this research is to study the essence and status of Mathematics Education as a domain of knowledge and research in Ethiopian context.

Sample and Methods. The methodological frame for this study is a Qualitative Meta-synthesis. Postgraduate academic programs, conferences, published articles were reviewed. Besides, trends in the Mathematics (Professional) Association of Ethiopia were observed. An article that talks something about Mathematics Education in Ethiopian context was sought. During 6th March-17th September 2019, I have collected 68 articles published in June 2000 through 17th September 2019. The main sources were HISSAB: Ethiopian Journal of Mathematics, (the) Ethiopian Journal of Education, Ethiopian Journal of Education and Sciences, and Bahir Dar Journal of Education. Based on a first round screening, 15 articles were found highly mathematical. Thus, the remaining 53 articles were referred for the meta-synthesis. Yet, only 4 articles (Abraha, 2006; Degu, 2015; Semela, 2012; & Weldeana, 2016) were entitled as Mathematics Education.

Results. Mathematics Education is a well-versed amalgamation of "Mathematics" and "Education". In 2000/01, the Department of Pedagogical Sciences (Pd.Sc) at Bahir Dar University introduced composite majors' degrees. That was the foundation for the emergence of the Discipline in Ethiopian context. Yet, Pedagogy and Mathematics composite major and other Master's of Education in Mathematics were characterized by absence of blending the indispensable components – mathematics and education/pedagogy. On the other hand, a Notable Conference/Workshop was held in the College of Science at Bahir Dar University in 2015. Practitioners from Mathematics, Mathematics Education, and Education/Behavioral Studies were involved. Similarly, the Mathematics (Professional) Association of Ethiopia has been inviting contributions from the discipline under discussion. Most publications were related to the teaching learning process. Collectively, the reviewed articles tended to demonstrate the process or activity aspect rather than the disciplinary values of mathematics education. Whereas a Mathematics teacher educator, Mathematics education researcher and Mathematics educator are existing viewpoints in the discipline, the first one is prevailing. This could be attributed to the dynamics of teacher educational

programs over the last two decades. That is due to the fact that discourse is a function of knowledge, subjectivity and power.

Conclusions. It was found that practitioners in the discipline are mathematics teacher educators whereby different stakeholders play their role. Mathematics Education is beyond that. A concern for, study on and practice with concepts, theories, methods, organizations, conferences and literature would be vital. It can be said that mathematics education as a discipline with its own right is at a premature stage in Ethiopia.

Implications. The idea of mathematics education as an academic discipline in its own right and with its own forms of theory and theorizing is a way in which the academic study of the field has developed in other settings (Biesta, Allan, & Edwards, 2013). The coming International Congress in Mathematics Education (ICME) considers 62 study areas of Mathematics Education and the revised Encyclopedia of Mathematics Education recognizes 102 sub-topics in the field. Accordingly, mathematics education and its various subfields need to be promoted in Ethiopia.

Exploring and Fostering Second Graders' Mathematical Patterning

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Background. The study of patterns has embedded algebraic reasoning in the elementary grades (Blaton and Kaput, 2005). Students from prekindergarten to grade two are expected to recognize, describe, and extend patterns; and analyze how both repeating and growing patterns are generated (NCTM, 2000). Moreover, Bay-Williams (2001) indicated that "first graders enjoy working with patters" (p.196). Similarly, Warren and Cooper (2005, 2008) have shown that 8-year-old children in grade 2 can successfully learn functional thinking through the analysis of growing patterns. Patterns as separate topics using figures or shapes as visual representations are appeared only in the current grade 1 and 2 mathematics curricula. Although such inclusion reflects the intention of the curriculum developers fostering students' algebraic thinking at the early ages, the patterning contents and activities displayed only in two pages of grade 1 and 2 are not enough even to understand patterns. There is a need to include enough activities so that pupils create and learn about the core elements of repeating patterns. Although the syllabi recommend using manipulatives so that students, being in groups, play pattern creation games, the textbooks provided and required students just to simply extend given patterns or complete missing terms in given sequences. Students are not required to create and inquire with their own patterns. Thus, there is a need to include more patterning activities. However, to recommend the inclusion of more and differing patterning activities, it requires exploring their capacities to learn and fostering them what they can do. In other words there is a need for understanding what children are capable of learning patterns. Thus, this teaching experiment is guided by the following research question.

Sample and Method. This teaching experiment was conducted in two periods each lasting for two and half an hour on 25 grade two pupils who got permission from parents to participate in the experiment in the opposite school shifts at Dona Ber Primary School, Bahir Dar City. Taking the position that learning is an investigative process, pupils were divided into groups each having five members and engaged in creating and extending patterns, identifying the core units and their lengths and predicting terms of sequences. Data have been collected using different tools such as, task-based group interviews, field notes, observations, and pupils' sample works captured through camera.

Results. Provided with beads, matchsticks, counters, and bottle tops, out of five groups two constructed constant linear patterns. After they have been provided and inquired with an analogy and discussed about the differing attributes that could help to form repeating patterns, one group created six different repeating patterns with a unit of repeat length two and another group formed two complex repeating patterns. The rest two groups made errors and with the teacher-researcher's scaffolding, they corrected their mistakes by their own and created repeating patterns. The fifth group created one correct alternating pattern using the color attribute ignoring shape (white green) having five elements and were unable to settle their argument about a second unfinished pattern using bottle tops and beads. One student was arguing against the rest four. This student and the rest four were right regardless of their failure to listen each other. Concerning prediction, they can

predict near elements either by extending or counting. Although they predicted the far elements of patterns with two unit of repeat, it was difficult for them to predict far elements of repeating patterns with more than two length of core unit.

Conclusions. With teacher scaffolding, grade two pupils can create varying repeating patterns including complex ones, extend and predict near terms easily. Predicting far elements of repeating patterns with more than two length of unit of repeat is difficult for them.

Implications. Although integrating mathematical patterns into the early grades are fundamental for developing algebraic thinking, the patterning activities at grade two require teacher's scaffolding. Consequently, teacher professional development should consider teachers' understanding of mathematical pattering.

The Role of Epistemic Beliefs as Cognitive Prerequisites for Learning through Inquiry
Abstract

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Background. The generation of problems or questions which lead students to autonomous and active engagement on authentic tasks so that they achieve higher level learning goals characterizes inquiry learning and instruction. Literature on the possible challenges and enabling factors for learning through inquiry mostly focus on factors outside individual learners such as teachers' beliefs and values about students, teaching and education; teachers' commitment to content coverage so as to prepare students for exams; challenges in relation to assessment and new teacher and student roles inquiry learning and instruction requires; inadequate in-service education to prepare teachers for the new roles and responsibilities; lack of resources etc. Besides such *external-to-the student* factors, questions worth considering in relation to success in inquiry learning and instruction are those of the role students' beliefs about knowledge and knowing (epistemic beliefs) may play in their engagement in inquiry. *What possible assumptions can be made in relation to epistemic beliefs as facilitators or barriers for inquiring? How can epistemic beliefs motivate and guide the way in which one inquires?* Hence, the purpose of this paper is to discuss about the role epistemic beliefs may play as cognitive prerequisites for learning through inquiry and the ways by which students' epistemic beliefs can be enhanced so as to promote learning through inquiry.

Conclusion. Engagement in inquiry demands generating questions and becoming a self-regulated learner so as to achieve higher level learning goals in the context of authentic learning experiences. For students to engage in inquiry, they need to have mindsets which help to promote rather than discourage from being inquisitive. In the present paper, it is argued that beliefs about knowledge and knowing (epistemic beliefs) can be one of the bases for learners' mindset to become inquisitive and inquiry minded. Unless learners have the tendency to believe in the uncertainty of most knowledge, in their own ability to generate and justify knowledge and in the complexity of knowledge, they will not have the initiative to become inquisitive and engage in inquiry. It is whenever such sophisticated epistemic beliefs are evident in learners that learning through inquiry will become effective and successful.

Implications. Efforts need to be made to support learners change their epistemic beliefs to more sophisticated ones. Educational experiences themselves are determinants of such a change (Valanides and Angeli 2005). In their review, Brownlee et al. (2016) identified engagement in higher order thinking and explicit reflection on epistemic beliefs as the main ways through which epistemic beliefs can be changed. Teachers can engage learners in higher order thinking by letting them experience contradictions in opinions and theories (Walker et al. 2012). In a study by Walker et al. (2012), it has been found that instructional interventions which focus on contradictory texts and critical thinking have helped to bring change in epistemic beliefs. Furthermore, asking learners to explicitly reflect on their own beliefs about knowledge and knowing (Brownlee et al. 2001) helps them to become aware of their beliefs and subsequently move to sophisticated ones with the help of teachers. In such ways, it will be essential to set the stage for learners to engage in inquiry learning and instruction.

Graduates of the first batch of MED in Educational Sciences (partially seen)

Project partners