The Eurasia Proceedings of Educational & Social Sciences

EPESS

ISSN: 2587-1730

ICEMST 2020: International Conference on Education in Mathematics, Science and Technology

March 21 – 24, 2020
Istanbul, Turkey

Edited by: Mehmet Ozaslan (Co-chair), Gaziantep University, Turkey

ICEMST 2020 SEPTEMBER

Volume 16, Pages 1-49 (September 2020)
The Eurasia Proceedings of Educational & Social Sciences EPESS
e-ISSN: 2587-1730

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Edited by: Mehmet Ozaslan
Articles: 1-5
Conference: ICEMST 2020 : International Conference on Education in Mathematics, Science and Technology
Dates: March 21 – 24
Location: Istanbul, Turkey
Conference Chair(s): Prof.Dr. Mack Shelley, Iowa State University, USA & Prof.Dr. Mehmet Ozaslan, Gaziantep University, Turkey

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Educational & Social Sciences (EPESS)
ISSN: 2587-1730

The Eurasia Proceedings of Educational & Social Sciences (EPESS), 2020

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ICEMST 2020: International Conference on Education in Mathematics, Science and Technology

Students' Views on Difficulties in Conceptual Understanding of Science at Secondary Stage

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Abstract: Present research investigates students' difficulties in conceptual understanding of science at the secondary stage (Class ninth and Class tenth) with a sample of 920 students spread over 23 schools in five States of India. Questionnaire and field notes were the tools of the study. Students' views and suggestions to overcome their difficulties have been sought through a semi-structured focus group interviews (n=222).The major findings of the study are - 70.22 percent students say that they have difficulties in understanding some science concepts.40 percent of class ninth and 49 percent of class tenth students are hesitant in asking questions in the class for the fear of being ridiculed. 31.11 percent say that they do not find any relevance of science concepts in their everyday life. Almost all students (97 percent) suggest that there should be more experiments and activities in the class and more interaction among students and with teachers so that they can be aware of each other's ideas about the science concept being transacted in the class. They want that classroom environment should be such that they can ask, pose and raise questions without any fear of being ridiculed. The paper gives an insight to the stakeholders for the enrichment of teaching-learning process. Students express that they want to be engaged in inquiry, field visit, projects, discussion, debate, group work and sharing of everyday life experiences. National Curriculum Framework (NCF)-2005 (NCERT,2005) says,"Child-centred pedagogy means giving primacy to children's experiences, their voices, and their active participation". As recommended by NCF-2005, it is imperative for the teachers and the teacher-educators to recognize and address students' difficulties and concerned ideas to familiarize themselves with students' perspectives of understanding science concepts. It is concluded that students' views and ideas regarding their difficulties must be valued and teaching-learning approaches and strategies must be adjusted according to students' learning needs and learning styles.

Keywords: Students' views, Conceptual understanding, Experiments, Activities, Child-centred pedagogy

Introduction

Many researchers have highlighted the importance of incorporating students' views for the enrichment of the teaching-learning process (Mitra, 2003; Kushman, 1997; Johnston,& Nicholls, 1995; Johnson,et al.,198l). Children's voices and experiences do not find expression in the classroom. Often the only voice heard is that of the teacher. When children speak, they are usually only answering the teacher's question or repeating the teacher's word (NCERT, 2005).Teachers spend most of their time teaching knowledge-based science in a learning environment that ignores their students' experiences. Students do not fully engage mentally in such classrooms, as they find a disconnect between teaching and their range of experiences (Rohandi, 2017).

Consulting with students on their views of teaching and learning has improved students' understanding of how they learn, helped students to gain a stronger sense of their own abilities, and improved teaching-learning so that teachers do a better job of meeting student needs (Johnson and Nicholls, 1995).In her research based on students' voices Mitra (2003) shows how listening to students can help in improving their learning experiences.Walker (2008) enlists many benefits for learners who are involved in shaping and leading their own learning.These benefits include: greater sense of ownership over their learning ; increased motivation; improved self-esteem ; greater achievement; improved relationships with peers and educators;increased self-efficacy.At the same time, failure to engage with learners in the education process risks increasing disengagement and disillusion amongst learners with their educational experiences.

According to Levin (2000), understanding students' perceptions and involving them in discussions about education can teach us a lot about changing classroom and school processes, and determine whether students are committed to learning. Study of Karanja and Oralado (2020) reveals that students can contribute to almost all aspects of learning. In some cases with some deep insights, well informed and, well-considered notions based on their personal, classroom experiences on what factors impacts their learning, those that help them learn as well as those that hinder them from learning. Seeking such contributions is one of the features of child-centred pedagogy.In child-centred pedagogy as recommended by National Curriculum Framework (NCF)-2005 (NCERT-2005),it is imperative for the teachers, teacher-educators and policy makers to recognize and address students' difficulties and concerned ideas to familiarize themselves with student's perspectives of understanding science concepts.Child-centred pedagogy means giving primacy to children's experiences, their voices, and their active participation. This kind of pedagogy requires us to plan learning in keeping with children's psychological development and interests. (NCERT,2005).Looking from this perspective,the present work has been conceived on two premises - students'views on difficulties in their conceptual understanding and the ideas they have to resolve those difficulties.We have taken students'views on the teaching-learning process of science only and difficulties they face in this process.Though there might be various dimensions of conceptual understanding, we have focused on students' perceptions on thier conceptual understanding of science.

What do we actually mean when we say students have conceptual understanding? According to Moran & Page (2015),'when students have an understanding of a concept, they can (a) think with it, (b) use it in areas other than that in which they learned it, (c) state it in their own words, (d) find a metaphor or an analogy for it, or (e) build a mental or physical model of it. In other words, the students have made the concept their own. This is what we call conceptual understanding.'

Teaching-learning of science empowers students to make sense of natural and physical world. It is about engaging them in practices of science and facilitating them to apply their understanding in novel situations.It is to communicate in their own ways, not just reproducing crammed version of the textbook . In a formal set -up, one of the evidences of conceptual understanding can be through students' achievement in the examination.If students are not able to apply their understanding in novel situations,it can be presumed to have difficulties in conceptual understanding as one of the impeding factors of low achievement.

Backdrop

The National Achievement Survey (NAS) class X (NCERT, 2015), that was conducted on a sample comprising of 2, 77,416 students in 7,216 schools across 33 States /Union Territories (presently, India has 28 states and 8 Union Territories)) and Examination Boards of India, reveals that only two percent of students could achieve above seventy-five percent marks. The Ministry of Human Resource Development, Government of India has entrusted the National Council of Educational Research and Training (NCERT) to conduct a nationwide achievement survey of students at the end of Class X, on a sample basis. NAS is a large-scale national study. The survey reveals that there is a need for significant improvement in the teaching-learning of science at the secondary stage. Various reasons may be attributed for the low achievement of students. One of the reasons might be that students face difficultiesin conceptual understanding of science.

Secondary stage education is a link between the elementary (class 1- class 8) and higher secondary (class11-class 12) stage. If students' difficulties in conceptual understanding of science are not resolved at this stage, generating interest and establishing a strong foundation to cultivate scientific temper in them will be adversely affected. It is in the above backdrop, an attempt has been made in the present study to investigate what difficulties students face in conceptual understanding of science and how can teacher facilitate them to soften such difficulties. Though there might be various dimensions of students' views, this paper aims to examine students' views on the conceptual understanding of science so as to improve learning outcomes.

Research questions

Our study is guided by the following questions-

- What difficulties do students face in conceptual understanding of science at secondary stage?
- What are the reasons of the difficulties faced by students in conceptual understanding of science at secondary stage and what should science teacher do to make those difficult concepts easy?

Method, Sample and tools

Mixed method approach was followed in the study in which quantitative and qualitative methods were combined. The study covered twenty-three schools spread over five States / Union Territories of India. The schools selected were affiliated to the Central Board of Secondary Education (CBSE) which is a national level board of education in India. The sample comprised 920 students of Secondary Stage. Out of these, 461 students were studying in class ninth and 459 students in class tenth. A questionnaire was administered to all of them. In addition to the questionnaire, semi-structured focus group interview was also conducted with 222 students. Number of students in the focus group was five for each of the classes. Participants were assured of complete confidentiality. Medium of teaching-learning was English in all the schools. The researcher recorded many contextual observations in her field notes. For qualitative analysis, field notes and responses of focus group interview were coded and analysed. Observing the emerging patterns, the responses were categorized into different themes for discussion.

Findings and discussion

Quantitative analysis: findings

70.22 percent of students say that they have difficulties in understanding some or other concepts of science. This was the warm-up item of the questionnaire in the beginning .It seems remaining 29.88 percent students could not recall or think about any difficulties at the beginning of the administration of the tool, because later, all students mentioned some or other suggestions and views on improvement of teaching-learning of science which is discussed in the next section. This is one of the very significant findings.

Quantitative analysis of students' views was done item-wise, as given below. Table: 1 shows class ninth and class tenth students' affirmative responses in percentage to the items related to the difficulties they face in conceptual understanding of science.

For some of the questions, (items no 3, 4, 5, 8, and 10) responses in percentage were found to be approximately the same for both the classes. About 48 percent of students accept that they have forgotten the concepts of their previous classes. They are not able to link the concepts being transacted in the class with their previous experiences, which is one of paramount importance for construction of knowledge. Other reasons attributed by 37 percent of students were that the pace of teaching in the class was too fast to understand. However, it was verified by the researcher that the teachers follow the academic calendar provided to them. Answering to item number 5, about 60 percent of students said that they perform activities and experiments in the class. On further probing, it came out that hardly six-seven activities were conducted, that too in an isolated way. Experiments were not integrated with the theoretical concepts. The response of item number 8 brings the science teachers in very good limelight.

Table 1.Class ninth (n= 461) and Class tenth (n= 459) students' response

Item No.	Students' response to the difficulties they face in conceptual understanding	Response in YES % Class ninth	Response in YES % Class tenth
1.	The course is too vast in the Science syllabus to learn.	50.66	43.58
2.	The lesson is taught in English and I have difficulty in understanding English.	10.00	5.08
3.	I have forgotten the concepts of the previous classes, so I find it difficult to connect the concepts.	48.88	47.12
4.	The pace of teaching in the class is too fast to understand.	36.22	37.39
5.	I perform experiments/activities during teaching-learning.	59.77	59.95
6.	My participation in all teaching- learning process is encouraged in the class.	77.33	73.45
7.	I have many questions but do not ask questions in the class for the fear that class will laugh at me / for the fear of being ridiculed.	40.00	49.34

8.	The teacher is accessible for discussion/ clearing doubts during or after the class.	88.88	87.67
9.	I feel that number of periods allotted for science teaching is less, so I do not get sufficient time to learn the concepts.	37.33	21.02
10.	I do not find the relevance of the classroom teaching with my everyday life.	31.11	29.20

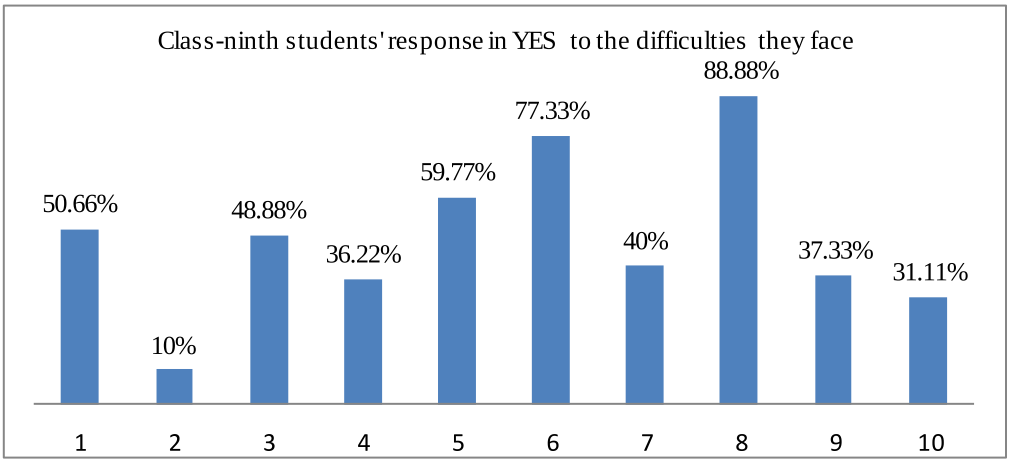

Fig. 1.Class-ninth students' response in % to the difficulties in conceptual understanding

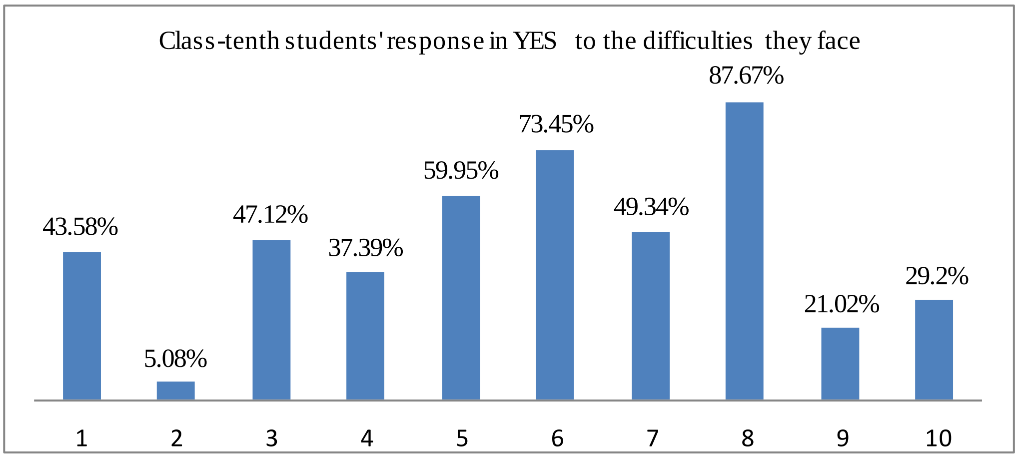

Fig. 2.Class-tenth students' response in % to the difficulties in conceptual understanding

88 percent of students say that teacher is accessible for discussion / clearing doubts during or after the class. The answer of item no 10 is a matter of great concern, as about 30 percent students do not find the concepts being transacted to be relevant to their everyday life.

It was found that 50.66 percent of class ninth and 43.58 percent of class tenth students feel that the course of science is too vast to learn. Though, English was the second language of the sample students, few students expressed their difficulties with the language problem. About 77 percent students of class ninth and 73 percent students of class tenth say that their participation is encouraged in the class. The percentage of responses to item number 7 is 40 percent and 49 percent respectively. 40 percent of students of class ninth and 49 percent of class tenth have many questions but they are hesitant to ask in the class for the fear of being ridiculed. 37.33 percent of students of class ninth feel that number of periods allotted to the class is less, so they do not get sufficient time to learn the concept, while this percentage is comparatively low (21.02 percent) for the students of class tenth.

Discussion

Each student is unique and learns with her/his own pace. Paying attention to the learning needs and learning styles of students is an essential part of teaching-learning process. One framework of the academic calendar prepared cannot suit all students. Teachers are hard pressed for time to cover the syllabus. Their capacity of uncovering, rather than covering the syllabus with a child-centred approach should be developed. A large majority of students feel that the syllabus is vast, though experts develop it after long deliberation. It implies that how to transact the concepts in the allotted time framework with students' friendly pace should also be part of the capacity building programme of the teachers. Each learner is valuable, hence, view of a few students that using their mother -tongue along with English can facilitate them in conceptual understanding is important.

Response to item no 3 (they have forgotten concepts of their previous classes) implies that 48 percent of students know — what they do not know. This awareness of their learning needs to be addressed. It is of paramount importance to link the concepts being transacted with students' existing ideas and the relevant concepts they have. New concepts need to be anchored on those concepts. This need has been mentioned in NCF-2005 (NCERT, 2005) as, 'learners actively construct their own knowledge by connecting new ideas to existing ideas on the basis of materials/activities presented to them (experiences).' One of the ways to find their existing ideas can be relating the concepts through their daily life experiences. This can make students find its relevance to their daily life and hence facilitate understanding. It is important to link within the classroom and beyond the classroom experiences to help students in making meaning of the concept.

Experiments and activities need to be carried out with an inquiry approach integrating them with the science concepts being transacted. Performing experiments with a spirit of inquiry and thinking critically about various aspects of the material and apparatus as well as concepts of the experiment can lead students towards meaningful understanding of science (Prabha,2016).Number of experiments is not of much importance, how these experiments are performed so as to spark curiosity and reativity is more important. NCERT (2010) recommends that there is a need for providing a few longer periods lasting an hour, or one and a half hours, in the school time table that allows for other kinds of activities, such as laboratory work, projects, etc. This can facilitate teachers to better integrate experimental work with concepts being transacted as well as recognize and address the concepts that students find difficult.

Though, most of the students say that teachers are available for clearing their doubts and their participation in the class is encouraged, still 40 percent of class nineth and 49 percent of class tenth students express hesitation in asking questions in the class for the fear of being ridiculed. This response was further clarified from the researcher's field notes. It seems there is only formal interaction among students and teachers. Students do not find classroom environment conducive to interact on the basis of their out of the box thinking. Teachers need to create an emotionally safe learning environment in the class to encourage students to ask questions.

Qualitative analysis of students' views

Students' response to the open-ended question, 'What should science teacher do to make the difficult concept easy?' was analysed. The data provides an insight into multiple factors that cause learning difficulties in conceptual understanding. Almost all students (97 percent) suggest that there should be more experiments and activities in the class and more interaction among students and with teachers so that they can be aware of each other's idea about the science concept being transacted in the class. They want that classroom environment should be such that they can ask, pose and raise questions without any fear of being ridiculed.

Findings

Observing the response patterns of students' of class ninth and tenth both on reasons of difficulties in conceptual understanding of science, it was categorized into following eight themes. Their views are mentioned below.it is very interesting that all students have some or other views on reasons of difficulties in conceptual understanding of science.

1. *More experiments and activities*
2. *Pedagogy*
3. *Interactive classroom*
4. *Examples from everyday life*
5. *Use of technology*
6. *Medium of instruction*
7. *Textbook*
8. *Infrastructure*

1. *More experiments and activities:* 'Conduct more experiments and activities.' 'Explain the concepts showing many experiments and activities.' 'Let students do experiments individually.' 'Perform practical more frequently.' 'Make students perform practical.' 'Relate experiments with each chapter.' 'Practical based teaching so that we can understand easily.' 'Take us to the laboratory. '

2. *Pedagogy*: 'Make us do group activities.' 'Teach through flowchart/more diagrams/mind map.' 'Explain the concepts two-three times.' 'Allow students to ask questions, why only teacher asks questions?' 'Clear our doubt; solve our difficulties.' 'Ask with students, whether they have understood.' 'Ask questions in between teaching.' 'Think positively about the questions asked by the student.' 'Take us to field visit /take an outdoor class.' Ask logical questions, not only memory type questions.' 'Take us outside the class and make us interact with nature and society.' 'Give equal attention to each student. 'Teacher should continuously take feedback regarding the concepts from the students to check their understanding.' 'Explain the concepts in easy words/easy language.' 'Tell stories related to science.' 'Respect each student-good or bad.' 'Give difficult numerical problems.' 'Make teaching enjoyable /funny/make us laugh during teaching.' 'Seminar should be conducted for some topics.' 'Do not tell us only conclusion, explain how do we get the conclusion.' 'Take test after each topic.' 'Teach us slowly /take more time to teach.' 'Ask students to explain the concept after teaching.' 'Put less pressure on students.' 'Take revision classes and give individual attention.' 'Teach for understanding, not for completing the syllabus. 'Do not talk about examination, it puts pressure on us.' 'Teacher should teach in a friendly manner.' 'Teach through the advanced book, not only from a textbook.' 'I want to know the genesis of ideas, teach from the root, how people got the ideas (Science facts and principles).' 'Give more explanation of the term used or the first time.' 'Teacher should teach in a way which students find interesting. ' 'Teacher should pay attention to average students also, not only to weak students.'

3. *Interactive classroom***:** **'**There should be more exchange of ideas in the class.' 'Just sitting and listening in the class is boring, make it interactive.' 'Each student should get chance to express her/his opinion so that we can know which book s/he is studying.' 'Students should be given opportunities to make presentations in front of the class and the teacher should be friendly and open.' 'Make good interaction with us.'

4. *Example from everyday life***:** 'Relate the topics to our daily life/real life.' 'Give many examples to explain a concept.' 'Link the topic with day-to-day examples.' 'Give highly relatable examples which help to understand difficult concepts.' 'Connect the topic with our everyday life experiences.' 'Add everyday ideas about the topic in all chapters.'

5. *Technology:* 'Show us videos related to chapter/concepts.' 'Explain pointwise using ppt (PowerPoint Presentation).' 'Show concepts in a digitized way.' 'Show videos of experiments.' 'We want more video class/smart class as the brain receives visual picture better than audio presentation.' 'Use smart board in teaching.' 'Use video, animation, ppt in teaching, digital illustrations of practical. 'Show us audio-video examples.'

6. *Medium of instruction*: 'Teaching in the mother tongue will make our understanding easy. 'Teach in Hindi and English both.' 'First teach in our mother tongue, then in English.'

7. *Textbook***:** **'**Make language simple.' 'Add more illustrations and figures in the chapters.' 'Technical terms should be printed in bold.' 'Add more numerical questions.' 'Write in small paragraphs.' 'Add explanations of basic concepts in a separate column on each page.' 'Include more examples for difficult concepts.'

8. *Infrastructure***:** 'Seating arrangement should be flexible, not of the traditional type.' 'Classroom should have Laboratory corners.' 'There should be a smart board in the class.' 'There should be a cupboard for each student so that they need not carry books every day. 'There should be a separate seat for each student, not a bench.' 'There should be an air conditioner in each class.'

Discussion

It is found that students' views on reasons of difficulties in conceptual understanding of science are closely aligned with some of the theoretical aspects of science pedagogy i.e. integrating experiments and activities with science concepts in teaching-learning of science; integrating assessment with teaching-learning; connecting science concepts with students' everyday life experiences; making the class more interactive; providing challenging learning opportunities to students; making each student feel valuable; use of Information and Communication Technology (ICT) to reinforce the concepts. Hence, their views are worth paying attention to.

Analysing students' views, it can be realised that their expectations are not beyond the realm of classroom process. They are expecting something that is achievable. Pre-service as well as practising teachers are trained to address these aspects of pedagogy of science. Why do teachers not able to implement them can be a matter for further research.

Students feel that conducting more experiments and integrating science concepts with laboratory work can ease their difficulties in conceptual understanding. This finding is also supported by earlier researches Lunetta, Hofstein & Clough, (2007) have found that laboratory work helps students to have meaningful understanding about scientific concepts and enhances students' motivation to learn science. In a study on Junior High School students of Indonesia (Rohandi (2017) it emerges that 89% of 107 students preferred to learn science through hands-on activities.Present study finds 97% of high school students prefer more experiments and activities in teaching-learning of science. Developing conceptual understanding through engaging in the practices of science is more productive for future learning than simply memorizing lists of facts (Clark, 2006; Driver et al., 1996). Analysis of students' views show that they like to make conclusion about science concept based on their own observations and experimentation, not on the basis of what is just transmitted to them verbally in the classroom.

Students express that they want to be engaged in inquiry, field visit, projects, discussion, debate, group work and sharing of everyday life experiences.They want interactive classrooms because they can know what other students are reading,what learning resources they are using . Interactive classroom with teacher's mediation can provide them opportunities to reflect on each other ideas in the process of construction of their knowledge. Driver et al. (1996)argues that students benefit from considering the range of ideas that, their classmates may have to describe the same phenomenon and developing ways of evaluating these explanations. Through such interactions, students can come to appreciate the criteria on which judgments in science are made. There is a growing body of research that shows that when students work in small groups and cooperate in striving to learn subject matter, positive cognitive and affective outcomes result (Johnson et al., 1981). Research has shown that learning is enhanced in a community setting when students and teachers share norms that value knowledge and participation (Cobb et.al, 2001).

Students view that one of the ways of softening their difficulties can be connecting concepts being transacted in the class with their everyday life experiences. Rohandi(2017) shows similar findings, that, students expect the learning of science to be more relevant to their everyday life, to include more practical/hands -on activities, and to provide greater opportunity for discussion and participation. Relating, linking, integrating and sharing their knowledge with science concepts can make students feel that their experiences and voice are important to the class. When science learning does not make connections to learners' interests and experiences, students may have pervasive negative views of science (Basu & Barton, 2007). To be effective, science teachers need to possess the ability to represent important ideas and abstract concepts in a way that makes them understandable to students. The ability to make this connection is the root of effective teaching; effective teachers possess content knowledge and the pedagogy skills most effective to teach the subject matter (Dewey, 1939).

For an enriched pedagogy, students have plenty of ideas. It shows that different students learn differently and they value different issues for making their understanding easier. Design of teaching- learning experiences must respond to students interset, their learning preferences and learning needs. Assessment must be integrated with the teaching-learning processes without putting pressure on students. Field visits should be its essential comopent. Teacher should maintain a friendly environment in the class so that students do not fear to express their ideas and ask any question.All students should be treated equally. It is of utmost importance for science teachers to engage students actively in the process of inquiry and diversify their strategies. Students feel that some challenging learning situations can make science interesting and easier. Science teachers should remain open to bring variety, diversity and flexibility in the choice of her/his pedagogical approaches so as to cater multiple learning needs of different students.

Numerical problems play a vital role to understand various concepts of science. It facilitates students to make connection between physical situations and mathematical equations. In the present study students feel that many times the conceptual terms appearing in the numerical problems in Physics are difficult and more practice of solving difficult problems should be done in the class for conceptual clarity.This finding is congruent with one of the findings of Phonapichat, et al.(2014), 'students have difficulties in understanding the keywords appearing in problems, thus cannot interpret them into mathematical sentences, in the context of mathematical problem solving difficulties of elementary school students.

Based on the positive effect of science teaching enriched with technological applications in the research, it can be said that teaching should be supported with technology to enrich the learning-teaching process and technological applications should be included in education. (Yildirim & Sensoy 2018). Their findings are in line with students' perception that their difficulties in conceptual understanding will ease with the use of more video, animation, digital illustrations, PowerPoint Presentations and smart boards. Creative and interactive use of Information and Communication Technology (ICT) facilitating contributions of students for its development should be part of teaching-learning in today's scenario. It can be helpful to all, especially visual learners.

Language is one of the fundamental competencies that provides the foundation to all educational activities. Teachers need to interact with students giving due attention to students' preferences to the medium of instruction. Many students expressed conceptual understanding will be easier if science concepts are first explained in their mother tongue, then in English.

Students have their suggestions for the science textbook also. A significant suggestion is to include basic, previous, and related concepts in a separate column on the relevant page. Though textbook is a tool for teaching-learning, and teacher is expected to link the present concept with the previous concepts; incorporating the above suggestion can be helpful to students in managing their own learning and removing one of the hurdles in conceptual understanding. Though difficulties related to infrastructure were not part of the study, some students expressed the issues, as the item of the questionnaire was open-ended. No doubt, a good infrastructure provides an enabling learning environment.

It emerges from the findings that if a conducive environment is created to express their views and learning preferences, students can provide very valuable feedback to enrich teaching-learning process. This is in line with the observation of Thomas (2012) that teacher education courses and professional development activities should make it obvious to prospective and practising teachers that there is need for them to set aside time so that students can reflect on their learning processes, how they might be improved and what it might mean to be an effective science learner.

We should never lose sight of the fact that children and teachers in classrooms are conscious, sentient, and purposive human beings, so no scientific explanation of human behavior could ever be complete (Berliner ,2002). There is a remarkable scope for further studies in the area of students' learning difficulties in conceptual understanding of science. Similar studies can be taken for higher secondary classes (class eleventh - class twelfth). Studies can be taken on correlation between students' difficulties in conceptual understanding of science and teachers' difficulties in transacting those concepts. It would be interesting to investigate the efficacy of pedagogical interventions to address students' difficulties in conceptual understanding of science and find answers of the question, 'what difficulties teachers face in implementing those pedagogical practices in science.' The study was limited to only five states of India and CBSE (Central Board of Secondary Education) schools . Status and limitations of infrastructures in schools were beyond the scope of the study. However, many students expressed their views on this issue in open- ended item of the questionnaire.

Conclusion

In the present work, secondary stage students' views on difficulties of conceptual understanding of science were investigated. Two key conclusions emerge from the research. Firstly, it provides valuable insights to educators and policymakers for reinforcement of learner- centred pedagogy of science. The findings of the study provide useful information regarding pedagogical aspects of science and design of teacher-education programmes for prospective as well as practising teachers. Students' views also provide hints to develop various teaching - learning materials including e-resources on the concepts students find difficult at the secondary stage.

Secondly, the research throws some light on the metacognitive aspects of students. It is clear that students are conscious of difficulties in their conceptual understanding of science; they can identify the reason for their difficulties and express informed views to address and resolve them. They know how they can learn best. It offers a very optimistic framework to educators and policymakers.

However, at the first place, making students aware that they can also express their views on teaching - learning of science and their views are important to modify classroom processes and soften their difficulties, is important.Students can develop a better sense of belongingness to school and learn meaningfully if they find their voices are heard. Giving primacy to students' views in teaching-learning can develop a greater interest and greater realisation of learning outcomes and hence greater academic achievement.This aspect is vital to enrich their learning and to achieve excellence in education.

Recommendations

It is recommended that science teachers invite, ponder and use students' views on their difficulties in conceptual understanding and the reasons thereof as a continuing process to enrich teaching-learning of science. Their views must be valued and teaching-learning approaches and strategies must be adjusted according to their learning needs and learning preferences. Issues and concerns expressed in students' views need to be addressed in capacity building programmes for science teachers.

Acknowledgements

The author acknowledges the support and financial grant sanctioned by the National Council of Educational Research and Training, New Delhi, an apex body in school education under the Ministry of Human Resource and Development, India.

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The Eurasia Proceedings of
Educational & Social Sciences (EPESS)
ISSN: 2587-1730

The Eurasia Proceedings of Educational & Social Sciences (EPESS), 2020

Volume 16, Pages 11-17

ICEMST 2020: International Conference on Education in Mathematics, Science and Technology

Technological Pedagogical Content Knowledge: A Review of Mathematics Education Literature

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Abstract: In teacher education literature, Technological Pedagogical Content Knowledge (TPACK) was defined as the teacher knowledge required for successful technology integration. It is based on the notion of Pedagogical Content Knowledge, which elaborated the teacher knowledge in terms of content-specific pedagogy. Along with other areas, TPACK studies in mathematics education have gained momentum in recent years. This study aims to review the peer-reviewed articles published between 2005-2019, which examined mathematics and pre-service mathematics teachers' TPACK under three main themes: an examination of TPACK studies based on its components, the development of TPACK and the strategies for developing TPACK. The findings indicated that the studies on TPACK mostly focused on general technological pedagogical knowledge without considering the content dimension. Another noteworthy issue is the large number of recent studies that have examined teacher and student beliefs as a component of TPACK. In contrast, assessment has been a neglected issue in TPACK studies. Finally, our investigation indicated a gap in the literature concerning strategies for developing TPACK.

Keywords: Technological pedagogical content knowledge, TPACK, Mathematics teachers, Pre-service mathematics teachers

Introduction

Digital technologies have been used in the teaching of mathematics especially in the last three decades. Researchers had investigated the effects of tools such as educational software (e.g. dynamic geometry systems) and graphical calculators on students' learning in the context of mathematics. Studies found that use these tools promoted a conceptual understanding of mathematics (Habre & Abboud, 2006). However, the success of using these tools depends on teacher expertise and knowledge. They should have adequate knowledge of using technology in their classrooms effectively. The knowledge required for successful technology integration had been defined as Technological Pedagogical Content Knowledge (TPCK) by Pierson (1999), Niess (2005), and Mishra and Koehler (2006). Later, Koehler and Mishra (2009) referred to the framework as TPACK. In this section, we will elaborate on the Technological Pedagogical Content Knowledge (TPACK) framework further.

TPACK framework is based on Shulman's (1986, 1987) notion of Pedagogical Content Knowledge (PCK) which he defined as an important domain of teachers' knowledge and an amalgam of teachers' content and pedagogical knowledge. Shulman (1987) emphasizes that "pedagogical content knowledge is the category most likely to distinguish the understanding of the content specialist from that of the pedagogue" (p. 8). Pierson (1999), Niess (2005) and Mishra and Koehler (2006) conceptualized the TPACK framework as the intersection of three knowledge domains: content knowledge, pedagogical knowledge, and technological knowledge (See Figure 1). Technological Pedagogical Content Knowledge is different from and more powerful than technological, pedagogical, and content knowledge as separate knowledge domains (Akkoç, 2013) just like pedagogical content knowledge is a different domain than pedagogical and content knowledge. Mishra and Koehler (2006) defined the intersections of different knowledge domains in Figure 1. We have already defined pedagogical content knowledge (PCK) as the pedagogical knowledge specific to a particular subject.

Technological content knowledge (TCK) is concerned with the way technological tools represent a particular subject matter. Technological pedagogical knowledge (TPK) is the general pedagogical knowledge (not specific to a particular subject) for integrating technology into instruction e.g. using the opportunities of technological tools such as getting instant feedback from the computer or the knowledge of the classroom management in a computer lab.

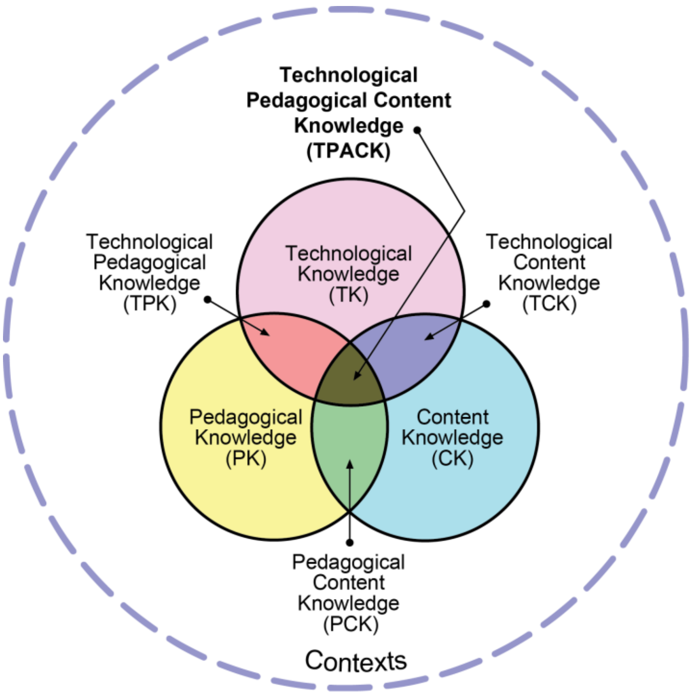

Figure 1. TPACK Framework (Reproduced by permission of the publisher, © 2012 by tpack.org)

Technological pedagogical content knowledge (TPACK), as represented as the intersection of three sets in Figure 1, is the knowledge required for teaching a particular subject matter using technology effectively e.g. how to choose suitable software and use it with appropriate pedagogy to introduce derivative at a point. TPACK builds on the PCK construct and is "achieved when a teacher knows how technological tools transform pedagogical strategies and content representations for teaching specific topics" (Jang, 2010, p. 1744).

After the emergence of the TPACK framework, researchers elaborate on the framework in terms of its development process and its components. Niess (2005) adopted Grossman's (1990) study on PCK components and defined the components of TPACK as the knowledge concerning: (1) what it means to teach a particular subject integrating technology in the learning, (2) instructional strategies and representation for teaching particular topics with technology, (3) students' understanding, thinking, and learning with technology in a particular subject, (4) curriculum and curriculum materials that integrate technology with learning in the subject area.

This study aims to explore how mathematics education literature (2005-2019) conceptualized and investigated the TPACK framework.

Method

The review focused on the peer-reviewed articles published between 2005-2019, which examined mathematics and pre-service mathematics teachers' TPACK. Articles were searched in December 2019 by exploring Google Scholar. The keyword employed was "technological pedagogical content knowledge" and "TPACK" OR "TPCK". We excluded book reviews, conference proceedings, and Ph.D. dissertations. We reached 12 articles all of which are empirical studies. Seven of them focused on pre-service mathematics teachers and five of them on mathematics teachers. An in-depth analysis of these studies revealed three main themes: an examination of TPACK based on its components, the development of TPACK, and the strategies for developing TPACK. Below, we present findings for each theme in detail.

An examination of TPACK studies based on TPACK's components

In this section, we will provide a review of the literature based on the TPACK framework's components. The determined by adapting the components determined for PCK in Depaepe et al. (2013). We also added the assessment and evaluation component which emerged from our review.

Tablo 1. Studies in mathematics education based on TPACK's components

Authors	Students' (mis)conceptions and difficulties	Representations and instructional materials	Mathematical tasks and cognitive demands	Educational ends	Curriculum and media	Technological knowledge	Content knowledge	Pedagogical knowledge	Teachers' and students' beliefs	Assessment and evaluation
Lee ve Hollebrands (2008)						x		x		
Niess et. al.. (2009)						x		x		
Ozmantar, Akkoc, Bingölbali, Demir and Ergene (2010)		x								
Bowers and Stephens (2011)		x				x				
Haciomeroglu, Bu, Schoen, Hohenwarter (2011)						x		x		
Larkin, Jamieson-Proctor, and Finger (2012)						x		x		
Doğan (2012)					x				x	
Akkoç (2015)		x			x	x				x
Hansen, Mavrikis, Geraniou (2016)		x				x				
Psycharis and Kalogeria (2017)		x			x		x	x		
Young et al. 2019						x				
De Freitas and Spangenberg (2019)						x	x		x	

As can be seen in Table 1, the component, "representations and instructional materials", is the most frequent one. This is followed by "curriculum and media" and "technological knowledge". Opposite to PCK studies, we did not find any study regarding the component, "students' (mis)conceptions and difficulties". The component, "assessment and evaluation", was only studied by Akkoç (2015) in the context of formative assessment in a Geogebra environment. It is also a neglected component in PCK literature. TPACK Studies focused on the nature of TPACK in a general sense rather than students' difficulties with a specific topic. Another remarkable finding is that student and teacher belief is a focus of attention in TPACK studies as oppose to PCK studies in the context of mathematics education.

An examination of the mathematics education literature on the development of TPACK

In this section, we will provide a review of mathematics education literature that focused on the developments of mathematics teachers' or pre-service mathematics teachers' TPACK. What is meant by the development of TPACK is the development of the knowledge and skills concerning the use of technology with appropriate pedagogies for teaching mathematics. Studies mostly investigated the TPACK development at the end of a course, a module, or a project. Most of them used the existing TPACK models or components while others (Niess et.al., 2009) re-conceptualized the framework to build TPACK development models.

Among the studies that used existing TPACK components, Lee and Hollebrands (2008) offered an integrated approach to developing technological pedagogical content knowledge to prepare mathematics teachers to teach data analysis and probability topics using specific technology tools. They shared and discussed some examples from materials developed by the Preparing to Teach Mathematics with Technology (PTMT) project. Their integrative approach emphasizes the content dimension when developing mathematics teachers' technological knowledge. In a similar sense, Haciömeroğlu et. al. (2011) focused on a specific technological tool (Geogebra) and investigated pre-service mathematics teachers' TPACK in the context of methods courses. They examined

68 pre-service teachers' TPACK development using their written reflections, lesson plans, and classroom observations.

On the other hand, Niess et. al. (2009) revised the TPACK framework and offered a five-stage development model called the "Mathematics Teacher Development Model". They attempted to answer the question of what knowledge is needed to teach mathematics with digital technologies. To do that, they first defined "Mathematics Teacher TPACK Standards" which offer guidelines for thinking about the framework in the context of mathematics. They emphasized that these standards "may guide teachers, researchers, teacher educators, professional development consultants, and school administrators in the development and evaluation of professional development activities, mathematics education programs, and school mathematics programs" (p.4). They offered a Mathematics Teacher Development Model to describe the development of TPACK toward meeting these standards.

Their five-stage developmental process when learning to integrate a particular technology in teaching and learning mathematics is as follows (Niess, 2009, p. 9):

> 1. Recognizing (knowledge), where teachers are able to use the technology and recognize the alignment of the technology with mathematics content yet do not integrate the technology in teaching and learning of mathematics.
> 2. Accepting (persuasion), where teachers form a favorable or unfavorable attitude toward teaching and learning mathematics with an appropriate technology.
> 3. Adapting (decision), where teachers engage in activities that lead to a choice to adopt or reject teaching and learning mathematics with an appropriate technology.
> 4. Exploring (implementation), where teachers actively integrate teaching and learning of mathematics with an appropriate technology.
> 5. Advancing (confirmation), where teachers evaluate the results of the decision to integrate teaching and learning mathematics with an appropriate technology.

As can be seen from the quotation above, the model describes how teachers develop the knowledge for integrating technology rather than the components of TPACK. Although the model emerged from a research study with mathematics teachers, it could be used to investigate the development of TPACK of teachers for other subject domains.

An examination of the mathematics education literature on the strategies for developing TPACK

In this section, we will provide a review of mathematics education literature that focused on the strategies for developing mathematics teachers' or pre-service mathematics teachers' TPACK. We purposefully distinguished this theme from the theme above (development of TPACK) because studies that will be mentioned in this section particularly describe and prescribe the strategies for developing TPACK rather than merely reporting the development of TPACK. In other words, they give a detailed account of the intervention that aimed at the development of TPACK.

Ozmantar, Akkoc, Bingölbali, Demir, and Ergene (2010) conducted an intervention and suggested strategies for developing TPACK is. In their wider project, they developed a course for pre-service teachers to develop their TPACK and specified five content-specific components of the framework. In their study, they focused on one of the components of TPACK (concerning multiple representations of derivative). Teacher preparation course content and method of delivery were based on the defined TPACK framework. They defined content-specific learning gains for TC, TCK, TPK, PCK, and TPCK. They found that the course improved pre-service mathematics teachers' lesson plans and micro-teaching concerning their knowledge of representations, of connections established among the representations, and of the aspects of derivative emphasized by these connections in technology-rich environments.

Bowers and Stephens (2011) offered a different TPACK perspective than Ozmantar et. al.'s (2010) study to help pre-service mathematics teachers develop their TPACK. Instead of a conception of TPACK as a subset of knowledge skills, their perspective considers learning as a social process motivated by communication. In their study, preservice teachers engaged in "technology-enhanced mathematical explorations with the explicit goal of discussing how technology enabled them to describe relationships among objects on the screen that could not have been developed without the tools employed" (p. 291). A 6-week course that took place at a large university in the United States. Each pre-service teacher prepared a final project which included choosing a mathematical topic, developing a geometer's sketchpad sketch, and exploring how technology could be used to enhance a textbook-only lesson. Analysis of these projects and discussions of them were used to investigate pre-service teachers' TPACK development. The study concludes that TPACK may better be viewed as an orientation than a set of subskills or knowledge constructs and that this view could guide teacher educators to plan instruction for pre-service teachers. More specifically, the findings shed a light on "various pedagogical moves such as probing questions and unique technological features that support the need for causal explanations to support deeper mathematical understanding" (p. 301). Another strategy that made the course effective was guiding students' metacognitive processes as they reflect on their learning and development efforts.

Young, Young, Hamilton, and Pratt (2019) used meta-analytic thinking which compares their results to prior results from similar studies to evaluate the effects of a technology professional development. Their quantitative study investigated the effects of a three-week professional development for urban mathematics teachers on TPACK and how the effects compare to previous interventions to increase teacher TPACK. Their strategy for the technology professional development was based on drag/drop, hide/reveal, highlighting, movement/animation using interactive whiteboards (as the TK dimension), arithmetic, algebra, statistics, and geometry (as CK dimension) and demonstration, discussion, drill/practice, modelling, simulation (as the PK dimension). Pretest- posttest analysis of a survey illustrated teachers' development on TPACK and Interaction Whiteboard (IWB) use in the classroom.

Results and Discussion

This study aimed at an analysis of TPACK studies in mathematics education literature to reveal the current situation and shed a light on the future direction of research in that area. We reviewed the TPACK studies published between 2005-2019 under three themes: an examination of TPACK based on its components, the development of TPACK, and the strategies for developing TPACK.

Regarding the TPACK components, mathematics education literature focused most on certain components of TPACK: "technological knowledge" and "representations and instructional materials". Technological knowledge is also the main component of the framework in teacher education studies as well as mathematics education (Akkoç, 2013). The notion of multiple representations is an important area of research in mathematics education especially in the context of technology-enhanced environments. Therefore, representations and the way they are used constitute an important component of TPACK. On the other hand, our review also revealed that certain components were neglected in mathematics education literature. "Students' (mis)conceptions and difficulties" and "mathematical tasks and cognitive demands" are two of them. They are both closely related to the subject-matters such as overcoming students' difficulties with functions using technological tools. There is no study on mathematical concepts targeting overcoming student difficulties and misconceptions using technological tools. The content dimension is a neglected issue in TPACK studies in general (Akkoç, 2013). Another neglected component is "assessment and evaluation". We came across only one study focusing on this component (Akkoç, 2015).

Concerning the development of TPACK, we only found three studies two of which used the existing TPACK models or components. Niess et. Al. (2009), on the other hand, put forward a new model of TPACK development which is an important contribution to the field. Although they call it the "Mathematics Teacher Development Model", it has the potential to be used in other fields of teacher education that would focus on TPACK development.

Regarding the strategies for developing TPACK, we found three studies that particularly described their intervention that aimed a TPACK development. We found that strategies differed in the way they conceptualize the TPACK framework. While some of the studies separately used dimensions and/or components of the framework to design their courses on TPACK (Ozmantar et. al., 2010; Young et. al, 2019), Bowers and Stephens (2011) treated the TPACK as an orientation than a set of subskills or knowledge constructs and that this view could guide teacher educators to plan instruction for pre-service teachers.

Conclusions

The findings indicated that the studies on TPACK in mathematics education literature mostly focused on general technological pedagogical knowledge without considering the content dimension. Another noteworthy issue is the large number of recent studies that have examined teacher and student beliefs as a component of TPACK. In contrast, assessment has been a neglected issue in TPACK studies. Finally, our investigation indicated a gap in the literature concerning strategies for developing TPACK.

Recommendations

We suggest mathematics education researchers to focus on TPACK, components "students' (mis)conceptions and difficulties", "mathematical tasks and cognitive demands", and "assessment and evaluation" by bringing the content dimension into play. We also recommend teacher education researchers to conduct intervention studies that would adopt Niess et. al.'s (2009) five-stage TPACK development model to other fields in teacher education. We also recommend future studies that would elaborate the effective strategies to develop teachers' and pre-service teachers' TPACK.

Acknowledgment

This study is part of a research project (project number EGT-A-150218-0081) funded by the Marmara University Scientific Research Projects Commission (BAPKO).

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The Eurasia Proceedings of
Educational & Social Sciences (EPESS)
ISSN: 2587-1730

The Eurasia Proceedings of Educational & Social Sciences (EPESS), 2020

Volume 16, Pages 18-28

ICEMST 2020: International Conference on Education in Mathematics, Science and Technology

A MATLAB Supported learning and Students' Conceptual Understanding of Domain and Range of a Function of Two Variables: Wolkite University, Ethiopia

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Abstract: A case study design was conducted at Wolkite University to investigate MATLAB supported learning and students' conceptual understanding in learning Applied Mathematics II using four different comparative instructional approaches: MATLAB supported traditional lecture method, MATLAB supported collaborative method, only collaborative method and only traditional lecture method. Four intact classes Mechanical Engineering groups 1 and 2, Garment Engineering and Textile Engineering students were selected by simple random sampling out of eight departments. The first three departments were considered as treatment groups and the fourth one "Textile Engineering" was assigned as a comparison group, randomly. Qualitative data were collected through reasoning part of the multiple choice items of pre-test and interview items of the post-test were analyzed using APOS analysis based on proposed genetic decompositions. The results of the data show that the majority of the students' conceptual understanding lies in action conception. Students' conceptual understanding on domain and range is a straight forward as that of a function of a single variable which reveals that students haven't developed new schemata for a function of two variables, as different from a function of a single variable. Majority of the respondents were poor on extending a previous concepts to the new concept and had difficulty to represent domain and range using graph. The results also show that there is no difference between students learning through MATLAB supported in combination with collaborative approach and other instructional approaches like MATLAB supported learning in combination with traditional lecture method, traditional lecture method and collaborative method on conceptual understanding. This might be due to lack of students' experience on technology supported learning in such advanced courses. Thus, this study recommends further study on software supported learning in combination with collaborative method for betterment of conceptual understanding.

Keywords: MATLAB supported learning, Collaborative method, Conceptual understanding, Domain and range, Functions of two variables

Introduction

The concepts of domain and range of a function are ideas that help an individual's understanding of the relationships in a function. Every function relies on a specific domain and range that helps to apply to a real world situation (Bennett & Briggs, 2007). Domain of a function is defined as the set of valid or meaningful input x whereas range is the set of coordinating outputs y (Adams, 2003; Stewart, 2008).

According to Rockswold (2010) domain of a function is represented using the concept of interval notation instead of drawing a number line graphs as (,), (,], [,), or [,]. Moreover, Bittinger, Ellenbogen and Johnson (2010) describe domain and range of a given function using an ordered pair like for instance given that {(2,3),

- Selection and peer-review under responsibility of the Organizing Committee of the Conference

(4,5), (6,7), (8,9)} the set of the first entries of the given ordered pair is called domain i.e. {2,4,6,8} whereas the set of the second entries is called range of the function i.e. {3,5,7,9}. On top of these, Bittinge et al. (2010) indicate that students could use graphical representation in order to determine domain and range of a given set of ordered pairs. These describe the domain of a function as the set of all x-values that fulfill the curve whereas range is the set of all y-values that are results of the function, whose coordinate point lies on the curve.

Functions of several variables are extensions of functions of single variables. It is a real valued function of n-real variables that take as input (represented by the variables $x_1, x_2, x_3, \ldots, x_n$) to produce another real number, commonly denoted by $f(x_1, x_2, x_3, \ldots, x_n)$. From this one would see that the domain of functions of several variables is a region on which the function is defined. The range is the set of values that f takes. Whereas, in case of a function of a single variable domain of the function is the subset of real numbers that make the given function defined and the range is the set of values that f takes (Adams, 2003; Stewart, 2008). Here, a function of a single variable is considered as a pre-requisite for a function of several variables.

So, in order to tackle poor conceptual understanding of the students, there are researches that highly recommend to use instructional method that enables the students to discuss with one another and let them construct their own understanding in general and collaborative method in particular (Wong, 2001). There are also some other researches that recommend the utilization of different mathematical software to develop students' understanding (Mulugeta, Zelalem & Kassa, 2015).

According to Al-Ammary (2013) technology supported learning can be considered as a solution to instructional problems that improve the effectiveness and efficiency of learning within education context. It lets learners to be motivated, have clear mental pictures about the content, enhance instructional methods, increase productivity, and equip with up-to-date information. That is why the National Council of Mathematics Teachers (NCTM) (2002) included technology as one principle of mathematics education since it influences content to be taught and enhances students' learning.

Technology has a significant impact on classroom and make student beneficiary. Stoops (2010), claims that technology integrated learning promotes positive attitudes toward learning and encourages low achievers to succeed. It is true that technology, particularly software integrated learning makes the classroom more interactive, and encourage the students to construct their own understanding rather than passive receivers. There is a positive relationship between technology and students' motivation, and also there is a direct association between students' motivation and learning mathematics (Shin & Mills, 2011). MacLuckie (2010) also shows that using technology increases motivation and retention of subject matters. Many scholars recommended that the use of educational technology in the classroom as one way of strategies to enhance student's conceptual understanding and problem solving skill (Al-Ammary, 2013; NCMT, 2000; Jaun, Huertas, Cuypers & Loch, 2012; Majid, 2014).

There is widely available software used for the purpose of teaching. For instance, hand held tools like calculators and mind tools like MATLAB, Mathematica, Maple, Fortran, C++ and so forth (Andreatos & Zagorianos, 2009; Charles-ogan, 2015; Eyasu, Kassa & Mulugeta, 2013; Ogunkunle & Charles-Ogan, 2013; Mulugeta, Zelalem & Kassa, 2015). Specially, MATLAB is used to visualize and plot different 2D and 3D graphs for better understanding and imagination of the problem (Charles-Ogan, 2015; Furner & Marinas, 2013), analyze data, develop algorithm, computation, modeling and simulation. It is also simple to use when compared with other software. A lot of research is done on mathematics software integrated learning and had positive result on students' motivation to learn mathematics (Furner & Marinas, 2013).

MATLAB supported learning was chosen because of its applicability in wide areas of discipline like electrical engineering, mechanical engineering, computer science and so forth for the purpose of simulation work and program writing. On top of this, it is used as a teaching and learning aid for mathematics students specially on sketching graphs of 2D and 3D. Thus, in this study MATLAB supported learning in combination with collaborative and traditional lecture method of teaching is used to find out its effect on student's conceptual understanding.

Method

Research design

This study was conducted to explore MATLAB supported learning and students' conceptual understanding of a domain and range of a function of two variables. Though conceptual understanding could be treated in a number of ways, the research method that fits for this study was a case study research design. It gives more emphasis on understanding the phenomenon under investigation through bringing a word or picture data for thick description and interpretation (Tewksbury, 2009).

Sample and sampling techniques

The study involves the use of four intact groups (Mechanical engineering group 1 and group 2, Garment engineering and Textile engineering) and assigns three of them as treatment and the remaining one as a comparison group using simple random sampling. The intact classes were assigned randomly to comparison and treatment group. All groups were exposed to different learning approaches in order to identify which learning approach is more effective to foster students' conceptual understanding. So, Mechanical Engineering group 1 students learnt though MATLAB supported learning in combination with the traditional lecture method, Mechanical Engineering group 2 students learnt though MATLAB supported learning in combination with collaborative learning method, Garment Engineering students learnt through collaborative method only and Textile Engineering students learnt through the traditional lecture method only. To help substantiate the students’ levels of understanding and the nature of their schemata development qualitative approach was employed. The number of students involved in this study from each department was 30, 29, 35 and 32 respectively. Two intact classes (Mechanical engineering group 1 and group 2) were from the main campus of Wolkite University whereas the other two groups were from the cluster campus of the same batch of 2016/17 academic year. All groups have almost equally likely the same when looking at their Applied Mathematics I performance. This indicates that almost the groups are homogenous.

Purposive sampling method was employed to select a sample of students for interview from each of the selected classes. The students selected for interview were from the lower, medium and higher achievers in each group. The cutoff for achiever levels were done based on the students' previous Applied Mathematics I grade report. Those students who scored A- , A and A+ were categorized under higher achievers, C+ , B-, B and B+ were grouped in the medium achievers and those whose grade is below C+ were grouped under low achievers. Totally, there were 12 students selected for interview.

Data collection tools

Eight two tiered conceptual test of reasoning part as a pre-test and eight semi-structured interview questions as a post-test were designed by the researchers to collect qualitative data in order to get in-depth understanding on students' conceptual understanding. All questions are open ended items and the entire respondents were asked the same questions. Semi-structured interview allows the researchers to capture a deeper understanding of the topic to develop relevant and meaningful results i.e. to understand students' mental construction as per the genetic decomposition proposed after interventions were administered, hereunder. Each questions of the semi-structured interview derived from each questions of the conceptual test and needs further clarifications and discussions about the concept.

Data Collection Procedure

The data collection procedure emanates from the designed genetic decomposition that included classifications of concept categories. In this study the concepts under investigation were classified into four categories. Those were: definition, extending definition, algebraic/symbolic representation and graphic representation of a domain and a range of a function of several variables. In order to investigate the students' conception, the researchers used a genetic decomposition predicted beforehand based on their experience and relating these with available literature.

The genetic decomposition proposed for the concepts of a function of two variables had four different activities. Those activities were set to help students make constructions predicted. In these activities, students were asked about domain and range of a function of a single variable and required to move those concepts to a function of two variables so that they can be able to interiorize those actions into a process. Then, they were asked to find domain and range of a function of two variables, and they were also asked to show those concepts using graphical representations. Lastly, students were probed to thematize different concepts of a function of two variables.

The initial genetic decomposition proposed for the concepts of functions of several variables backed by the four different activities were set to help students make constructions predicted. These include the task for which students were asked to 1) define, 2) determine, 3) algebraically and graphically represent the domain and range of functions of single variables and 4) extend the concept of a function of single variable into a function of two variables.
Students were asked the above four questions before they deal with domain and range of a function of two variables. Besides, the following activities were designed.

1. An action conception which enables to define, extend definitions, and state rules and principles of domain and range of a function of two variables, whose rules are given in the algebraic/symbolic form.
2. A process conception which enables to determine domain and range of a function of several variables. This could involve studying the structure of the function, detecting whether a rule could be applied or whether the function should be written in a standard form which enables the application of the appropriate rules to solve a given problem.
3. An object conception which enables the seeing of strings of processes as a totality and performing mental or written actions on the internal structure of the given functions of several variables which enables to convert algebraic representations to graphical representation and vice versa.
4. Organizing the action, process, and object related to the concept of a function of two variables and linking them into a coherent framework. This framework includes various interpretations of functions of several variables in different contexts, and possible techniques for finding domain and range, and applying rules in finding domain and range.

Trustworthy of the Genetic Decomposition

Initially genetic decompositions were proposed by the researchers and then the proposed genetic decompositions were tested through pilot study. The hypotheses of the proposed genetic decompositions were checked and refined to better describe what students do and to design activities that help students to construct their understanding and exhibit difficulties (Martinez-Planell & Gaisman, 2013; Martinez-Planell, Gaisman, & McGee, 2015). Based on the results of the pilot study, the genetic decompositions were refined and made ready for the actual study.

Method of data analysis

The qualitative data collected were analyzed through thematizing students' reasoning into four different areas related to definition, extending definition to the new concept, algebraic/symbolic representation, and graph representation of a domain and range of a function of two variables. These were analyzed base on the APOS Theory framework.

Results and Discussion

A function of two variables is a function whose domain is a subset of the plane $\mathbb{R}^2$ and whose range is a subset of $\mathbb{R}$. If the domain is denoted by D, then a function f is a rule that assigns every point $(x, y) \in D$ to a unique real number $f(x, y) \in \mathbb{R}$. For functions of three variables, every point $(x, y, z) \in B$ where $B \subseteq \mathbb{R}^3$ is assigned to a unique real number$f(x, y, z) \in \mathbb{R}$ (Adams, 2003; Stewart, 2008).

Students were asked to choose the correct answer and justify their responses for conceptual tests. Their responses were categorized into different mental constructions as per APOS theory and based on the proposed genetic decompositions. Questions were given to the students to determine their understanding on domain and range of a function of two variables. These questions were given to assess the way students' defined domain and range, extend concepts of domain and range of functions of a single variable to that of several variables, algebraic representation/ symbolic representation of domain and range, and graphical representation of domain and range of functions of several variables. Thus, data gathered through reasoning part of the pre-test of conceptual understanding items and interview items of the post-test were analyzed using APOS theory to determine the level of students' conceptions before and after the interventions.

Before giving any treatments, students' conceptions were probed by the following table that defines a function f whose domain is represented by the variables x, y and whose range is represented by the variable $z: z = f(x, y)$. The values for x are in the first column of the table, the ones corresponding to y are in the first row of the table below (Table 1).

Table 1. Domain and range

x/y	**2**	**3**	**4**	**5**
0	3	4	5	6
1	5	2	4	3
2	6	2	5	5
3	7	3	3	4

Students' reasoning and interview data on definition of domain and range, extending definition of domain and range to functions of several variables, algebraic/ symbolic representations and graphical representation of each group under investigation have been extracted and the discussion for each is provided below.

In line with definition of a domain and a range of a function of several variables, students were given the above table of values so that they can define a domain and a range of a function of two variables. Even though the question given to the students was clearly indicating that domain is represented by the variables x and y and range as the value of $f(x, y)$, respondents did not show proper understanding to define domain and range of a function of several variables in general and a function of two variables in particular. For instance, the data reveal that before intervention was given students were defining domain as:

- *a set containing all elements in the first column of the given table* (respondents M1S3, M2S9, and GS13)
- *the first entry of the function* (respondent M1S2)
- *a value of* x (respondents M1S8, M2S1, GS1, & TS3)

Moreover, respondents were defining range as:

- *a set containing all elements in the first row of the given table*(respondents M1S10, M2S25, & TS29)
- *a value of* y (respondents M2S9 & GS13)

Definitions of domain and range as given above are basically correct only if the given function is a function of a single variable, but these do not serve a function of two variables. They were symbolically representing domain and range as $Df = \{x/x = 0,1,2,3\}$ (for instance M2S1, M2S2 and M2S5) and $Rf = \{y/y = 2,3,4,5\}$ (M2S4 and M2S11) respectively which is not correct. Such misconceptions were demonstrated because of lack of understanding the nature of the given function and extending some basic concepts of a function of a single variable to a function of two variables. Schwarzenegger (1980) and Tall (1992) state that if students had difficulty in understanding concepts of a function of a single variable, then it will cause difficulty to understand concepts of a function of two variables. Thus, no matter how the students have difficulties of conceptualizing prior knowledge or have better understanding, then they could be challenged to extend the prior knowledge to the new concepts.

In Regards to extending definition of domain and range of a function of a single variable to a function of two variables, students were given that $z = f(x, y)$ where both x and y are considered as independent variables whereas $f(x, y)$ is a dependent variable. It was conceptually wrong to think that a variable x as an independent variable and y as a dependent variable in a function of two variables. But, students were defining domain as "*the value of x and y in ordered pair*" (M1S10, GS3,) and "*a subset of a set of ordered pairs*" (M1S5, M2S16, TS1) whereas range as "*an output of f*" (for instance M2S16) and "*the value of y*"(for instance M1S10). Basically, some of the respondents seem to have acceptable conception, but the justification that consider the subset of a set of an ordered pairs as element of real number represented as $Df = \{(x, y) \in \mathbb{R}\}$ and the value of y i.e. $y = \{2,3,4,5\}$ as a range of a function of two variables is not correct. Such misconceptions might be demonstrated due to lack of understanding the nature of the dimension (space) on which the domain of a given function of two variables is defined and how to determine range of a given function.

Thus, the entire students' conception presented above on definition of domain and range of a function of two variables can be categorized under action conception as per the proposed genetic decomposition. This result is in favor of the research result done by Martinez-Planell & Trigueros (2009) whose research shows that, students' understanding on domain and range of a function of two variables is not different from that of a function of single variable.

Regarding representation, this study reveals that majority of the students have difficulty of interpreting the given function in tabular form and then define domain and range of the function. Even though the question given in the tabular form clearly indicates x and y as independent variables and z as a dependent variable in the given function, majority of the students could not understand the given questions, and were not able to define domain and range properly. Moreover, those students who answered the question properly have difficulties of justifying their answers. This difficulty might be due to lack of understanding of the tabular representation of the given function. Sajika (2003) states that if students are always introduced to a function as equation they have a difficulty to understand a function given in tabular or graphical form. Similarly, Metcalf (2007) suggests it is better to let students use various representations of function so that they can understand the concept.

Moreover, Carlson (1997) states that if students can be able to interpret features of a function from different representations and understand formal definitions, then they have deep conceptual understanding. This study reveals that students have difficulty to understand the given function in tabular form and poor conceptual understanding on concepts of domain and range of a function of two variables. Thus, majority of them could be categorized under action conception as per proposed genetic decomposition. The gap in using various representations might roll from the way they studies prior courses which needs further investigation.

Only few students were able to extend concepts of a function of a single variable to a function of two variables and chose a correct answer from the given alternatives. Regardless of their correct answer, except few students representing domain as $Df = \{(x, y) : (x, y) \in \mathbb{R}^2\}$ and range as $Rf \subseteq \mathbb{R}$, majority of them were not able to justify their answer. As excerpt, the researchers presented some of the responses to define domain as:

- *a subset of a set ordered pairs* (respondents M1S1, M2S3, GS4 and TS5)
- *a point at which the given function is defined* (respondents M2S8)
- *a set represented by variables x and y* (respondents M1S10, and GS11).

And, range as

- a *value represented by the variable* $z = f(x, y)$ (respondents M1S14, M2S3 and GS11)
- *the value of f* (respondents TS29)

Literally, all the definitions given seem to be correct. But, students were not able to represent their justification in various ways. The representations could be table, diagram, equation, and verbal description (Metcalf, 2007; Rockswold, 2010). The data reveal that students were at mild stage to represent a given function in different forms and also were weak to represent domain and range of the given function in an appropriate form using either algebraically or graphically. Thus, this study shows that students were demonstrating difficulties on using appropriate representation for different functions and transfer between the representations with relative ease (Dubinsky & Harel, 1992; Eisenberg & Dreyfus, 1994; Metcalf, 2007).

The reasoning in the pre-test in general shows that, students had difficulty in defining domain and range of a function of two variables, extending concept of a domain and a range of a function of a single variable to a function of several variables, and symbolically representing domain and range of a function of two variables. These results go in line with studies conducted by Akkus, Hand & Seymour (2008); Carlson, Oehrtman & Engelke (2010), and Davis (2007) that reveal that students had great difficulty of connecting various representations of functions including equations graphs, tables and word forms.

After intervention was given to the students, interviews were conducted to collect a thick data from the respondents. The researchers observed that there were students who continued to define a domain and a range of a function of two variables either in the same way as before or in another form, but wrongly. When they were provided the function $f(x, y) = \frac{xy}{x+y}$ and asked to define domain and range some students were defining domain in the same way as that of a function of a single variable. For instance, M1S1, and TS8 defined domain as "*the set of all real numbers except at a point* $x = -y$". M1S3, M2S4, GS9 & TS12 defined domain as "*the set of points at which the given function is defined*". Here, the students' conceptions were either wrong or not far from that of a function of single variable. They tried to define domain of a function of two variables within the set of real number which indicates that there is a misconception on concepts of domain of the given function, at least were not able to differentiate a subset of the set of real numbers and that of a region in the Cartesian plane. For example, conceptions of M1S1 and TS8 on domain are associated with a set of real number rather than a set of ordered pairs in the given surface. On top of this, others tried to define domain as a set of points which makes the given function defined but they failed to prove understanding when they justify it symbolically as if the ordered pairs are element of real number.

There were also some students who defined domain as:

- *x-intercept*(respondent, M1S2)
- *a set of ordered pairs*(respondent, GS10)
- *a set containing x and y* (respondent, GS11)
- *a number at which the given function is undefined*(respondent, M2S5) and
- *a subset of a set of an ordered pairs at which the given function is defined* (respondent, M2S6)

Moreover, students were defining range of the given function as:

- *the set of all real numbers* (respondents, M1S1, M1S3, TS8 and TS12)
- *y-intercept*(respondent, M1S2)
- *all values of x that make the function greater than zero*(respondent, M2S4)
- *the value that we get when we substitute domain within the given function*(respondents, M2S5, GS9, GS10)
- *the output of f* (respondents, M2S6, TS7)
- *all values of x that make the function different from zero*(respondent, GS11)

These data clearly show that students were demonstrating difficulty on understanding the nature of a given function even after intervention was given to them. They were defining domain and range of a given function almost in the same way as before. This indicates that there is no change of schema observed on students' conception particularly on Textile Engineering (i.e. students exposed to traditional lecture method) whereas other students from Mechanical Engineering group two (students learnt through MATLAB supported learning in combination with Collaborative method) and Garment Engineering (students learnt through Collaborative method only) were defining domain correctly even those who had a priory misconceptions. The data also reveal that students' difficulty of understanding a given function was not dependent on the way the function was presented to them. Because, in pre-test a function of two variables was given to the students in a tabular form, whereas during interview students were probed using an equation form but still there is a problem of understanding the given function and the respondents were unable to define domain and range of a function of two variables correctly.

It is possible to consider M2S5 who represented domain symbolically as$Df = \{(x, y) : (x, y) \in \mathbb{R}^2\}$ which was correct. But, his definition as presented above states that domain is a number at which the given function becomes undefined is not correct. Such numbers could be considered as a restriction that we have to exclude them from the domain. Similarly, M1S2 was defining domain and range of the given function through connecting it with the concept of intercept which could be considered as a wrong conception.

Moreover, out of the 12 students interviewed after intervention only three of them (i.e. M1S3, M2S6 and GS9) showed a process conception on domain and range of a function of two variables. All of them defined and clearly represented domain and range of a function of two variables. Their responses show that they have interiorized the actions described in the genetic decomposition throughout questions given to them. At this level students clearly identify that domain of the given function is the set of ordered pairs written in the form of $Df = \{(x, y) : (x, y) \in \mathbb{R}^2\}$at which the given function is defined, whereas range is an output of the given function and represented as $Rf \subseteq \mathbb{R}$. This is the basic difference represented between action conception and process conception. Here, they have interiorized the actions of finding all elements in the domain of the given function. This indicates that the respondents clearly understood the concept of a function of two variables, the nature of the function, and how to write domain and range of the function. Thus, they can be categorized under a process conception. This agrees with the results of Trigueros and Martinez-Planell (2007, 2010, and 2011) who indicate that those of students who had difficulties of representing ordered pairs on two dimensional space, treatment and conversion between different representations can be categorized under process conception.

Gaisman and Martinez-Planell (2010) state that at process level students had difficulty with some coordination of processes which seem to be important in the construction of an object conception. It is true that, all of them could not convert algebraic or symbolic representation in to graphical representation, or coordination of schemata for set, function and $\mathbb{R}^3$. Most of these difficulties showed that students were unable to develop $\mathbb{R}^2$ schema. In spite of the difficulties, all students attempted to determine domain and range of the given function, however. They also indicated that each pair of numbers goes to real numbers which is the range of the given function. This implies that it was expected to construct the processes involved in the conversion. This result is in agreement with the work of Duval (2006) who claims that students who had difficulty of transforming representations that happens within representation register were categorized under the process level of conception. Thus, this result shows that few of the respondents were categorized under the process conception after interventions except in the comparison group. This shows that the intervention has supported students improve their level of conception, but not to the highest level.

It was also revealed that none of the students arrived at object conception and schema conception. In order to arrive at schema conception students need to demonstrate action, process and object conceptions. This shows that students did not develop a new schema for a function of two variables in general, and a domain and a range of a function of several variables in particular. They were not that strong in algebraic representation and graphical representations, including treatments and conversion. This result agrees with the research result of Kerrigan (2015) and Martinez-Planell&Gaisman (2009) who revealed that majority of the students in their study had difficulty in describing the domain and range of functions of two variables and some of them had no clear idea of elements in the domain and type of function they are doing with. They also added that some of the respondents have no idea about the nature and type of functions they are talking about.

The result also reveals that students who learnt using MATLAB supported learning in combination with collaborative method improved students' level of conceptual understanding than that of other instructional approaches considered in this study. Literature indicates that supporting instructional method with educational software gives a privilege of learning how to learn through constructing their own understanding, and make the classroom environment attractive, interactive, and active as a cosmetic of teaching and learning process (Eyasu, Kassa & Mulugeta, 2013).

The result of this study also agrees with a research conducted by Gaisman and Martinez-Planell (2014) who indicated in their research that students had difficulty in transforming algebraic or symbolic representations to graphical representation, and vice versa. In this study, students were given both pre-test reasoning and post intervention interview form of questions. In both cases, students demonstrated difficulty to transform tabular to graphical and also algebraic representations into graphical forms. On top of these, Dubinsky & Harel (1992), Eisenberg & Dreyfus (1994) and Metcalf (2007) claim that if students understand the given concept, then they can be able to represent it in multiple ways like using appropriate symbolic representation, algebraic expression, graphical representation and transfer between the representations. Similarly, studies conducted by Drlik (2015) and Martinez-Planell&Gaisman (2009) show that students were demonstrating difficulty to connect the information given through table and in equation form. Hence, students had difficulty to represent a given concept in different ways even though they were exposed to different instructional approaches.

All difficulties mentioned in this study are related to the coordination of students' schema for $\mathbb{R}^2$ and that of a function of several variables. They had difficulty to write a domain and a range of a function of several variables analytically or graphically. They cannot consider sets of ordered pairs in the plane as possible domains of functions of several variables. They also had problem ofdetermining range using the domain of the function. In relation to range of a function, most students had difficulty of interiorization of an action needed to find values of functions into the process. Very few of students achieved a process conception and none of the students arrived at an object level. This result was in agreement with the result of Kashefi, Ismail &Yusof (2010) and Martinez-Planell & Gaisman (2009) that shows students had difficulty in understanding domain and range of functions of several variables.

Conclusion

This study shown that students' conception of domain and range of functions of several variables were not different from that of a function of a single variable except some group of the students who learnt through MATLAB supported learning in combination with collaborative method and collaborative learning method only. These groups got a chance to discuss with each other and were able to see the nature of the function through visualization and peer-support. The difficulties of the students in finding and describing domain and range of a function of two variables could be due to weak coordination between the schema of $\mathbb{R}^2$ and that of a function of a single variable. It seems that generalization is straight forward in an incremental learning such as one dimensional into two dimensional schemata, but for most of the students this does not work in the case of a function of two variables. Most of the students were not able to transcend the various forms of representations of functions of one variable into functions of two variables. The result shows that majority of students were not able to interiorize the notion of a function of two variables into a higher schema even those students who learnt through MATLAB supported learning in combination with collaborative learning method. All these convict that the instructional approaches did not help students to reach at the higher schemata, albeit moderate shift from action to process.

Recommendations

This study reveals that there is no as such a significant difference on students' conceptual understanding between students who learnt through anyone of the instructional approaches in learning a domain and a range of a function of two variables. This might be due to lack of students' exposure to such method of instruction or students were novice to instructional technology specifically MATLAB software. Thus, this needs further study.

Acknowledgements or Notes

Please provide acknowledgements or notes in a separate section at the end of the article before the references.

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The Eurasia Proceedings of
Educational & Social Sciences (EPESS)
ISSN: 2587-1730

The Eurasia Proceedings of Educational & Social Sciences (EPESS), 2020

Volume 16, Pages 29-37

ICEMST 2020: International Conference on Education in Mathematics, Science and Technology

Improve the Effectiveness of Mathematics Learning by Motivating Students

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Abstract: A lot of students have learning difficulties in mathematics because of both practical and emotional problems. All mathematics teachers have a challenge how help to students to solve this problem in learning mathematics. The aim of the research was, to give an answer to this question. If not a student ready to learn any subject in mentally, he or she can't go further through the subject. No matter what is the subject or how many we use teaching or learning techniques. Therefore, students first should be ready to learn in mind. We can do it through the motivation. The research was based on this concept and it had been doing for 5 years, from 2014 to 2018. The targeted group was the students of grade 11 at T/Trincomalee Girls' High School, Trincomalee, Sri Lanka. This paper describes the most important activity in achieving the success of mathematics learning is, motivating students in every activity.

Keywords: Mathematics learning, Students, Motivation

Introduction

Mathematics is the ancestor and the foundation of almost all subjects. Cockcroft writes "It would be very difficult – perhaps impossible – to live a normal life in very many parts of the world in the twentieth century without making use of mathematics of some kind". We have to correct Cockcroft as "It is impossible to live a normal life without making use of mathematics of some kind in 21st century". There is also impossible thinking of the development of science and technology without mathematics. However, the difficulty of learning mathematics is a common problem for students in both of centuries. If mathematics be the foundation of almost all subjects, why do more students hate mathematics? Mathematics teachers use a lack of mathematics learning processes too. But why do more students failure in learning mathematics. How we can stop students getting bored in learning mathematics? It is essential that innovative teaching in mathematics and more researches to develop the skills of teaching and learning mathematics.

When we consider mathematics education in the world, mathematics instructions differ from country to country. Stigler, J.W. and Hiebert, J. had been working for more than 10 years about that. According to them, teaching methods in Japan differed markedly from what they observed in all of the other countries. Japanese students, for example, spent an average of 15 minutes working on each mathematics problem during the lesson, in part because students often were asked to develop their own solution procedures for problems that they had not seen before. The researchers emphasized the importance of spending time engage in the serious study of mathematical concepts instead of spending more in practicing procedures. Hong Kong and Japan were the highest-achieving countries. In both countries, the majority of making connections problems are implemented as making connections problems; a much smaller percentage are transformed into lower-level using procedure problems. Programme for International Study Assessment (PISA) - 2015, Singapore became the first of the mathematics score. Hong Kong, Macau and Japan get second, third, and fourth places respectively among 72 countries. About the mathematics education in Sri Lanka will be discussed briefly later.

The rest of the paper is organized as follows:

The first sub-section discusses varied research activities which have done in mathematics teaching and learning. Mathematics education in Sri Lanka is described in the second sub-section. The methodology is presented in

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section 2 with describing the research participants and the research design in sub-sections. The section 3 presents the results and analysis. The research is concluded by the section 4.

Related Work

Prof. Michael T. Battista who focuses research on how students' knowledge of and fluency with mathematics develops, and how teachers understand and use research-based learning progressions discusses how engage students in meaningful mathematics learning. Yuanita, P. et al. discuss about identifying the role of mathematics representation as a mediator between mathematical belief and problem solving. They say that the Realistic Mathematics Education (RME) approach successfully increased the arithmetic problem-solving ability of students. According to their research, students who were taught using RME approach had higher mathematical belief than students who were exposed to the traditional method. Krainer, K. says "the growth of mathematics education as a scientific field can be regarded as a continuous process of having a deeper and deeper understanding of the complexity of learning and teaching". Kusmaryano, I. describes the importance of mathematical power to improve student's achievement in mathematics learning. The learning process in the classroom more focused on students' ability to memorize information. The ability to think is not developed by a learning process. Teledahl, A. examines that students' writing in school mathematics and the various understandings of the relationship between students' written communication and their achievements. Sidabutar, R. has done a research to investigate the effect of various, innovated teaching models to improve the student's achievement in various topics in mathematics. Student's achievement in the teaching of mathematics with the aid of contextual was found higher the teaching the same topic by using conventional methods. Student's achievement with another innovated teaching method by using of web for the teaching distillation was found higher than that with the conventional method. A related research to our research has done by Abramovich, S. et al. They show that the approach in mathematics education based on action learning in conjunction with the natural motivation stemming from common sense is effective. Also stimulating questions, computer analysis (internet search included) and classical famous problems are important motivating tools in mathematics, which are particularly beneficial in the framework of action learning. The main concluding message of their research is that by repeatedly utilizing concept motivation and action learning at all levels of mathematics education, overall student success has great potential to improve. The ability of problem solving is very important in mathematics. Eviyanti, C.Y., et al.say that the ability of problem solving in mathematics can be improved by the problem-based learning model. According their study, the increase in mathematical problem solving ability of students who received application of problem-based learning model is better than students who received conventional learning the material opportunities.

Mathematics Education in Sri Lanka

It is a common problem in Sri Lanka that students having low marks for mathematics comparing other subjects. There are two important public certificate examinations in Sri Lanka. One of these examinations is, the General Certificate of Education (Ordinary Level) examination. This examination is based on the Cambridge University Ordinary Level qualification. The other one is the General Certificate of Education (Advanced Level) examination. The G.C.E. (A/L) examination is based on the Cambridge University Advanced Level qualification. Students have to face 9 subjects for the G.C.E. (O/L) examination. They must pass at least 5 subjects with 3 credits to qualify for the G.C.E. (A/L). But, students can't sit for the G.C.E. (A/L) examination without pass G.C.E. (O/L) mathematics.

Table 1. G.C.E. (O/L) Examination – Sri Lanka- Performances of School Candidates (1st attempt) -from 2014 to 2017-

Year	2014	2015	2016	2017
Number of candidates sat for the G.C.E. (O/L) examination (5 or more subjects)	257,322	273,224	286,251	296,812
Qualified for the G.C.E. (A/L)	177,612	189,428	200208	216,815
The G.C.E. (A/L) qualified percentage	69.02%	69.33%	69.94%	73.05%

(Source: Results reports of Department of Examinations, Sri Lanka)

Table 2. G.C.E. (O/L) Examination- Sri Lanka – Mathematics Performance of School Candidates (1st attempt) - from 2014 to 2017-

Year	2014	2015	2016	2017
Number of students sat for the mathematics paper	256,800	272,723	285,537	296,205
Number of pass students	145,602	150,481	179,358	199,173
Pass percentage	56.70%	55.18%	62.81%	67.24%

(Source: Results reports of Department of Examinations, Sri Lanka)

In 2018, 235,373 of candidates qualified for the G.C.E. (A/L). The percentage of qualified candidates for the G.C.E. (A/L) was 71.66%.

Here we consider the G.C.E. (O/L) performances in Trincomalee district, Sri Lanka, because of the research was based on a school situated in Trincomalee. Trincomalee is the capital city of Eastern province, Sri Lanka. The city was severely affected for 30 years by the civil war. The nation of Trincomalee started to enter to the normal life since 2009, after the civil war. During the war, the education had been broken down. In this situation it is not effectiveness talking about mathematics teaching or mathematics learning.

According to the G.C.E. (O/L) results analyzing report of Department of Examination, Sri Lanka , Trincomalee district got 24th , 23rd and 25th places for performance of school candidates who qualified for G.C.E. (A/L) in 2016, 2017 and 2018 years respectively, among 25 districts of Sri Lanka. It manifests that the education in Trincomalee has to be more developed.

The G.C.E. (O/L) performances of school candidates (1st attempt) in Trincomalee district are described in the table 3.

Table 3. G.C.E. (O/L) Examination Performances of School Candidates (1st attempt) –Trincomalee District- -from 2014 to 2018-

Year	2014	2015	2016	2017
Number of candidates sat for the G.C.E. (O/L) examination (5 or more subjects)	4968	5653	5832	6065
Qualified for the G.C.E. (A/L)	3139	3199	3309	3858
G.C.E. (A/L) qualified percentage	63.18%	56.59%	56.74%	63.61%

(Source: Results reports of Department of Examinations, Sri Lanka)

4724 of candidates qualified for the G.C.E. (A/L), in 2018. The percentage was 53.17%.

Method

If not a student ready to learn any subject in mentally, he or she can't go further through the subject. No matter what is the subject or how many we use teaching or learning methods. Therefore, first should be ready to learn in mind. We can do it through the motivation. The research was based on this concept.

Participants

The research based on Trincomalee Girls' High School, Trincomalee, Sri Lanka and was started after 5 years of the ending of the civil war, in April, 2014. The grade 11 students of Trincomalee Girls' High School were the first targeted group. There were 12 students in the class. They had to sit for one of the national examinations of Sri Lanka, G.C.E. (General Certificate of Education) Ordinary Level examination. The G.C.E. (O/L) mathematics pass percentage was 50% , in 2013. There was a big challenge to increase G.C.E. (O/L) mathematics pass percentage up to 50% within 7 months, because of the examination holds on December, in every year.

Research Design

First, we discussed about the research with Mrs. Jayanthi Ranasinghe who was the principal of Trincomalee Girls' High School in 2014. She satisfied with the methodology and organized a parents meeting of the grade 11 students. We discussed with them about the research. But, they had no any idea about the research. They said that they only want to pass their children in G.C.E. (O/L) mathematics.

In the first day, lots of students had given up before started the mathematics lesson. They did not engage with the lesson. They were afraid of mathematics. Therefore, the first lesson was not about mathematics. It was about some people such as scientists, sportsmen, soldiers who had accomplished their goals with many difficulties.
From the second day, we started from the basic mathematics such as addition, subtraction, multiplication and division of the all types of numbers. The reason to start the research with the basic mathematics, it is very familiar to students. After these lessons, the students understood that they know something in mathematics. That step was the foundation of the research because of there was a reason to start motivation. "Look, you know mathematics. So, why do you afraid of mathematics? If you know these basic things of mathematics, you can get a good result easily for mathematics in the examination." were the first sentences of our motivation programme. After learning of basic mathematics, the students were exhorted to study the mathematics lessons which are targeted the G.C.E. (O/L) examination, by themselves. The teacher acted only as a facilitator. However, we had only 40 minutes for a day. Therefore extra classes were held after the school time. We tried with only few sentences. "You did it. Please go ahead." After 4 months, almost all students were very active in mathematics learning. Almost all participated to extra mathematics classes. Sometimes they had organized extra mathematics classes! If someone was success in learning, then she also acted as a facilitator for other students. This caused the G.C.E. (O/L) mathematics pass rate had increased to 75% in 2014.

Results and Discussion

Table 4. Comparison of G.C.E. (O/L) Mathematics Results in 2014with G.C.E. (O/L) Mathematics Results in 2013- Trincomalee Girls' High School

Year	**No of students sat for the G.C.E. (O/L) examination**	**Grades**					**Pass Percentage**
		A	**B**	**C**	**S**	**W**	
2013	6	1	-	-	2	3	50%
2014	12	1	2	3	3	3	75%

$$75\ marks \le A,\quad 65\ marks \le B < 75\ marks,\quad 55\ marks \le C < 65\ marks,$$
$$35\ marks \le S < 55\ marks,\quad W < 35\ marks\ (failure\ in\ mathematics\ paper)$$

There was no test control group. The success of the research was measured only by comparing the previous G.C.E. (O/L) mathematics results.

Because of the success of the research, it was preceded for next 4 years.

The programme was started again, since December 2014, for 2015 G.C.E. (O/L) batch. The students were motivated daily. Sometimes, only one sentence such as "wow, better solving than yesterday" was sufficient to achieve their mathematical goals. Almost all students were very active in solving mathematical problems related to geometry. Finally, the G.C.E. (O/L) mathematics results were increased to 78.2% in 2015. 65.2% of students had got above 54 marks for mathematics. (See the Table 5).

The programme was continued to 2016 batch with a new idea. Ten of the parents of grade 11 students were also motivated. Parents meetings were organized twice for a month. The results were, those parents had made a better environment to their children at the home and they also started to motivate their children. "Yes, you can", "You will pass the examination very well". The results were very amazing. The pass percentage decreases to 71.9%. But, every 1 of 3 students had got an "A" pass for G.C.E. (O/L) mathematics. (See the Table 5 and the Figure 1).

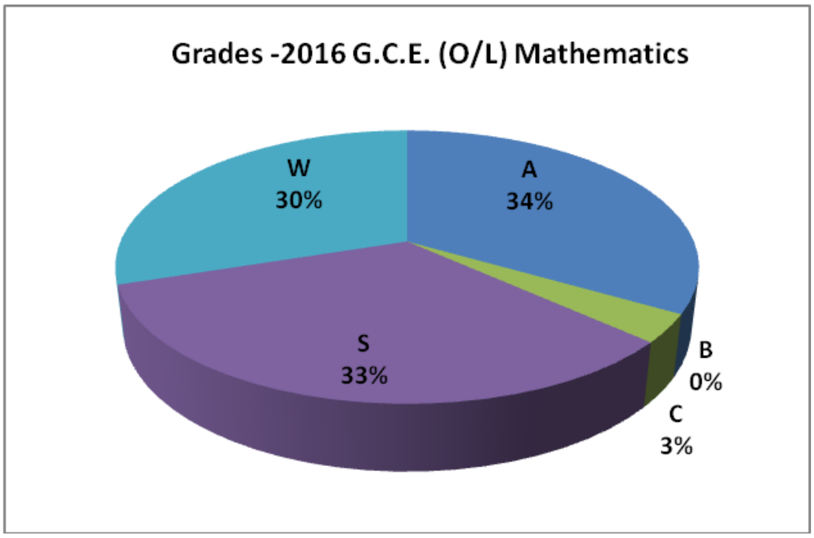

Figure 1. Grades - G.C.E.(O/L) Mathematics Results 2016 - Trincomalee Girls' High School

The research had been continued for next 2 years, 2017 and 2018 for grade 11 students who sat for the G.C.E. (O/L) examination. In 2017, all students of grade 11 and their parents were motivated. Some parents did not engage with the programme continuously. But, almost all parents engaged with the programme continuously. A mathematics seminar for the students also was organized by 2nd year engineering students at University of Peradeniya, Sri Lanka, in the last week of November 2017. The seminar had been held for 3 days. The most important thing was, the engineering students started the seminar by motivating grade 11 students as "If you exhort to get a good result for the G.C.E. (O/L) mathematics paper since now, you can do it. Don't worry about the time. The time is much enough for you. So, just try." The grade 11 students were highly motivated by these words. Finally, the G.C.E. (O/L) mathematics results increased to 80% in 2017. 53.3% of students had got above 54 marks for mathematics. (See the Table 5 and the Figure 2).

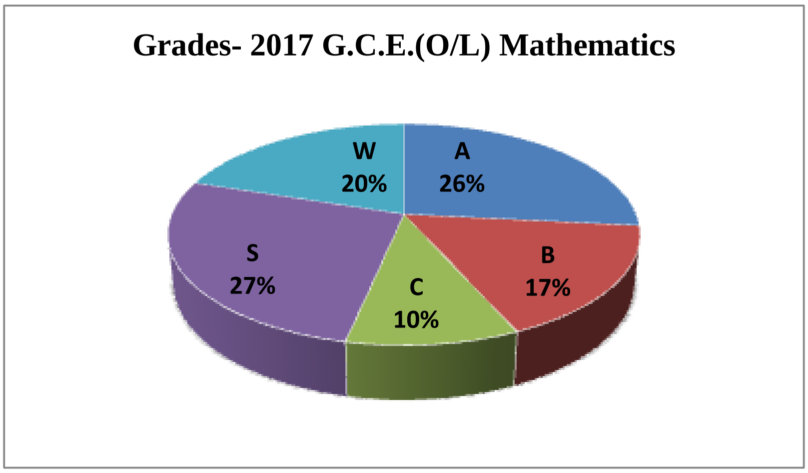

Figure 2. Grades - G.C.E.(O/L) Mathematics Results 2017 - Trincomalee Girls' High School

In 2018, mathematics lessons from basic were started with motivating grade 11students as previous years. In this year, almost all of their parents did not engage with the motivation programme. The G.C.E. (O/L) mathematics results of 2018 increased to 83.3%. But, 41.1% of students had got above 54 marks for mathematics. (See the Table 5).

Table 5. Comparison of G.C.E. (O/L) Mathematics Results from 2014 to 2018- Trincomalee Girls' High School

Year	No of students sat for the G.C.E. (O/L) examination	Grades					Pass Percentage
		A	B	C	S	W	
2014	12	1	2	3	3	3	75%
2015	23	1	4	10	3	5	78.2%
2016	32	10	-	1	12	9	71.9%
2017	30	8	5	3	8	6	80%
2018	24	3	2	5	10	4	83.3%

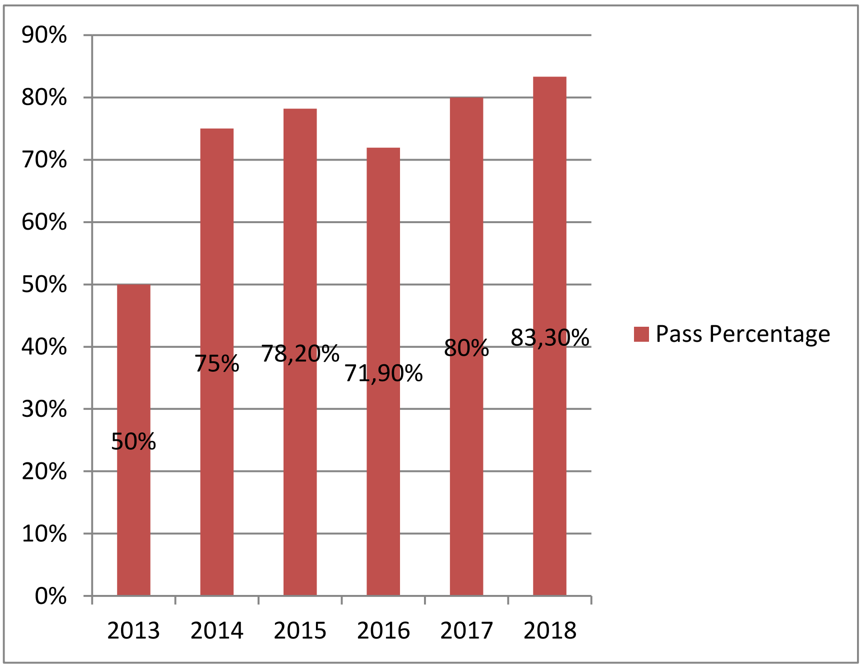

Figure 3. G.C.E. (O/L) Mathematics Pass Percentage Trincomalee Girls' High School from 2013 to 2018

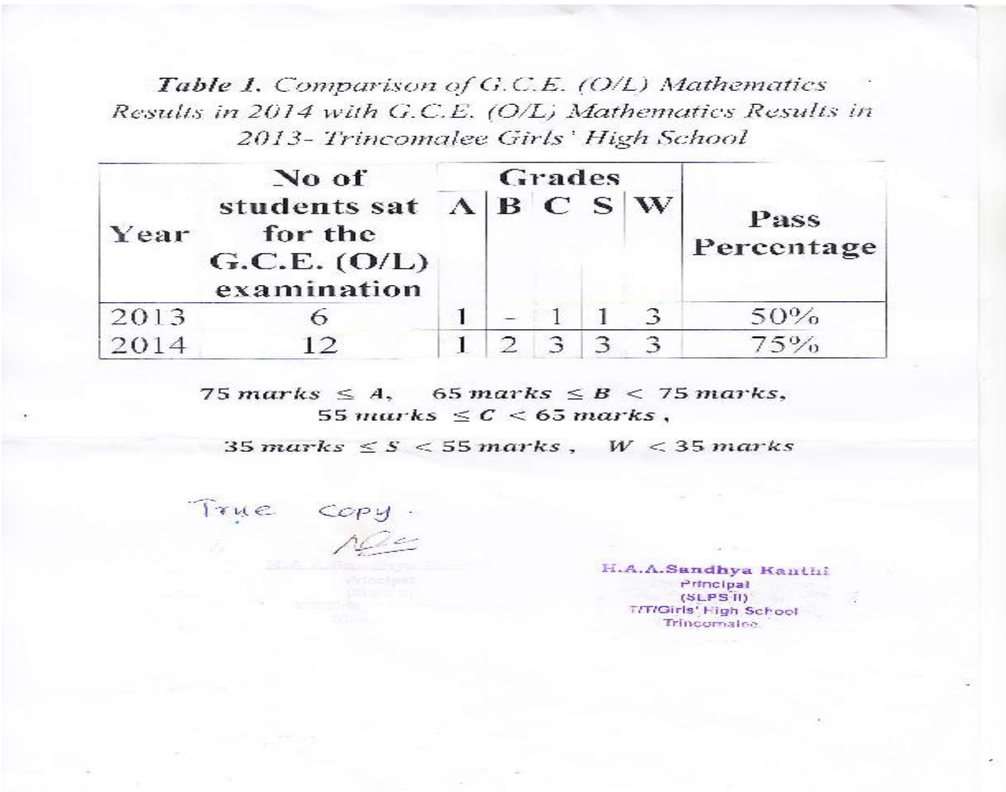

Table 1. Comparison of G.C.E. (O/L) Mathematics Results in 2014 with G.C.E. (O/L) Mathematics Results in 2013- Trincomalee Girls ' High School

Year	No of students sat for the G.C.E. (O/L) examination	Grades					Pass Percentage
		A	B	C	S	W	
2013	6	1	-	1	1	3	50%
2014	12	1	2	3	3	3	75%

$75\ marks \leq A,\quad 65\ marks \leq B < 75\ marks,$
$55\ marks \leq C < 65\ marks,$
$35\ marks \leq S < 55\ marks,\quad W < 35\ marks$

True Copy.

H.A.A.Sandhya Kanthi
Principal
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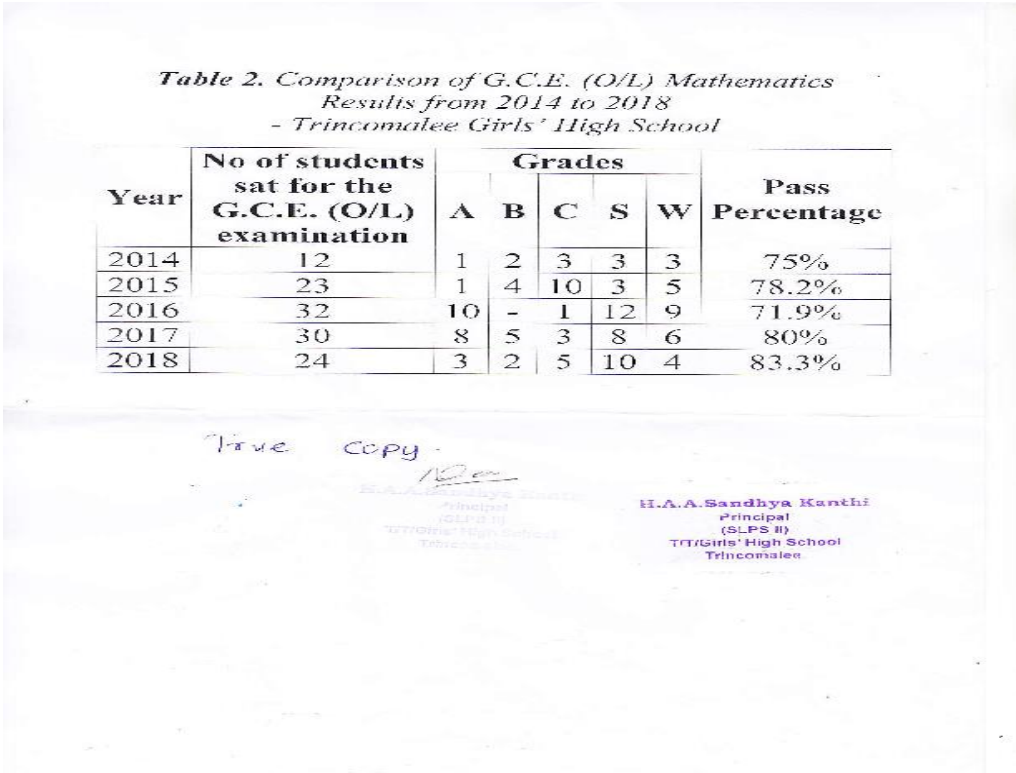
Figure 4. Certified Results by the Principal-Trincomalee Girls' High School, Trincomalee



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2016	32	10	-	1	12	9	71.9%
2017	30	8	5	3	8	6	80%
2018	24	3	2	5	10	4	83.3%

True copy.

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T/T/Girls' High School
Trincomalee

Figure 5. Certified Results by the Principal-Trincomalee Girls' High School, Trincomalee

Conclusion

The G.C.E. (O/L) mathematics results of Trincomalee Girls' High School were increased up to 83.3% within five years by motivating students. The students were not forced to do mathematics activities or were not forced on solving mathematics problems. When we motivated them, they had started to do mathematics activities and solve mathematics problems by themselves. The teacher acted only as a facilitator. Sometimes, we had to correct students carefully and respectfully in solving mathematics problems. Finally, students wanted to success in G.C.E. (O/L) mathematics paper. Therefore, they exhorted by themselves to get a better result for G.C.E. (O/L) mathematics. The foundation of the success only was motivating students. Based on the G.C.E. (O/L) results from 2014 to 2018, it can be concluded that the effectiveness of mathematics learning can be improved by motivating students.

The methodology is suitable for any student, any school or any country. We can use this methodology to improve the effectiveness in learning any subject too. The research had done with minimum facilities with no fund. If someone uses this methodology with more facilities, they can improve more the effectiveness of teaching and learning mathematics than us.

Acknowledgements

I would like to thank Mr. Mansoor, M.K.M. (Provincial Director of Education, Eastern Province, Trincomalee), Mrs. Arulanandan, J. (Zonal Director of Education, Trincomalee), Ms. Niroshani, D.M.M. (Assistant Director of Education- Mathematics & Primary, Provincial Department of Education, Eastern Province, Trincomalee), Mrs. Malani, D.H. (Assistant Director of Education, Zonal Education Office, Trincomalee).

I would like to thank Mrs. Sandya Kanthi (principal of Trincomelee Girls' High School) who provided a good background for the research programme since November 2017. I would like to express my deep gratitude to Mrs. Jayanthi Ranasinghe (Former principal, Trincomalee Girls' High School (May 2010-May 2016)) for the help and encouragements given us during the research work. She provided guidance and support that facilitated for the research programme. She also motivated us in the programme. I also thank Ms. Sriyani Padmalatha (former principal, Trincomalee Girls' High School (May 2016- November 2017)). She facilitated in continuing the research programme. I thank teachers, students and their parents at T/Trincomalee Girls' High School, who supported to success the research programme.

I would like to thank Mr. Sajun Badrajith, Ms. Enara and Ms. Yumethya for the support in organizing extra mathematics classes from 2014 to 2018.

I would also like to thank 2nd year engineering students (2017) at University of Peradeniya, Sri Lanka, for their contribution in increasing G.C.E. (O/L) mathematics results in 2017. The Engineering Students Union of Faculty of Engineering, University of Peradeniya, Sri Lanka organizes valuable seminar programmes called "Arunalla" for grade11 students who live in rural areas in Sri Lanka. Their aim is pass or grade up every student in G.C.E. (O/L) mathematics through these mathematics seminars. I would also like to thank Dr. Sandirigama, M. (Department of Computer Engineering, Faculty of Engineering, University of Peradeniya, Sri Lanka) for the support in organizing the mathematics seminar programme in 2017.

I thank Mrs. Shanthi and Mrs. Kannamma (Non-Academic Staff, T/ Trincomalee Girls' High School, Trincomalee) for their support during the research programme).

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ISRES Publishing

The Eurasia Proceedings of
Educational & Social Sciences (EPESS)
ISSN: 2587-1730

The Eurasia Proceedings of Educational & Social Sciences (EPESS), 2020

Volume 16, Pages 38-49

ICEMST 2020: International Conference on Education in Mathematics, Science and Technology

The First Model of Family Education on the Delivery of Bilingual British NCC Digital Literacy Qualifications in Dalian, China – Engaging and Motivating Children

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Abstract: It is well known that economic change in China has been both huge and rapid. Emerging children's education in technology has seen a significant challenge. As parents become more involved and busier with their work matters, their children run the risk of either being neglected to a degree of pressure that is applied on them to do better in exams, so as to "climb the social ladder" more easily. How to motivate children in technology education is an even more critical challenge. Having synthesised the relevant theories that underpin the Family Education Model, this paper reports Tulip Community Academy (China) as a social service organisation; shares its successful experience on how to undertake social responsibility to support children education in digital literacy, as well as illustrates the model using various cases including the one on how to understand data and data analysis. Tulip regulated its organisation and then achieved the accreditation awarded by British NCC Education Digi Programmes as a partner centre. The innovation began with the digital literacy delivery for 5-9 years old as well as their parents. Some of their parents are mothers who used to be teachers but have not been back to work since their childcare commitments; some are fathers who work in IT/Software industries. Tulip Family Education model consists of macro teaching technologies, whilst the micro teaching enabling better communicating to children.

Keywords: Children education, Digital literacy, Social community, ICT, Motivation

Introduction

As a social service organisation, Tulip shares the successful experience on how to undertake the social responsibility to engage and motivate children to learn by a new model of Family Education. Tulip regulated its organisation and then achieved the accreditation awarded by British NCC Education Digi Programmes (www.nccedu.com) as a partner centre based in Dalian City, China. The innovation began with the digital literacy delivery for 5-9 years old together with their parents. Some of their parents are mothers who used to be

- Selection and peer-review under responsibility of the Organizing Committee of the Conference

teachers but have not been back to work since their childcare commitments; some are fathers who work in IT/Software industries.

However, we also encounter some disadvantages of China's Family Education. It is well known that China has undertaken an enormous scale of change at astonishing speed and from many aspects. Amongst many, and sometimes challenging problems that education reform encounters (Chao, 1994; Barajas, 2011; Zhang et al, 2017; Li & Hein, 2019) is the increasing and wide spread commercialism which has been heavily influencing the national education policies, as well as overall school pedagogies and management. The model reported here tackles two such issues:

1) There are still many school traditional normative assessment systems, where the aim of teaching and learning practices are only to get children prepared to undertake the national school admission exams. This has led to flourishing commercial classes of tutorials out of schools paid by the parents (Wu, 2013 in Chinese; Zhang, 2019 in Chinese, Zhu, 2019). The expectations of parents for their children and their financial affordability to the classes drive such commercial development. Children's own interests and motivations in learning needs are, by and large, underdeveloped or even neglected (Zhou et al, 2008).
2) The relationships between schools and parents have become more complex, because the tutorial class out of school should play as a partner to facilitate the engagement with children, parents and schools (, rather than a mere medium connection that parents expect from the commercial market. In respect of digital literacy education, the national curriculums of digital literacy have not been fully developed. Whilst a massive scale of commercial courses led by AI robots coding is on sale, both schools and parents have already taken a commercial stake. All this is causing a great amount of anxiety - Parents only expect and believe what technical coding skills as sold by the commercial classes; they have been unable to realise how digital literacy will impact their children's future from many ways.

Tulip's research question is:

> How to develop a family education pedagogy engaging and motivating children between 5-9 years old in learning digital literacy?"

Method

To answer the question, Tulip has formulated a system approach to conduct a multi-method of research and development mapping the sub questions. A system approach is a way to identifying the most relevancies regarding the goal needed to be achieved; then concentrate on the relevant problem domains as a whole, rather than just studying each individual domain in isolation, i.e., "the whole is greater than the sum of its parts", so to say. The following section of literature review differentiates the problem domains that are largely associated with the use of multiple methods to enable us to investigate complex subject matter and, above all, to establish our model. As stated in (Lavrakas & Roller, 2015, p. 89)

> "Multi-method research enables the qualitative researcher to study relatively complex entities or phenomena in a way that is holistic and retains meaning. The purpose is to tackle the research objective from all the methodological sides. Rather than pigeonholing the research into a series of focus groups, or observations, the multi-method approach frees the researcher into total immersion with the subject matter."

The following section reviews the relevant literature, where we include the following problem domains and raise the rest of sub questions:

1) Action Based Research to innovate a model engaging and sustaining stakeholders, as well as Tulip' s development towards itself being a Learning Organisation.
2) Learning Centred Pedagogy to implement the curriculum, engage and motivate children.
3) Family Education and Parenting to innovate and facilitate the pedagogy.
4) Project Reflected Method to develop and sustain teacher training and other teaching resources.

Literature Review

There has been increasing research and development on social welfare agencies focusing on evidence-based interventions to help improve parenting skills; many such programmes are also developed consistently with family and client values (NASEM, 2016; CWIG, 2019). Whilst an enormous amount of literature exists in research areas of social services facilitating children's education, there is also much work found in the subject of parenting – its role in education, child wellbeing development, social policies, its relationships with schools, and its own education (e.g., Alkahtani, 2016; Daily et al, 2018). Family education generally refers to the process that parents and their adults in the family have the responsibility to educate their younger children (Liggett-Creel et al, 2017).

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Over several thousand years, China's Family Education has laid the good foundation for receiving kindergarten and school education; it is still widely believed that good family education is the catalyst to optimise children's mind; the family is the cell of the society (Sun & Huang, 2019). China's Family Education has helped in stabilizing society. We believe that we need to further enhance and sustain all the advantages of China's Family Education (Huang & Gove, 2012).

In particular, the overall exam orientated environment has driving learners to overburden their studies to prepare exams. The government has indeed realised this, i.e., such study suppresses the interest and personality of the children, limits their imagination and creativity and can even damage their physical and mental health (Zhou & Zhou, 2019). But the situation has not changed. Commercial tutorial classes are overwhelming, suggesting parents pay for their children to attend in order to get better exam outcomes (Liu, 2019 in Chinese). Parents must be guided, so as to perceive the various human value aspects of digital literacy education; so must many others who live in an environment where the distribution of educational resources is unreasonable; they cannot afford the cost of such after school classes. We agree with what Cara & Brooks (2012, p. 4) pointed that

> "[the] base for the wider benefits to parents of participating in family learning is thin … Most of the evidence came from studies of family literacy, with less from family language or numeracy, and hardly any from wider family learning. The range of benefits mentioned was multifarious, with very few covered in more than a handful of studies, even within the prior empirical work covered by the reviews."

In respect of the rapid economic development, we need to view Parenting Role in contexts of schools, learning and training centres in the commercial market; therefore, parents and their children are also viewed as stakeholders; many of these stakeholders have been surrounded by the emerging commercial environment (see the similar research: Lloyd et al, 2017). We raise the first research sub-question:

> How to enable the stakeholders to commonly focus on the human value aspect of digital literacy education v.s. what can be technically sold to the parents?

Action research method is applied. Action research is also known as Participatory Action Research (PAR), community-based study, co-operative enquiry, action science and action learning, to serve our purpose for improving the stakeholders' communications and participations from a range of different backgrounds in our digital literacy education (Constantinou & Ainscow, 2020). We adopt Action research to conduct systematic enquiries in order to improve the stakeholders' own practices, which, in turn to enable them to enhance their teaching and learning environment. We then develop a model to provide practical solutions, implementations, so as to empower stakeholders.

The human value aspects of digital literacy include skills for using, understanding and innovating digital technologies, as well as capabilities in managing ethics and empath, privacy and security, community engagement, digital health, consumer awareness, finding and verifying information, making and remixing digital content. Enabling the stakeholders to commonly focus on the human value requires, in theory, the processes of pre- and perinatal (PPN) parenting education which has been defined as "the knowledge, skills, and instructions provided to parents on how they can most effectively contribute to a problem's and later child's ... development" (Mckee et al, 2018).

Although stakeholders are perceiving the value of digital literacy education, learning from foreign advanced teaching concepts of digital literacy, is a great contrast from the current Chinese teaching concepts in particular. Here we need to address this further from two viewpoints.

Firstly, China's Family Education has its great advantages that we feel need to be enhanced and sustained. Family education generally refers to the process that parents and their adults in the family have the responsibility to educate their younger children. Therefore, China's Family Education is the starting point of educating people. Its educational goal should be to ensure the healthy development of children's body and mind before they enter the society to receive collective education (kindergarten, school education). Good family education is the catalyst to optimise children's mind. That is, the social activities that parents consciously influence their children through their own words, deeds and family life practices. Over the years, this had laid such foundation and has helped in stabilising society. However, China's Family Education is not in isolation. Here comes to the second viewpoint.

Secondly, parent are the stakeholders in school education and social education. Speaking of Chinese Family Education, most people will come up with that kind of rigid, mechanical teaching picture. When they talk about foreign education, what they think of is a relaxed, free, vivid and interesting picture.

Tulip has developed the method to establish an agreed basis for such education to be carried out, which will be presented in the next section. However, before introducing Family Education as a model to engage and motivate children, we need to raise the second research sub-question.

> How to transform the parent's mindset from China's traditional teacher led classroom view to advanced view of learning centred pedagogy?

Parenting pedagogy constitutes several research programmes for the 21st century on the topic of so called Pre- and Perinatal (PPN) parenting training, which has been defined as a teaching method by which "the knowledge, skills, and instructions are provided to parents on how they can most effectively achieve their role as parents" (Ponzetti, 2016). This includes "ways to positively contribute to a pre-born' and later child's emotional, cognitive, social, and physical development" (Ponzetti, 2016; also see McKee et al, 2018 formulated a historical overview of PPN parenting pedagogy dating from the 1300s to early 2000s).

It can be concluded, so far, that the most up to date parenting pedagogical models or programmes, e.g., the use of the National Extension Parenting Education Model (NEPEM) (DeBord, 2016), all appear to incorporate content areas of specific parenting skills; skills of care for self, guidance to understand, nurture, motivate, and advocate something, see: Collins, 2012) are still ongoing being taught by qualified parenting educators.

The current research of Tulip's team has identified:

1) There is a significant overlapped area between Tulip's expertise and empirical practices and the parenting post-birth and beyond reported in literature.
2) There is a timely and critical need for transforming parenting mindset into educational settings associating with curriculums, not just limiting the research to a framework level aligning with evolving theories.

We need to broaden such approaches to meet stakeholders' changing needs, e.g., engaging and motivating children in learning digital literacy, before any of the "best" practices can be carried out. Therefore, we have been approaching learning by applying Learning Centred or Student Participatory methodology to construct the pedagogy. In the west, a variety of constructivist and student-centred learning approaches have been widely implemented at the classroom and general social service level. On this dimension of our research, we are aiming to

1) Investigate learners in the holistic and meaningful activities that are interesting to them.
2) Follow the digital literacy curriculum.
3) Assess the learners' needs, questions, experiences and reflections.
4) Develop Scheme of Work.
5) Use Project Reflected Method to develop and sustain teacher training and other teaching resources
6) Provide or improve learning opportunities for learners.

Results and Discussion

Tulip has undertaken a system approach to enable us to use multi-methodology including Action Based Method to tackle various issues.

Re-orientate parent’s own expectations

This is on the ethical dimension of the model to re-orientate the stakeholders commonly concerned with the so called human value aspect of education, i.e., the mission of education in development of human wellbeing in the spirit of love and social community (Miovska-Spaseva, 2013). Miovska-Spaseva re-opened in the complex role of education with the pedagogical ideas of Maria Montessori, as well as her concept of education for peace as an instrument for reconstruction of the society and for improvement of human living. As discussed already, due to fact that contemporary society is distracting the education by the economic or consuming value, we found that we need to re-orientate the stakeholders before developing any suitable pedagogy.

Most of the parents in today's society look forward to their children achieving great things, which is also true in a typical family education within China. Aiming to obtain high exam scores has almost become the pillar of a child's family; parents' joys and sorrows are almost related to their children's test scores and enrollment. Many parents invite "tutors" and buy reference books for their children. Parents are even willing to suffer and suffer, with only one objective for their lives - all for their children, all for their children's learning and all for their children's scores.

There is another significant reason to re-orientate parent’s expectations. Because of China’s historical reasons, parents often put all kinds of "regrets" in the growing up process on their children with the best "hope". This means they have high expectations of their children's "success". There is nothing more concerning regarding children than their examination grades. Many parents think that as long as their children can get high marks, they will be successful. In addition to instructing the children to do exams well, they also accompany the children to participate in after school classes in their spare time, such as composition class, calligraphy class, English class, art class, and/or music class.

Tulip has developed the re-orientation programmes to establish its centres across the country. Participative parents are interested in incubating a business as a value added service to children’s education such as after school care centre, tutorial centre, nutrition, health and physical training advisory centre, children’s club, to name but few. Training "Seeding Members" with the qualification of Tulip's ethics. Seeding Members organise their group online meetings regularly via WeChat (a type of social media).

The basis for common interest shared among parents and their children has been established for the following reasons:

1) The social media groups themselves form the markets that are interesting to parents.
2) Many problems arising from the exam-driven education background are explained in cause-effective manors and shared within the group. So are the many learned lessons and problem-solving experience shared as well.
3) Guidelines for what and how can be done are clearly outlined. Parents have been following the guidelines and supervised by Seeding Members in order to carry out such professional practices.

Enabling the stakeholders to commonly focus on the human value aspect of digital literacy education v.s. what can be technically sold to the parents

On this dimension, an action based research has been undertaken to

1) Innovating a bilingual computing education with British Ofqual regulated NCC Digi qualifications for children between 5 to 9 years old.
2) Re-orientating stakeholders' learner centred pedagogy to engage with parents.
3) Involving parents in teaching and learning to engage and motivate children.

Thus, the engagement can motivate learning from three aspects:

1) Digital Literacy.
2) Linking STEAM (Science, Technology, Engineering, Arts, Mathematics) education.
3) Teaching in class involving parents as an effective extension to cross family children communication.

We refer "Digital Literacy" as (Eshet, 2004, p.2)

> "Digital literacy involves more than the mere ability to use software or operate a digital device; it includes a large variety of complex cognitive, motor, sociological, and emotional skills, which users need in order to function effectively in digital environments. The tasks required in this context include, for example, "reading" instructions from graphical displays in user interfaces; using digital reproduction to create new, meaningful materials from existing ones; constructing knowledge from a non-linear, hypertextual navigation; evaluating the quality and validity of information; and have a mature and realistic understanding of the "rules" that prevail in the cyberspace."

NCC Education, originally a division of the National Computing Centre, was first established as an IT initiative by the British Government in 1966. NCC Education started offering IT qualifications in 1976 and from 1997 developed its higher education portfolio to include Business, English language and Foundation level qualifications. In 1997, NCC Education was incorporated as an awarding body of British qualifications. We established our NCC centre at Dalian City (China) delivering Digi qualification programmes. Digi is a suite of primary and secondary school Computing programmes developed by NCC Education and launched in 2017. Our mission with Digi is to assist schools in their delivery of the English National Computing Curriculum at Key Stages 1-4.

Tulip's Seeding Members have applied the following key approach to re-orientate parents on the human value aspect of education in digital literacy.

1) Tulip's Seeding Members organise online seminars to share the emerging problems and challenges that parents have encountered under the current examination result driven education approach. The problems drive parents to realise the causes of such problems, what and why the current education systems cannot solve these problems, and therefore, by and large, limit the child development. After taking part in extra-curricular counseling, there are problems in the emotional communication between parents and children. When parents only expect their children to succeed in examinations, parents think that it is the best choice for children to go to after school's tutoring classes. Children have little spare time. Parents and students spend less time together, and therefore lack emotional communication between them. If parents don't know their children's behavior and habits, it is not conducive to assisting the teaching of teachers in school.
2) Bilingual NCC Digi curriculum can used as a tool symbolically illustrate what a modern education "looks like". Introducing a good international brand in education can indeed break the ice in the communication among stakeholders. Many institutions and after school tutorial classes also collaborate with international education curriculums. However, most of these collaborators appear to attract the elite groups aiming to enable learners to study abroad.
3) The NCC curriculum can also be used as a tool to re-orientate parents from the so called "mastery motivation" to "intrinsic motivation" which is based on "children's intrinsic tendency to interact with the environment and to continually adapt to it", because of the curriculum's different education cultural and education system background.

Transforming the parent's mindset from China's traditional teacher led classroom view to advanced view of learning centred pedagogy

After re-orientating stakeholders on the human value aspect of digital literacy, the teaching team developed bilingual Scheme of Work to design the learner centred pedagogy. We refer the term pedagogy as a range of methods such as inquiry-based, problem-based, activity-based and learning that are used to organise a class, as well as deliver a curriculum and instruct teaching. Such pedagogy is widely adopted internationally as one of the 'best practice' pedagogies.

Tulip developed the pedagogy by six elements:

1) A standard of Scheme of Work.
2) A class consists of Macro and Micro Teaching. Macro teaching manages and controls teaching underlined by digital literacy knowledge, technological notions, comprehensive uses of technologies, general practical and systematic operation procedures. Micro teaching supports learners' English learning, digital tool based practices, facilitates learners' cognitive processes and individual learning processes.
3) Scenario and picturesque enabled tools in bilingual such as word cards, digital games, activity games, quiz, videos, etc.
4) Class appraisal system.

5) Learners' class folder to enable learners to follow what need to be done on the class and what is on the next class.
6) End class feedback from the parents.

Interesting and Motivating Cases

Case A： Introducing the Concept of Data

The main objective was to enable children to have some ideas about Primary and Secondary Data based on the NCC Education syllabus. We see this as a greater challenge on:

1) it isn't something that the China's Education and Culture system would teach conventionally at a young age;
2) it is, however, an essential step to enable children to engage with data and begin to "see" data that could provide interesting information from many ways.

In addition, teaching the concepts are complex and the learning is usually very dry and boring. Tulip's model engaged children and parents with activities - assigning them to undertake a small social questionnaire research to obtain primary data. Having understood the concept of Primary Data that they collected by themselves, they were asked to consider: what happened if they need to interview many, many people? Or what would they do if they need to collect a lot more data in real time? Children and parents then bring their collected data to the class, and then use WeChat (a type of social media in China) to send the data to the teacher. The teacher then uses an Excel sheet allowing all the data collected from all the parties – this is plotted into graphs and charts. Once the collected data has been reported by individuals to the rest of the class, the teacher asks other questions - such as 'What would be the effect if a large number of people were interviewed?, or the data collected in real time?'

Case B： Stimulating Children’s Interests in Digital Technology Applied to Arts

This is also the first computing course of Tulip innovation, connecting with the STEAM education concerned worldwide. STEAM is the abbreviation of the first letter of the following interdisciplinary fields in Science, Technology, Engineering, Arts, Mathematics. The main purpose of the Tulip's project is not limiting children to participate in skill based competition in the future, but to broaden views and stimulate curiosities to Computing and Arts, Culture and Social Applications, e.g., we shall show the videos: digital virtual reproduction of world music heritage at the University of Central Lancashire, 2019; bilingual Italy returns to Chinese cultural heritage, 2019; and Jiangxi Museum 3D virtual exhibition, 2019.

Case C：Project of Social Community Digital Presentation - My Daily Life

Tulip bilingual 5-9-year-old family education computing course will enable children to design digital media reflecting "community digital presentation - my daily life”. At present, we have begun to experience the features and forms of digital information presentations, including bilingual annotation, text, color, video, film production, animation, background sound, life music, etc.

The purpose of this project is to develop a joint digital technology project with an international counterpart. Project participants are pupils from schools, learning centres or social communities, where they have been learning digital technology in the areas of Animation, Filming, Comic, Digital Image and/or Sound Recording. Tulip’s teaching centre is based in Dalian City where the programme is delivered by a unique family education approach including pupils and their mothers or fathers. Hence, to the extent of any safety concern, the project is carried out in a secure environment, because the mothers and fathers are not only our students to participate, but together with our teachers, supervise pupils in the project.

We would set up a common criteria and assessment method for the project, so as to carry out the project as a kind of formative assessment of their study programme similar to Tulip’s NCC Digital Qualification on Explorer Level. As an example, the multimedia would have to include Animation, Filming, Comic, Digital Image and Sound Recording, as well as English subtitles.

The collaboration and communication of the project would be carried out online. In addition to encouraging exchanging technical and problem-solving skills during the project development processes. Each group must exchange their multimedia presentation and integrate the two presentations together towards a “comparative and narrative” story.

Conclusion

We have reported our family education model as an effective pedagogy engaging children and parents with digital literacy education. The outcomes of this development, so far, are overwhelming from the following three aspects.

Firstly, the pedagogical engagement is not just giving to learners, but it also demands, from them, a relatively high level of communication and interaction in a class. The pedagogy must have the capacity to re-orientate the stakeholders, actively control over the curriculum, delivery content, process of learning, as well as what is learnt, and how. All this therefore must be based on the common interest of human value aspect of education, and then possibly shaped by learners’ needs, capacities and interests.

Secondly, Tulip has undertaken a system approach to adopt multi-methodologies to develop the model. Parents, schools and current after school commercial tutorial classes are stakeholders who do not have the capacities of reforming the education systems quickly enough for modern requirements. As a social service organisation, Tulip shares these successful experiences on how to undertake the social responsibility to support these children by a new model of Family Education. Tulip used system approach to identify the key problems domains in action-based method, parenting education, and learner centered pedagogy. Using an action-based method, Tulip developed Seeding Member leaderships to re-orientate parents back to the human value of education.

Thirdly, Tulip is using learner centred pedagogy and standard of Scheme of Work to stimulate or motivate the learning needs, foster the teaching methods, teaching and learning tools, as well as learning projects to actively manage and control the learning processes. Tulip has further developed the Learner-centered pedagogy from constructivist views, where the most critical task is to innovate an environment that is conducive to children's learning. Tulip regulated its organisation and then achieved the accreditation awarded by British NCC Education Digi Programmes as a partner centre. Some of their parents are mothers who used to be teachers but have not been back to work since their childcare commitments; some are fathers who work in IT/Software industries. The teaching practices are underlined by macro and micro teaching providing synergies between complex processes. Tulip Family Education model consists of macro teaching through the fathers to support teaching technologies, while the micro teaching by the mothers enabling better communication with children. The model has enabled children to

- have a earning space where they learning by doing their own activities
- have different activities available in the parenting environment
- learn from direct experiences from teachers and parents
- learn from practical experiences
- learn from explorative experiences
- learn through physically active experiences
- engage with different learning areas/activities
- learn while be indoors and outdoors.
- have parents extend children thinking by asking open (rather than closed) questions
- have parents encouraging children
- have parents monitor children's progress
- have collaborative and teach based learning opportunities

Acknowledgements or Notes

Many Tulip community members have supported the development of the model overwhelmingly. Special thanks to Mr Xun Yan and Mr Hui Liu who supported the IT system and software set up at the initial stage.

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