UNIVERSITY OF EDUCATION, WINNEBA

INVESTIGATING PRESERVICE MATHEMATICS TEACHERS PERCEPTION ON COGNITIVE NEEDS, TPACK LEVELS AND ALTRUISM

JONES APAWU

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FEBRUARY, 2019

DECLARATION

STUDENT'S DECLARATION

I, **JONES APAWU** declare that this Thesis, with the exception of quotations and references contained in published works which have all been identified and duly acknowledged, is entirely my own original work, and it has not been submitted, either in part or whole, for another Ph.D. degree elsewhere.

SIGNATURE:……………….....................…… DATE:……………………….........

SUPERVISORS' DECLARATION

We hereby declare that the preparation and presentation of this work was supervised in accordance with the guidelines for supervision of thesis as laid down by the University of Education, Winneba.

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PROF. C. A. OKPOTI (Ph.D.) **DATE**
Principal Supervisor

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PROF. ISSIFU YIDANA (Ph.D.) **DATE**
Co-Supervisor

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encouragement throughout my study.

DEDICATION

To All My Teachers,

To My Father, V. S. K. Apawu of blessed memory

To My Mother, Elizabeth Susan Abra Tawiah

To My Wife, Pascaline Diana Ahiawodzi

And To My Sons, Jayden and Jace

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ABSTRACT

This study examined the perception of preservice mathematics teachers on cognitive needs, TPACK levels and altruistic to teaching mathematics. The research design employed was the mixed methods approach specifically sequential explanation mixed methods. The population for this study was preservice mathematics teachers at the University of Education, Winneba of Ghana. The study employed the purposive sampling technique specifically homogeneous sampling technique to select level 300 mathematics teachers from the department of mathematics education of the University of Education, Winneba. In all, the level 300 students were 183. Sample size software tool was used to determine a sample size of 125 for the study. After the determination of the sample size, simple random sampling technique was used in selecting the respondents for the study. Questionnaire and interview protocol were used as instruments to collect data. Data collected through the questionnaire were analysed quantitatively and the interview data collected were analysed qualitatively. Results showed that: (i) the cognitive needs of the preservice mathematics teachers have been met to a very large extent; (ii) the perceived knowledge level of the preservice mathematics teachers on TPACK and its components were moderate and high; (iii) there were positive relationships among the components of TPACK, and all of the relationships were statistically significant; (iv) to a very large extent, the preservice mathematics teachers would have the altruistic to teach mathematics (especially core mathematics) after they have graduated (v) TPACK and its components combined related significantly to preservice mathematics teachers' altruistic to teach mathematics (AtTM) and technological content knowledge and technological knowledge were the individual predictor variables that related significantly to preservice mathematics teachers' AtTM. Recommendations were thereof made accordingly.

CHAPTER ONE

INTRODUCTION

Overview

This chapter is organised under the following headings: background, statement of the problem, rationale of the study, purpose of the study, objectives of the study, research questions, significance of the study, delimitation of the study, limitations of the study, definitions of terms and the organizational plan of the of the study.

Background

Year in, year out, the performance in mathematics (especially core mathematics) at the Senior High School (SHS) level in Ghana has been the least among the other core subjects (English Language, Integrated Science and Social Studies). For instance, it was observed in 2014 that the performance of SHS candidates in Core Mathematics had been poorer than in Integrated Science, Social Studies and English Language (Mensah, 2014). Also, Ministry of Education (MoE) (2018, p. xvii) stated that "in terms of learning outcomes, results from the West African Senior Secondary Certificate Exam (WASSCE) have been poor for both core and elective science and mathematics subjects, particularly in 2015". Similar complaints about WASSCE mathematics (especially core mathematics) results have been trumpeted by stakeholders (e.g. Parents, Civil Society Organisations (CSOs), Ministry of Education (MoE), West African Examination Council (WAEC), etc.) in education (Akaboha & Kwofie, 2016; CitiNewsRoom, 2018; Daily Graphic, 2011a; Daily Graphic, 2011b; Doozie, 2015; Ghanaian Times, 2016; Kumsah, 2017; McCarthy, Gyan, Baah-Korang, & McCarthy, 2015; Nyavor, 2014; Pulse, 2018; Yeboah, 2018). Poor performance in mathematics and science has brought down overall performance, and this trend has remained unchanged for several years (MoE, 2018). Among various reasons attributed to the poor performance in core mathematics is a poor teaching skill as claimed by the Executive Director of the National Council for Curriculum and Assessment of the Ghana Education Service (GES) (Ansah, 2016). Also, Doozie (2015) asked that Are the teachers found in our various schools up to the standards to teach mathematic? Doozie (2015) similarly asked whether the institutions (e.g. the University of Education, Winneba (UEW) that train these mathematics teachers producing the right calibre of mathematics teachers that are capable of handling especially core mathematics?

The question that comes to mind is how are the preservice mathematics teachers in Ghana prepared to teach mathematics at the SHS level? Are the preservice mathematics teachers needs met to some extent before they go out for teaching practice or before graduation? Needs are somethings that are required because they are essential or very important (Need, 2019). There are fundamental needs (e.g. content, pedagogy and technology needs) of preservice mathematics teachers that are acquired through the various courses that are taught to them. Lutz (2014) said preservice mathematics teachers have basic needs to be met in order to grasp concepts that are taught at the pre-tertiary levels. Demir (2019) also said that the more needs are met, the more preservice mathematics teachers would learn so that they can teach mathematical concepts when they find themselves on the teaching field.

According to Cooney (2019), preservice mathematics teachers are trained in diverse ways, depending to a great extent on the context in which the education occurs and the kind of courses that are offered to them. Most often, preservice mathematics teachers do not tell stakeholders (e.g. departments training preservice mathematics teachers) whether the courses they have taken have addressed their needs or not. For instance, a large number of preservice mathematics teachers in Ghana entered training via SHS and they have been taught core mathematics and some even were taught both core and elective mathematics. They should be able to tell their views about the courses offered them, whether the courses have met their needs or not. Demir (2019) was of the view that preservice mathematics teachers should be able to choose what they want to learn.

Preservice mathematics teachers could build their confidence for classroom instruction when their needs are met to some extent (Li & Kulm, 2008) and that could be ascertain when their perceived views are sought about the courses they have been taught. As put by some researchers (Bramald, Hardman, & Leat, 1995; Calderhead & Robson, 1991; Carter & Doyle, 1995; Thompson, 1992), preservice mathematics teachers entering training have pre-conceptions about teaching and about mathematics and the likes and are capable of telling whether what is been taught meet their needs. The academic achievement of preservice mathematics teachers is normally measured by grade point averages, while preservice teachers' adaptation to their new social environment is measured through such things as retention rates and graduation rates (Flaniken, 2009) and how courses address the needs of preservice mathematics teachers are normally overlooked.

Pedagogic Content Knowledge starts to build up through preservice mathematics education (Bilash, 2011). Educational institutions in Ghana are now trying to restructure their educational programmes and classroom facilities, in order to be able to integrate ICTs into the teaching and learning processes. For instance, core mathematics teachers at the SHS in Ghana are to assist students to use the calculator to enhance their understanding of numerical computation and solve real life problems (Ministry of Education, Science and Sports (MoESS), 2012). Similarly, elective mathematics teachers are to help students to make competent use of Information and Communication Technology (ICT) in problem solving and investigation of real-life situation (MoESS, 2008). Are preservice mathematics teachers trained enough to integrate technology into the teaching and learning processes when they find themselves on the teaching field?

The world continues to be highly impacted by the availability and use of technology. As knowledge about technology advances rapidly, responsibilities and opportunities are great for preservice mathematics teachers to be able to incorporate technology in the learning environment after leaving school. SHS students would like to use more technology such as mobile devices, Smartphones, Web 2.0 tools, and social networking sites to assist learning in school (Manzo, 2009); and how prepared are Ghanaian preservice mathematics teachers to guide students to use such devices?

Many developing countries like Ghana are in dire need of mathematics teachers and that better mathematics content, pedagogy and technology knowledge is often not mentioned. It is worth noting that advocacy is nothing more than a meekly drastic interpretation of a prevailing national trend. In training preservice mathematics teachers, three developments may emerge. The first is the emphasis given to preservice mathematics teachers' acquisition of pedagogical knowledge, second is acquisition of content knowledge and the third is acquisition of technological knowledge (Koehler & Mishra, 2009). Thus, it does not make good sense to make preservice mathematics teachers believe that they can make a full-scale assault on mathematics instruction without first acquiring a strong good technological, pedagogical and content knowledge when they find themselves in a mathematics classroom (Landry, 2010). Preservice mathematics teachers' acquisition of pedagogical knowledge, content knowledge and technological knowledge is very paramount during their training. The knowledge needed for preservice mathematics teachers to use technology strategically in mathematics instruction is a topic that has gained much attention (Mishra & Koehler, 2006; Niess et al., 2009). TPACK described by Mishra and Koehler (2006), "represents a thoughtful interweaving of all three key sources of knowledge – technology, pedagogy, and content" (2006, p. 14). However, previous studies have not adequately taken into account preservice mathematics teachers who one-way or the other have taken courses in the three main domains (Content, Pedagogy and Technology) of TPACK and have been trained in how to incorporate technologies into the teaching of mathematics. Besides, a review of 74 journal articles on TPACK by Chai, Koh, and Tsai (2013) revealed that studies in higher education setting should be carried out and more investigations into specific content areas such as mathematics are needed. Similarly, according to Koehler, Mishra, Kereluik, Shin, and Graham (2014, p. 109), "… there is still much to be done — particularly in the area of measuring how TPACK works in different disciplinary contexts" such as mathematics. With the review by Chai et al. (2013), the TPACK studies were conducted in North America, Europe, Mediterranean and Asia Pacific with no mention of any country from the Africa continent. It does not mean that studies on TPACK are not been undertaken in Africa. It may due to the slow pace TPACK studies are undertaken in Africa and for that matter Ghana. Most TPACK studies (e.g. Agyei & Voogt, 2012; Bowers & Stephens, 2011, Bulut, 2012, Niess, 2005) were one-shot trial of a technology interspersed with a pedagogic approach to measure preservice mathematics teachers' perceived levels on TPACK and its components.

The mathematics education department of the University of Education, Winneba (UEW) undergraduate programme train preservice mathematics teachers of which majority find themselves at the SHSs in Ghana. The department since 2003 has restructured her courses for the undergraduate programme of which how to use ICTs interspersed with pedagogies in the teaching of mathematics have been added. As of now, by level 300 before the preservice mathematics teachers leave for their internship programme, they would have taken 17 content courses, 6 pedagogy courses and 6 ICT courses from the mathematics education department albeit they would have taken other courses from the psychology education department, special education department, African studies department, etc. Some of the pedagogy courses seem to be like pedagogical content knowledge but with the wisdom of the department, they are referred to as methodology/pedagogy courses. According to Ball (1991) and Grossman (1990), Shulman (1986) is of the view that preservice mathematics teachers could develop their PK through methods courses. Shulman (1987) is of the view that PCK is not just a repertoire of multiple representations of mathematics but it is also the development of pedagogical reasoning.

How preservice mathematics teachers of UEW are trained in how to integrate ICTs into the teaching and learning processes is presented in Table 1. As mentioned earlier, the training was done through 6 ICT courses (with different technologies) interspersed with eclectic of approaches.

Table 1

How preservice mathematics teachers were trained to integrate ICTs in teaching via ICT courses

Course	Some activities
Introduction to ICT Systems and Tools for Mathematics Teachers	• In teams, student teachers were guided to develop mathematics lesson plans. • Through exposition approach, student teachers use the equation feature of Word to type mathematical entities. • Student teachers were guided to draw mathematical shapes • Student teachers use Excel to do basic manipulation of numbers as well as drawing of graphs and charts. • Student teachers in groups use Excel to implement School Base Assessment (SBA). • Student teachers were exposed to using PowerPoint in designing sophisticated slides on topics from the core mathematics syllabus. • Student teachers in groups use the Google search engine to search for relevant mathematics materials. • Student teachers were guided on how to use YouTube to look for mathematics lesson videos relevant to topics from mainly the SHS core mathematics syllabus.
Fundamentals of Computer Programming	• In group projects, student teachers use the Visual Basic (VB) Programming Language to write programmes that could solve some mathematical tasks in different areas from mainly the SHS core mathematics syllabus.
Courseware Design and Development Using Multimedia Tools	• Student teachers individually use the SnagIt software to take onscreen shots of mathematical entities. • Student teachers in teams use the advanced features of PowerPoint to design a self-directed lesson on mathematical concepts using PowerPoint.

Table 1 Continuation

Course	Some activities
Courseware Design and Development Using Multimedia Tools	• Student teachers use a plethora of software (e.g. Camtasia, CamStudio, SnagIt, Flash, Authorware, Adobe Master Collections CS3, etc.) to develop interactive software (courseware) for training, instruction, and learning on mathematics topics from especially the SHS core mathematics syllabus.
Computer Applications for Teaching and Learning Mathematics	• Student teachers through independent learning use Microsoft Mathematics Add-in to: (i) compute standard mathematical functions, such as roots and logarithms (ii) compute trigonometric functions, such as sine and cosine (iii) find derivatives and integrals, limits, and sums and products of series (iv) perform matrix operations, such as inverses, addition, and multiplication (v) perform operations on complex numbers (vi) plot 2D graphs in Cartesian and polar coordinates, and 3D graphs in Cartesian, cylindrical, and spherical coordinates (vii) solve equations and inequalities (viii) calculate statistical functions, such as mode and variance, on lists of numbers (ix) factor polynomials or integers (x) simplify or expand algebraic expressions • Student teachers via active-based approach use Excel to: (i) simulate tossing of coin and die (ii) subtract, add and multiply matrices (iii) find the inverse of matrices (iv) solve simultaneous linear equations in 2 and 3 variables (v) draw graph of functions (vi) solve linear programming problems (vii) implement numerical methods. • Student teachers in teams use GeoGebra to: (i) draw polygons and angles (ii) measuring lines (iii) construct a perpendicular bisector of a line segment (iv) construct angle bisector of an angle (v) construct a circumscribe of a triangle (vi) perform arithmetic operations (vii) expand and factorise polynomials (viii) solve equations

Table 1 Continuation

Course	Some activities
Computer Applications for Teaching and Learning Mathematics	algebraically and numerically (ix) find derivative and integral of functions (x) solve trigonometric identities (xi) construct trigonometric graphs (xii) graph inequalities (xiii) perform transformation geometry (e.g. reflection, rotation, enlargement, etc.) (xiv) find the mean, median and mode of a data set (xv) draw a histogram (xvi) find quartiles, standard deviation and variance (xvii) calculating area under a curve (xviii) perform tasks under coordinate geometry (e.g. finding the equation of a line, equation of a circle, etc.) and other mathematical stuffs. • Student teachers were exposed to how to use GNU Octave with any methodology to: (i) perform basic numeric calculations including fractions (ii) perform matrix operations (iii) solve simultaneous linear equations (iv) implement linear programming (v) perform operations on polynomials (vi) finding the roots of polynomials (v) find derivatives and integrals (vi) numerical integration (vii) perform descriptive statistics (viii) perform correlation and regression analyses etc.
Introduction to Computer Programming for Mathematics Teachers	• In groups, student teachers write Java programs to solve mathematical problems relating to especially topics from the SHS mathematics curricula
Web Technologies for Mathematics Teachers	• Student teachers through collaboration assess mathematical websites that could be suitable for their classroom discourse when they find themselves on the field. • Student teachers implement a project by designing and developing Web portals for teaching and learning using HTML, CSS, Photoshop, Flash, and JavaScript/DHTML on the Front-end, PHP as a Middleware enabler and MySQL.

From Table 1, it is imperative to measure the preservice mathematics teachers of the Department of Mathematics Education of the University of Education, Winneba perceived knowledge levels on TPACK and its components and compare them with other works that were on a technology interspersed with a teaching approach.

Preservice mathematics teachers having what it takes to teach after graduation and how to incorporate technologies into the teaching of mathematics could not impact on their will be students if the desire is not there. Having the altruistic to teach is an area where preservice mathematics teachers showcase their willingness to teach after they have graduated. As of now, research on the altruistic to teach mathematics is rare.

A review of the literature shows limited studies focusing on how preservice mathematics teachers perceived the kind of courses they have taken during training. Also, measuring preservice mathematics teachers perceived TPACK and its constituent levels for preservice mathematics teachers who went through using eclectic technologies with plethora of methods to teach mathematics topics is limited. Furthermore, having the altruistic to teach mathematics is an area that have not been well explored. This study investigated UEW preservice mathematics teachers' needs (i.e. whether the departmental courses they have taken have addressed their needs), their TPACK levels and their altruistic to teach mathematics after graduation. Finally, this study investigated how TPACK and its components relate to preservice mathematics teachers altruistic to teach mathematics (especially core mathematics).

To guide this study's investigations, Maslow's theory of hierarchy of needs (specifically the cognitive need), the Technological Pedagogical Content Knowledge (TPACK) framework by Koehler and Mishra (2006, 2008, 2009) and the altruistic theory were employed as theoretical underpinnings in addition to a developed conceptual framework.

Maslow (1954) was of the view that needs in every situation need to be met before people can function effectively. If preservice mathematics teachers' cognitive needs are not met before they graduate, then the students they would be teaching may be in trouble.

TPACK refers to the interrelationship of the three key components of effective teaching: content, pedagogy, and technology. TPACK is a framework for understanding the specialised, multi-faceted forms of knowledge required by preservice mathematics teachers to integrate technology in their teaching (Koehler & Mishra, 2009). The availability of a range of new, primarily digital technologies and the requirements for learning how to apply them to mathematics teaching have changed the nature of the mathematics classroom and as a result knowledge of technology/ICT has become an important aspect of the overall preservice mathematics teachers' knowledge (Mishra & Koehler, 2006). The TPACK framework emphasised that the knowledge and skills of the 21st century preservice mathematics teacher must intersect three fundamental areas: content knowledge, pedagogical knowledge and technological knowledge. Koehler and Mishra (2009) urged that rather than looking at each of these components (i.e. technological knowledge (TK), pedagogical knowledge (PK) and content knowledge (CK) in isolation, there is also a need to look at them in pairs: pedagogical content knowledge (PCK), technological content knowledge (TCK), technological pedagogical knowledge (TPK), and all three taken together as technological pedagogical content knowledge (TPACK). TPACK was developed to assist with the integration of technology/ICT across the curriculum and the implication is that properly prepared mathematics teachers can take advantage of the unique features of technology/ICT to teach content in ways they otherwise could not (Garofalo, Harper, So, Schirack, & Stohl, 2001). The TPACK framework was appropriate for the study because the study investigate preservice mathematics teachers perceived knowledge levels on TPACK and its dimensions.

Altruism is the willingness to do things that bring advantages to others, even if it results in disadvantage for yourself (Cambridge University Press, 2019). Being altruistic could be equated to the saying "one who is truly good winces even when seeing a tile broken" (Nivison, 1996, p. 70). With altruistic traits, preservice mathematics teachers may provide support for their learners (Bartal, Decety, & Mason, 2011) when they find themselves on the teaching field. Details of the theoretical underpinnings are explained in chapter two.

Statement of the problem

According to Demir (2019), preservice mathematics teachers are supposed to choose what they want to learn. However, it is self-evident that preservice mathematics teachers are often not allowed to give feedback on whether the courses they have taken have met their cognitive needs or not. Notwithstanding, some studies (Boyd, Grossman, Lankford, Loeb, Wyckoff, 2009; Miller & Davidson, 2006; Masters, 2009; Norton, 2010; Whitworth, 1996) found that when preservice mathematics teachers views are sought concerning the courses they have taken at a particular level, it help in the restructuring of courses and also, it would help policy makers to do some tweaking to courses that need to be reviewed. In the case of the Department of Mathematics Education of the UEW, it is only the instructors that make suggestions to the review of courses. If learners are not asked whether courses, they have taken have addressed their needs, how can those involved in course reviewing know what to add, what to subtract and how to arrange courses? It was very intriguing when an intern on teaching practice in one of the SHSs in Ghana was explaining the properties of indices to SHS learners and one of the learners asked for clarification of $(x+2)^3$ when the intern explained that $(ab)^n = a^n b^n$. The intern said $(x+2)^3 = x^3 + 2^3 = x^3 + 8$ which is not correct. Similarly, another SHS learner asked the intern the simplification of $2\left(\frac{2}{3}\right)^n$ and the explanation from the intern was that $2\left(\frac{2}{3}\right)^n = 2\left(\frac{2^n}{3^n}\right) = \frac{2^n}{2.3^n} = \frac{2^n}{6^n}$ which is not correct. Even when the learners were not convinced due to previous explanation of properties of indices, the intern tried to convince them. The lesson has to be stopped by the supervisor for further directions. Preservice mathematics teachers who do not themselves know the content well, are not likely to have the knowledge they need to help SHS students learn the content (Ball, Thames, & Phelps, 2008). It is very logical to find out preservice mathematics teachers perceived views on the courses they have taken before going for an internship programme or before they graduate.

When investigating the literature on teacher training and mathematics teacher training for that matter, it could be seen that works are generally about school performance, experiments and the likes but very less of them are about their ideas and opinions of trainees on university training programmes (Baştürk, 2011; Dursun & Kuzu, 2008; Eraslan, 2008; Eraslan, 2009; İnal & Büyükyavuz, 2013; Memduhoğlu & Topsakal, 2008; Mete, 2013; Sarıtaş, 2007; Sezgin Nartgün, 2008; Tüfekçi Aslım, 2013; Yıldırım, 2013). So, this study looked into the views of preservice mathematics teachers on the courses they have taken. Whether the courses have met their needs or not.

Often, stakeholders of education in Ghana (e.g. Parents, CSOs, MoE, WAEC, etc.) are eager to comment on WASSCE mathematics (especially SHS core mathematics) performance of students without finding out how preservice mathematics teachers are trained in relation to for instance how to integrate technologies into the teaching process. Researchers in mathematics teacher education have long been interested in the issue of educating preservice mathematics teachers to use technology/ICT in their teaching (Kaput, 1992; National Council of Teachers of Mathematics [NCTM], 2000). The Republic of Ghana ICT for Accelerated Development (ICT4AD) policy 2003 have it that Ghana's educational system should be modernised in terms of infrastructure (Republic of Ghana, 2003) and in this 21st century, it is necessary for preservice mathematics teachers to be prepared to utilise and take advantage of a 21st mathematics classroom. Advances in technology are developing at an exponential rate and it is necessary for preservice mathematics teachers to be prepared to utilize and take advantage of these advances. From the review of the literature, it was realised TPACK is concerned with bringing CK, PK and TK but previous studies have not adequately taken into account preservice mathematics teachers who are trained to integrate technologies interspersed with different methods to teach mathematical concept. What most of the previous studies have done was to pick a technological tool with an appropriate methodology in teaching a content in mathematics and after that measure TPACK levels of the participants. It appears there is a research gap and it would be expedient to carry out study on UEW preservice mathematics teachers perceived TPACK and its components levels since they have been trained semester by semester in integrating technologies with different approaches to teach mathematics concepts.

The TPACK framework describes good teaching with technology by including the components of content, pedagogy, and technology. Shulman's (1986, 1987) idea of pedagogical content knowledge (PCK) is the basis for the TPACK framework with the inclusion of the domain of educational technology/ICT. TPACK describes how knowledge of technology, content, and pedagogy interact to use technology strategically for instruction. Grandgenett (2008) describes six characteristics of preservice mathematics teachers with strong TPACK:

1. they would be open to experimentation with technological tools and trying new lessons using technology when they find themselves on the teaching field.
2. they would stay on task when teaching mathematics topics.
3. they would have clear pedagogical strategies, knowing where their students are academically, what their students need to know, and how it should be taught.
4. they would help SHS students understand why technology is important.
5. they would use technology for classroom management, for assessment, etc.
6. they would be comfortable and optimistic about changes in technology.

The TPACK framework for using technology in classroom instruction does not encourage technology as being a "stand alone" support to mathematics teacher education but as a tool specifically and uniquely applied to mathematics instruction (Landry, 2010). Not only should preservice mathematics teachers be able to integrate technology in their instruction, they should learn to use technology to transform teaching and create new opportunities for their students (Harris, 2008).

Some preservice mathematics teachers normally make up their minds not to teach after leaving school. Is it that they lack altruistic traits? Also, is it that they did not have the willingness to teach mathematics (especially core mathematics)? Besides, is it that they did not have altruistic traits?

Researchers (e.g. Batson, 1998; Bar-Tal, 1985; Bar-Tal, Sharabany, & Raviv, 1982; Eisenberg & Miller, 1987; Berkowitz, 1972; Krebs, 1970; Leeds, 1963; Smith, 2009; Staub, 1978) presenting altruistic approach arguments approve that the important features of altruism include an act performed voluntarily and intentionally with the primary goal of benefitting another person. According to Pavenkov and Rubtcova (2016), lack of altruistic traits by preservice mathematics teachers may lead to a situation whereby they will not be interested in helping their learners when they find themselves on the teaching field. Research on preservice altruistic traits is limited within the area of mathematics education. It is worth researching to find out whether preservice mathematics teachers would have the altruistic to teach mathematics (especially core mathematics) after graduation. Research works (e.g. Klisanin, 2011; Ma & Chan, 2014; Pee, 2018; Prasarnphanich & Wagner, 2009) shows that technological knowledge could lead to altruism. Similarly, studies (Laohasongkram, 2017; Marchel, 2003; Olitalia, Wijaya, Almakiyah, & Saraswati, 2013; Palta, 2019) show that pedagogical knowledge could lead to altruism. There is limited works on how TPACK and its constituents relates to teaching (especially teaching of mathematics).

This research empirically addressed the limited literature and information on preservice mathematics views on whether their cognitive needs have been met by the courses offered to them. Also, this study investigated the knowledge levels of preservice mathematics teachers on TPACK and its components. Furthermore, this study made an attempt to bring forth preservice mathematics teachers' altruistic to teach mathematics and how preservice mathematics teachers' TPACK and its components relates with their altruistic to teach mathematics literature.

Rationale of the study

In any higher institution, continual research could help in transforming courses offered by students in a particular department. The rationale of this study was premised on The UEW Act (2004) which stated inter alia:

> … ensure that practical research experience in the classroom is undertaken in the subject which are taught in the University but with special emphasis on philosophy and psychology which relate to the social, cultural, political, economic, scientific, technical, technological and other issues that exist in teaching and learning (p. 4).

In this study, UEW preservice mathematics teachers perceived: cognitive needs, TPACK levels and their altruistic to teaching mathematics (especially core mathematics) were investigated and they were in line with the UEW Act.

Purpose of the study

The purpose of this study was to use mixed methods to examine the perception of preservice mathematics teachers on: cognitive needs, TPACK levels and altruism by adapting instruments from Schmidt, Baran, Thompson, Koehler, Mishra, and Shin (2009a) and Landry (2010) in addition to self-developed items. According to Simon (2011) and Creswell (2012), some identifiers in purpose of a study include: methodology (qualitative/quantitative/mixed), participants in the study, instrument(s), etc.

Results from this study shed light on some ways UEW content, pedagogy, and ICT courses can be restructured for her preservice mathematics teachers so that their needs could be met to a large extent so that they can better teach mathematics (especially core mathematics) at the SHS level. This study also showcased preservice mathematics teachers perceived knowledge levels on TPACK and its components. Besides, this study brought forth preservice mathematics teachers perceived altruistic to teach mathematics (especially core mathematics).

Objectives of the study

The objectives that guided this study include:

1. to find out how the content, pedagogy and ICT courses addressed the cognitive needs of preservice mathematics teachers.
2. to find out the perceived knowledge level of preservice mathematics teachers in relation to technology, pedagogy, and content, as well as the combinations of these domains in the field of mathematics.
3. to find out the relationships among the perceptions of preservice mathematics teachers' TK, PK, CK, PCK, TCK, TPK and TPACK.
4. to find out whether preservice mathematics teachers have the altruistic/altruist traits to be mathematics teachers and not change their profession after graduation.
5. to find out how preservice mathematics teachers' TK, PK, CK, PCK, TCK, TPK and TPACK relate their altruistic to teach mathematics (especially core mathematics).

Research questions

The following research questions guided the study:

1. how do content, pedagogy and ICT courses address the cognitive needs of preservice mathematics teachers?
2. what are the levels of preservice mathematics teachers' perceptions on their TPACK in the field of mathematics?
3. what are the relationships among perceptions of preservice mathematics teachers' TK, PK, CK, PCK, TCK, TPK and TPACK?
4. to what extent will preservice mathematics teachers have the altruistic to teach mathematics after they have graduated (before internship)?
5. how do the following factors: TK, PK, CK, PCK, TCK, TPK and TPACK relate to preservice mathematics teachers' altruistic to teach mathematics (especially core mathematics)?

Significance of the study

According to Wilson and Cooney (2002), research suggests that preservice mathematics teachers need knowledge in technology, pedagogy and content during their coursework in order to be able to blend all the three to teach. Through this research, mathematics teacher trainers, researchers, practitioners, and those planning professional developments can ascertain the perceived cognitive needs of newly trained mathematics teachers (preservice mathematics teachers going on an internship) before they are given learners to teach. Also, this study could inform the mathematics education department of the UEW of whether to relook at the various courses offered by the undergraduate students or not. This study could also serve as the basis for a tracer study that could be undertaken by the department of mathematics education of UEW to trace her graduates (especially 2016/2017 preservice level 300 educators) to find out whether they are teaching (especially core mathematics) after graduation.

Besides, this study has added up to the perception of preservice mathematics teachers' TPACK and its constituent levels as well as the relationship among them literature. There has been TPACK research in other national contexts, but there are differences in the Ghanaian settings that has been closely examined especially taking preservice mathematics teachers who have been trained in incorporating technologies into the teaching of mathematics. Nevertheless, this study contributes not only to the Ghanaian context, but also to the international research arena and may enrich the relevant literature.

Having preservice mathematics teachers with selfless traits before they leave training could help reshape the teaching of mathematics at the SHS level. This study opened up a new chapter of the altruistic concept in relation to mathematics education. Finally, there has been an attempt to relate TPACK and its components to altruistic to teach mathematics and there is going to be a fresh perspective that would provoke research on TPACK in relation to mathematics.

Delimitation of the study

The focus of this study was to investigate UEW preservice mathematics teachers' perceived needs, TPACK levels and their altruistic to teach mathematics. This study did not involve other preservice mathematics teachers from other universities in Ghana. The choice of UEW preservice mathematics teachers was informed by the fact that they go through mathematics content, mathematics pedagogy and ICT courses and they are also taught how to integrate technologies combined with methods in teaching of mathematical concepts. Since this study was time slice, only level 300 of the 2016/2017 academic year preservice mathematics teachers took part. In terms of instruments, only questionnaire items from Schmidt et al. (2009a) and Landry (2010) instruments were adapted in addition to self-developed questionnaire items and interview protocol. The interview protocol helped in triangulation of some relevant data gathered with the questionnaire. This study was on perceptions of preservice mathematics teachers' TPACK related to mathematics and not the development of their perceptions on TPACK.

Limitations of the study

Although this study was carefully prepared, the researcher was still aware of its limitations and shortcomings. There are a lot of preservice mathematics teachers needs but this study examined only the cognitive needs. All the same, the findings concerning the three needs examined adds to other needs which may pertain in similar settings.

While the findings of this study may potentially provide the sort of evidence on the undocumented of UEW preservice mathematics teachers altruistic to teach mathematics (especially core mathematics) in particular and in the world in general, the small sample size may not be representative of all preservice mathematics teachers in Ghana concerning their altruistic to teach mathematics. Also, with the small sample size, generalizability of the findings on altruistic to teach mathematics to other preservice mathematics teachers should be cautioned. The construct, altruistic to teach mathematics (AtTM) items were somehow new. Though AtTM shows scientific reliability and validity, more studies are required before it is established that the items are acceptable to measure the construct for determining altruistic to teach (especially mathematics).

It would have been expedient to examine in-service mathematics teachers who have completed UEW so that since they are already on the field, they would have been in the best place to tell whether their cognitive needs have been met to a very large extent or not. Identifying in-service mathematics teachers in that regard was difficult and also, it is likely memory decay may set in so they may not be able to picture the courses they have taken in the department of mathematics education of UEW. Also, some of them may not fall within the period where ICT courses have been included in the curriculum and training in how to pick an appropriate technology with a methodology in teaching mathematical concepts. Furthermore, there has been curriculum review in 2012 which made it difficult to involve the in-service mathematics teachers. Notwithstanding, the preservice mathematics teachers' responses gave a clear picture of the benefits of the courses they have taken from the department of mathematics education of UEW.

Since only self-report measures were used, common method variance and response consistency effects may have biased the observed relationships. However, perceptions of the latent variables examined in this study were not objective measures. Perceptions are necessarily self-reported, such measures are the most effective at measuring these cognitions/latent variables. Therefore, this is an unavoidable criticism of the study. In addition, since the interview sessions were conducted by the researcher, it is unavoidable that in this study, certain degree of subjectivity can be found. In fact, it would have been sort of objective if it had been conducted by another person.

Definitions of terms

Civil Society Organisations (CSOs): are non-governmental, generally not-for-profit, not representing commercial interests, and pursing a common purpose for the public interest.

CSOs help shape education policies and monitor programmes, and hold governments accountable for their duty to fulfil the right to education.

Common Method Variance: is variance that is attributable to the measurement method rather than to the constructs the measures represent.

Confidence Level: is the amount of uncertainty you can tolerate.

Content Knowledge (CK): Content knowledge is "teachers' knowledge about the subject matter to be learned or taught" (Koehler & Mishra, 2009, p. 63). It is located in the mind of a teacher (Shulman, 1986). In this study, CK refers to preservice mathematics teachers' knowledge of mathematics. It also includes knowledge of major facts and concepts in mathematics. Content knowledge was measured by content knowledge dimension of perceived TPACK in relation to mathematics.

Homogeneous Sampling Technique: is a type of purposive sampling that focuses on one particular subgroup in which all the sample members are similar.

Margin of Error: is the amount of error that you can tolerate.

Multicollinearity: is the occurrence of high intercorrelations among independent/predictor variables in a multiple regression model.

Pedagogical Knowledge (PK): Pedagogical knowledge is "teachers' deep knowledge about the processes and practices or methods of teaching and learning" (Koehler & Mishra, 2009, p. 64). In this study, PK refers to the knowledge of preservice mathematics teachers related to strategies and methods of teaching and learning. Moreover, it includes knowledge in classroom management, assessment, lesson plan development, and student learning. PK dimension was assessed by pedagogical knowledge dimension of perceived TPACK in relation to mathematics.

Pedagogical Content Knowledge (PCK): Pedagogical content knowledge is the intersection of content knowledge and pedagogy knowledge (Shulman, 1986). In this study, PCK refers to preservice mathematics teachers' pedagogical knowledge about mathematics. It was assessed by pedagogical content knowledge dimension of perceived TPACK in relation to mathematics.

Perceptions on TPACK and its components: Perception is defined as the way you think about something and your idea of what it is like (Perception, 2019). In this study, perceptions on TPACK and its components refer to how preservice mathematics teachers perceive technological pedagogical content knowledge and its dimensions in relation to mathematics.

Preservice mathematics teachers: Preservice mathematics teachers refer to level 300 students who are enrolled in BSc. (Mathematics Education) undergraduate programme in the faculty of Science Education of the University of Education, Winneba.

Response Consistency Effects: are variations in responses that result from seemingly inconsequential aspects of design and administration. Susceptibility to these effects varies depending on the stability of one's beliefs. Those without a strong attitude on an issue, for instance, would be more prone to response effects than those strongly for or against the issue.

Statistically Significant: means not due to chance. That is a statistically significant result is a result that is not attributed to chance.

Technological Knowledge (TK): Technological knowledge is the knowledge about technologies which range from standard technologies such as pencil, paper to more advanced technologies such as Internet, interactive whiteboards (Schmidt et al., 2009a). In this study, TK refers to preservice mathematics teachers' knowledge about a plethora of computer technologies, and properties of these technologies, and it is measured by technological knowledge dimension of perceived TPACK in relation to mathematics.

Technological Content Knowledge (TCK): Technological content knowledge is "the knowledge of how technology can create new representations for specific content" (Schmidt et al., 2009a, p. 125). In this study, TCK is preservice mathematics teachers' knowledge concerning a lot of mathematical technologies, such as Octave, GeoGebra, Excel, PowerPoint, Word, SnagIt, Camtasia, etc. and it was measured by TCK dimension of perceived TPACK in relation to mathematics.

Technological Pedagogical Knowledge (TPK): Technological pedagogical knowledge is the intersection part of technological knowledge and pedagogical knowledge (Mishra & Koehler, 2006). In this study, TPK refers to the knowledge of how teaching and learning can change when preservice mathematics teachers use various technologies in particular ways, and it was measured by TPK dimension of perceived TPACK in relation to mathematics.

Technological Pedagogical Content Knowledge (TPACK): Technological pedagogical content knowledge is the knowledge of any topic within mathematics, which is taught with good pedagogy by using appropriate technological tools (Koehler & Mishra, 2005a). It means that TPACK is the interconnection and intersection of three knowledge types: content, pedagogy, and technology (McCormick &Thomann, 2007; Mishra & Koehler, 2006; Niess, 2005). In this study, TPACK refers to preservice mathematics teachers' knowledge regarding the interrelationship between content (mathematics), pedagogy (plethora of methods and student learning), and technology (various technologies). TPACK was assessed by technological pedagogical content knowledge dimension of perceived TPACK in relation to mathematics.

Type I error: is when the null hypothesis is true and you reject it.

Type II error: is when the null hypothesis is false and you fail to reject it.

Variance inflation factor (VIF): is a measure of the amount of multicollinearity in a set of multiple regression variables. VIF measures how much the behaviour (variance) of an independent variable is influenced, or inflated, by its interaction/correlation with the other independent variables.

The organization of the study

The study was organized in five chapters. In chapter one, the study background, statement of the problem, rationale of the study, purpose of the study, objectives of the study, research questions, significance of the study, delimitation of the study, limitations of the study, definitions of terms and the organizational plan of the of the study were presented. The relevant literature review was presented in chapter two. The researcher described the research design and methodology in chapter three. Results and discussion were done in chapter four. Chapter five consisted of summary of key findings, implications for practice, conclusion, recommendations, and areas for further research.

CHAPTER TWO

LITERATURE REVIEW

Overview

This chapter reviewed related literature relevant to this study. It involved systematic identifications, setting and analysis of documents containing information related to the research problem. This chapter made the researcher to be aware of the contributions of other researches that have been done. The gaps that were identified in the extant literature were examined in the discourse. Most of the reviews were based on international works because of the rare nature of national works relating to this study. The review was done under the following subheadings: theoretical underpinnings, appraisal of education in schools, the perceived needs of preservice mathematics teachers, the perceived knowledge level of preservice mathematics teachers in relation to TPACK and its components, research studies on preservice mathematics teachers' perceived TPACK, the relationship between TPACK and its components, preservice perceived altruistic to teach mathematics and, how TPACK and its components relate to preservice mathematics teachers' altruistic to teach mathematics.

Theoretical underpinnings

This section discussed the theoretical perspectives that undergird this study.

Maslow's theory of hierarchy of needs

Need is something that is required because it is essential or very important rather than just desirable (Need, 2020). Abraham Maslow developed the Hierarchy of Needs model in 1940-50s, and the Hierarchy of Needs theory remains valid today for understanding human training, and personal development (Businessballs, 2019). Maslow (1943, 1954) stated that people are motivated perfectly when certain needs are met. Maslow initially have a five-model hierarchy of needs (Physiological needs, Safety needs, Love and belongingness needs, Esteem needs and Self-actualization needs) and continued to refine his theory based on the concept of a hierarchy of needs over several decades (Maslow, 1943, 1962, 1987). Regarding the structure of his hierarchy, Maslow (1987) proposed that the order in the hierarchy "is not nearly as rigid" (p. 68) as he may have implied in his earlier description.

It is important to note that Maslow's (1943, 1954) five-stage model has been expanded to include cognitive and aesthetic needs (Maslow, 1970a) and later transcendence needs (Maslow, 1970b). The needs have also been segmented into deficiency needs (*D-needs*) and growth or being needs (*B-needs*) (see Figure 1). Deficiency needs arise due to deprivation and are said to encourage people when they are unmet. Growth needs continue to be felt and may even become stronger once they have been engaged.

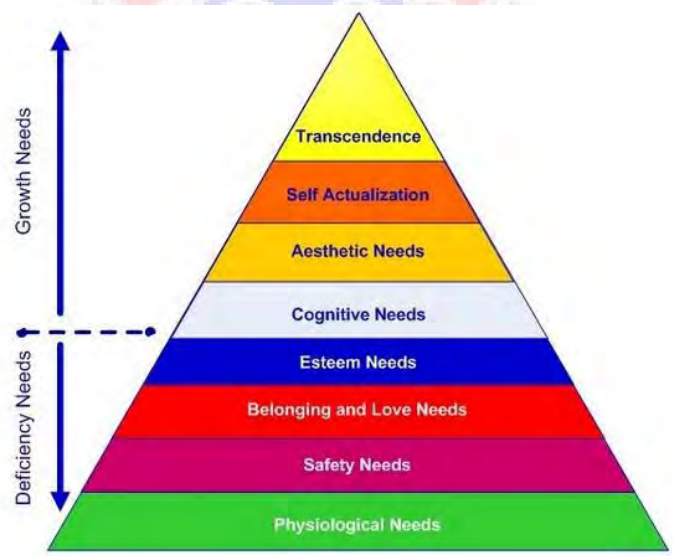

Figure 1. Maslow's Hierarchy of Needs.
Source: https://www.simplypsychology.org/maslow.html

Though Maslow's work fell out of favour with many academics, his theories are enjoying renaissance due to the rising interesting in positive psychology (Cherry, 2019). Maslow's hierarchy of needs have been applied in psychology, biology, management, marketing, education, etc. but limited in mathematics education. The explanation of Maslow's hierarchy of needs in relation to mathematics with the work of Yong (2016) in perspective is as follows:

Physiological needs: these are requirements for a preservice mathematics teachers' survival. For instance: air, food, drink, shelter, clothing, warmth, sleep, etc. If the lecture room is not conducive for a preservice mathematics teacher, the likelihood of not paying attention would be very high. Similarly, a preservice mathematics teacher may fall asleep instead of completing task because s/he did not sleep the night before, and thus sleep is the inspiring factor for his/her behaviour, rather than learning.

Safety needs: besides the need for safety from bodily harm, there are two other forms of safety to be considered in the mathematical classroom: emotional and intellectual. Preservice mathematic teachers should not be afraid of being made fun of, being criticized, etc. That kind of emotional safety is crucial for preservice mathematics teachers to be open to learning in a classroom. This is also why anti-bully campaigns are important in a mathematics classroom for preservice mathematics teachers. Preservice mathematics teacher's intellectual safety is possible when s/he feels that her/his ideas are valued by others even if they are incorrect or there is disagreement. Most crucial moments for fostering intellectual safety occur when reacting to a preservice mathematics teacher's incorrect answer or idea.

Belonging needs: there are lots of things that instructors can do to help preservice mathematics teachers feel a sense of belonging to (1) the mathematics classroom, and (2) to a larger community of practice of mathematics educators after leaving school. Some of these include:

- by learning preservice mathematics teachers' names early on, it gives them a sense that they belong in class.
- having a very lit classroom exude a sense of calm, warmth and belonging for preservice teachers.
- when you give high fives to all of your preservice teachers every day of the year, there is a stronger connection with all of them.
- an instructor's sense of humor can sometimes be a great tool for helping preservice mathematics teachers feel a sense of belonging.
- group work can lead to amazing results, but when implemented poorly it can also lead to disastrous results. When left untreated, status issues in a group of students can lead to students feeling excluded from the group.

These are just a few examples of how to build a sense of belonging in the mathematics classroom for preservice mathematics teachers.

Esteem needs: Cherry (2019) describes esteem as a need to feel appreciated… to have self-esteem and self-respect. The equivalent of esteem in the mathematics classroom is a preservice mathematics teacher's self-concept as a learner of mathematics. Every time a preservice mathematics teacher is presented with a mathematical task, that student's self-concept is activated in the form of an appraisal of her/his own abilities as a learner of mathematics based on prior achievements, comparisons with peers' abilities, and perceptions of the mathematical task at hand. That appraisal of success at the task gives the preservice mathematics teacher confidence or reluctance to take on the task. Preservice mathematics teachers with low self-concept would become disruptive or disengaged when presented with a task that they thought they would not be able to complete.

Cognitive needs: this deals with knowledge and understanding, curiosity, exploration, need for meaning and predictability. So, in relation to preservice mathematics teachers, it is getting knowledge and understanding about what courses can help them teach effectively after graduation. Maslow (1970a) believed that preservice mathematics teachers have the need to increase their intelligence and thereby chase knowledge from what they are been taught. Cognitive needs are the expression of preservice mathematics teachers need to learn, explore, discover and create to get a better understanding of mathematical concepts. Gautam (2007) states, this growth needs for self-actualization and learning, when not fulfilled leads to confusion and identity crisis within preservice mathematics teachers' mind. When preservice mathematics teachers' cognitive needs are met, they would be able to go out there and teach without any much difficulty.

Aesthetic needs: based on Maslow's (1970b) beliefs, it is stated in the hierarchy that humans need beautiful imagery or something new and aesthetically pleasing to continue up towards Self-Actualization. Humans need to refresh themselves in the presence and beauty of nature while carefully absorbing and observing their surroundings to extract the beauty that the world has to offer. This need is a higher level need to relate in a beautiful way with the environment and leads to the beautiful feeling of intimacy with nature and everything beautiful. Aesthetic needs can be related to amazing mathematical shapes, diagrams, charts, graphs, etc.

Self-actualization needs: according to Maslow (1943), self-actualization refers to the desire to accomplish everything that one can, to become the most that one can be. When one has achieved a certain level of success with mathematics, it is natural to wonder what else one can achieve and then to try to do it. One way that instructors can help Preservice mathematics teachers mathematically self-actualize is to have high (but reasonable) expectations for all of them. As an analogy, when an instructor doesn't expect a preservice mathematics teacher to do well, s/he is probably not going to expect much of himself/herself either. Self-actualization can take many forms, depending on the individual. These variations may include the quest for knowledge, understanding, peace, self-fulfillment, meaning in life, or beauty.

Transcendence: Self-actualizing people have many such peak experiences and eventually feel inspired to actively seek them, extend them and stabilize them. Hence, Maslow (1970b) added the goal of self-transcendence as the final level, the capstone of the pyramid. The desire is to go beyond our ordinary human level of consciousness and experience oneness with the greater whole, the higher truth, whatever that may be. In relation to mathematics, it is the ability to look for answers to unresolved mathematical problems.

To be able to investigate whether the courses taken by preservice mathematics have met their needs, this study was situated in the cognitive needs level of the Maslow's theory of hierarchy of needs. The cognitive needs level of Maslow's hierarchy of needs was operationalised as preservice mathematics teachers' cognitive needs (PSMTCN). The details of PSMTCN is explained in the ensuing subheading.

PSMTCN Conceptual Framework

To be able to investigate the perceived cognitive needs of preservice mathematics teachers based on the courses they have been taught, this study conceptualized PSMTCN framework base on Maslow's cognitive needs. The PSMTCN is a tripartite which encompasses content needs (CN), pedagogy needs (PN) and technology needs (TN) (see Figure 2).

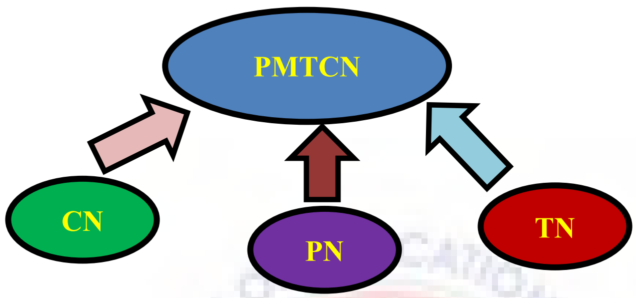

Figure 2. PSMTCN framework.

The CN was viewed in this study as preservice mathematics teachers perceived views on whether the content courses, they have taken have met their needs or not. The PN was viewed as preservice mathematics teachers perceived views on whether the pedagogy cum pedagogical content courses, they have taken have met their needs or not. The TN was viewed as preservice mathematics teachers perceived views on whether technology/ICT courses, they have taken have met their needs or not. It depends on where preservice mathematics teachers are trained and the kind of courses that will be related to CN, PN, and TN.

The CN draws on the works of Masters (2009), Miller and Davidson (2006), Norton (2010), Shulman (1987), Keith (2004), Fennema and Franke (1992), Leikin (2006) and Hill, Ball, and Schilling (2008) that content knowledge is needed in training preservice mathematics teachers. PN is necessary in training preservice mathematics teachers so that they can transmit mathematics concepts to their learners when found on the teaching field (Emerick, Hirsch, & Berry, 2003; Keith, 2004; Ma, 1999; Miller & Davidson, 2006; Shulman, 1987, 1999; Silvernam & Thomson, 2008). TN is needed for preservice mathematics teachers to be able to incorporate technologies/ICTs into the teaching of mathematics (Pacific Policy Research Center, 2010, Powers & Blubaugh, 2016)

TPACK framework

To be able to examine preservice mathematics teachers' perceived knowledge levels on TPACK and its components, the theoretical framework that underpinned this study was the TPACK framework. The TPACK framework was seen as appropriate for this study because "…even as a relatively new framework, the TPACK framework has significantly influenced theory, research, and practice in teacher education and teacher professional development" (Koehler et al., 2014, p.101) such as the training of preservice mathematics teachers. Furthermore, the TPACK framework has been widely used in teacher education researches regarding technology/ICT issues (e.g.; Niess, 2006; Özgün-Koca, Meagher, & Edwards, 2010; Polly, McGee, & Sullivan. 2010; Vacirca, 2008; Shin et al., 2009). Additionally, the TPACK framework was employed to undergird this study because of its dynamic characteristic and how researchers try different methods to measuring preservice mathematics teachers perceived knowledge levels on TPACK and its components (Karataş & Tutak, 2015). Nevertheless, TPACK has been heavily critiqued by some works (e.g. Edublogs, 2009; Edu 653, 2015; Kompa, 2018; Parr, Bellis, & Bulfin, 2013). For instance, Edublogs (2009) referred to TPACK as more teacher-centered rather than student-centered and asked where does the student fall on the diagram. Also, Kompa (2018, p. 5) is of the view that "TPACK, to state the obvious, is not a theory that can be empirically verified". Parr, Bellis, and Bulfin (2013, p. 1) are of the view that "…it is time to step back from the hype, and develop an awareness of the tensions and contradiction implicit in the TPACK model". Despite the critiquing of TPACK by some works, Koehler et al. (2014) are of the view that among other frameworks, the TPACK framework has received the most traction in research and in professional development approaches, as evidenced by over 600 journal articles about TPACK.

Most TPACK studies on measuring the perceived knowledge levels of preservice mathematics teachers did not take into account preservice mathematics teachers who have been taught how to integrate various technologies with different approaches in teaching mathematical concepts every semester. This study investigated preservice mathematics teachers who went through training every semester in using various appropriate technologies and good methods in teaching mathematical concepts.

Research suggests that preservice teachers' knowledge plays an important part in determining their actions and inactions in the classroom (Hughes, 2005). Hence, it is essential to better comprehend the altering process of preservice teachers' knowledge (Fives & Buehl, 2008) especially preservice mathematics teachers' perceived knowledge levels on TPACK and its components. Building on Shulman's (1987; 1986) idea of pedagogical content knowledge (PCK), Koehler and Mishra (2006, 2009) added technology to PCK and designed a model that they call 'technological pedagogical content knowledge' (TPACK) to refer to the interrelationship of the three key components of teaching and learning: content, pedagogy, and technology. TPACK is a framework for understanding the specialised, multi-faceted forms of knowledge required by preservice mathematics teachers to integrate technology/ICT in their teaching (Koehler & Mishra, 2006). In 2005, the term Technological Pedagogical Content Knowledge (TPCK) was introduced as a conceptual framework and in 2007, TPCK was changed to TPACK (pronounced "tee-pack") to better reflect the interdependence of the three contributing knowledge domains, and in 2008 "context" was added to the framework because it was argued that teaching with technology/ICT does not occur in seclusion but is each time located in a specific educational context (Fisser, Voogt, van Braak, & Tondeur, 2015). Since then, the TPACK framework and the accompanying Venn diagram (see Figure 3) has been embraced by many researchers and practitioners for describing the knowledge and skills that are needed for the effective integration of information and communication technologies (ICTs) in teaching (Fisser et al., 2015). According Fisser et al. (2015), it has also led to the desire to measure whether preservice mathematics teachers have sufficient TPACK.

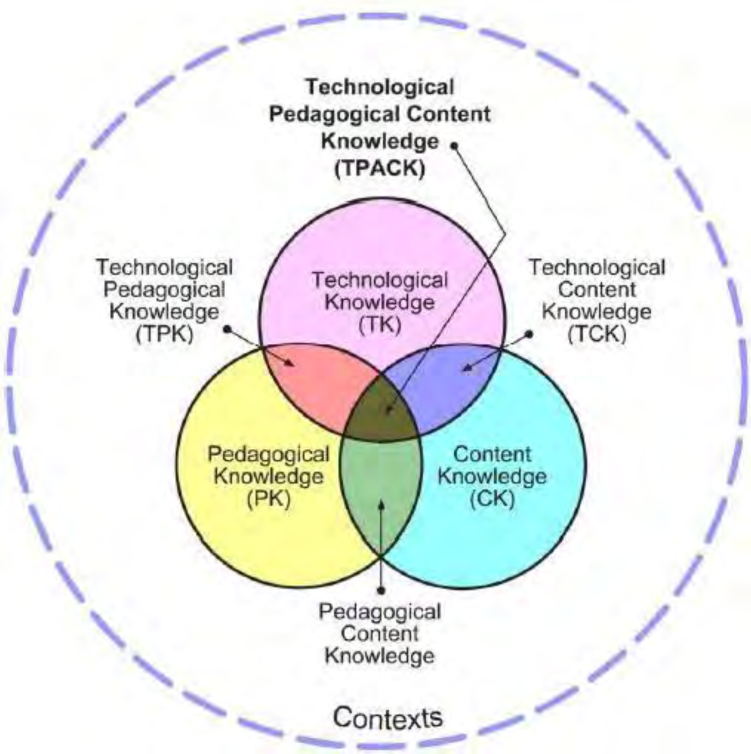

Figure 3. The TPACK framework and its knowledge components.
Source: Koehler, Mishra, Kereluik, Shin, and Graham (2014)

According to Koehler and Mishra (2006), the availability of a variety of new, mainly digital technologies and requirements for learning how to apply them to teaching have changed the nature of the classroom or have the potential to do so. Accordingly, "knowledge of technology has become an important aspect of overall teacher knowledge" (Koehler & Mishra, 2006, p. 1024). TPACK highlights that the knowledge and skills of the 21st century preservice mathematics teacher intersects three fundamental areas: content knowledge, pedagogical knowledge and technological knowledge. Koehler and Mishra (2009) urged that rather than looking at each of these components (i.e. content knowledge, pedagogical knowledge and technological knowledge) in isolation, one should also look at them in pairs: pedagogical content knowledge (PCK), technological content knowledge (TCK), technological pedagogical knowledge (TPK), and all three taken together as technological pedagogical content knowledge (TPACK) (see Figure 3). To separate the three knowledge domains constitutes a real bias regarding ICT integration in educational practice (Al-ruz & Khasawneh, 2011). Learning and teaching by means of technology takes place in an energetic operation of relationships among the three main domains of the TPACK framework (Koeler & Mishra, 2006). TPACK was developed to assist with the integration of technology across the curriculum, the implication is that properly prepared mathematics teachers can take advantage of the exclusive features of technology to teach content in ways they otherwise could not (Garofalo et al., 2001). Many TPACK studies have used the current diagrammatic demonstration of TPACK framework (see Figure 3) developed by Koehler and Mishra (2005) after over decades of ongoing research studies. As a result, the TPACK framework has been used in this study. Descriptions of the knowledge domains or components of TPACK have been explained and discussed in detail thereof.

Content Knowledge

"Content Knowledge (CK) is knowledge about the subject matter that is to be learned or taught" (Harris, Mishra, & Koehler, 2009, p. 397). According to Shulman (1986), the content knowledge is located in the mind of preservice mathematics teacher, and in the content knowledge, preservice mathematics teachers should not only be able to explain the truths of the mathematics field, but they should also be able to explain why the truths are needed and worthy to know. Content knowledge includes knowledge of major facts and concepts in mathematics (Grossman, 1990). In this present study, perceptions of preservice mathematics teachers' knowledge on mathematics have been assessed. To illustrate, in content knowledge dimension of this study, item 48, "my sufficient knowledge about mathematics is" on the scale of poor to excellent, measures respondent's perceptions related to their content knowledge.

Pedagogical Knowledge

Pedagogical Knowledge (PK) is the knowledge concerning the procedures, processes, practices, strategies, and methods of teaching and learning (Koehler & Mishra, 2005b; 2009). Goals and values of education, general classroom management skills, lesson planning, teaching and assessment strategies, and methods are involved in this knowledge (Koehler & Mishra, 2009). Morine-Dershimer and Kent (1999) claimed that pedagogical knowledge can be categorized as 'general pedagogical knowledge' and 'personal pedagogical knowledge'. Classroom communication and discourse, classroom management and organization, and instructional models and strategies affect general pedagogical knowledge; whereas personal beliefs, or perceptions, and practical experience affect personal pedagogical knowledge. Shulman (1987) states that general pedagogical knowledge includes broad principles and strategies of classroom management and organization. Moreover, according to Grossman (1990), general pedagogical knowledge includes general knowledge, beliefs and skills about teaching. Generic theories and methods of instruction, and classroom management are essential parts of general pedagogical knowledge (König, Blömeke, Paine, Schmidt, & Hsieh, 2011). In this present study, perceptions of preservice mathematics teachers' knowledge about teaching methods, assessments and selecting materials for teaching have been measured. As an example, item 35, "my knowledge of how to assess student performance in a classroom is" on the scale of poor to excellent, takes part in PK dimension of this study.

Pedagogical Content Knowledge

In Koehler and Mishra's (2005b) model, Pedagogical Content Knowledge (PCK) is similar to Shulman's (1986) idea for PCK. The blending of content and pedagogy constitutes PCK. It means that preservice mathematics teachers are able to organize particular topics, problems or issues, represent them, adapt different interests and abilities of students, and present for instruction (Shulman, 1987). Niess (2005) and Lowery (2002) define PCK in a similar way as the intersections of knowledge of subject (e.g. mathematics) and knowledge of teaching and learning (or pedagogy). PCK is a special form of knowledge, which lumps knowledge of learners, learning, and pedagogy (Ball, Lubienski, & Mewborn, 2001).

According to Ball et al. (2008), PCK includes everything about preservice mathematics teachers' knowledge in a particular topic, their actions, reasoning, and beliefs. Besides, it includes essential knowledge of teaching, learning, curriculum, assessment and reporting, pedagogical techniques, and students' prior knowledge (Koehler & Mishra, 2009). Harris et al. (2009) state that PCK also covers alternative teaching strategies in a particular discipline and common content-related misconceptions. In PCK, the knowledge of content-specific activities (or strategies) and the knowledge of representations are combined in order to facilitate student learning (Cox & Graham, 2009). In this present study, preservice mathematics teachers' perceptions related to knowledge of teaching methods, which they will use while teaching especially at the SHS level, was considered in pedagogical content knowledge dimension. In PCK part of this study, preservice mathematics teachers' knowledge on common conceptions and misconceptions about mathematics held by SHS students, their knowledge on the possible sources of these conceptions and misconceptions, the strategies that preservice mathematics teachers use to explain the key facts, concepts, principles and proofs on mathematics have been investigated. To exemplify, item 55, "my ability to select effective teaching approaches to guide student thinking and learning in mathematics is" on the scale of poor to excellent, takes part in pedagogical content knowledge dimension of this study.

Technological Knowledge

Defining technological knowledge (TK) is problematic, since it is always in a state of flux (Harris et al., 2009). However, Koehler and Mishra (2005a) state that the technology covers both modern technologies such as computers, the internet and standard technologies such as books and blackboard. The technological knowledge means knowledge about technologies which range from standard technologies such as pencil, paper to more advanced technologies such as Internet, interactive whiteboards (Schmidt et al., 2009a). Besides, it includes the skills which require operating particular technologies, knowledge of how to install and remove peripheral devices and software programs (Mishra & Koehler, 2006). Cox (2008) states that TK refers to the ability of using computer technology, manipulating programs and hardware, and producing the desired results. According to Mishra and Koehler (2006), technology can be changed or may disappear in the years to come. The only thing that matters is to have the ability of learning and adapting new technologies to mathematics education, so preservice mathematics teachers had better try to improve such skills before they graduate. In this study, technological knowledge refers to advanced technologies like software, Internet, computer and their competencies in educational knowledge. To give an example, item 43, "my ability to learn technology easily is" on the scale of poor to excellent measure respondent's perceptions related to technological knowledge dimension of this study.

Technological Content Knowledge

Technological Content Knowledge (TCK) is the knowledge that technology and content affect each other (Mishra & Kohler, 2009). TCK is also knowledge of how subject matter is altered by the technology (Koehler & Mishra, 2005a). The impact of technology on the practices and knowledge of subject matter can be understood by TCK (Koehler & Mishra, 2008). According to Mishra and Koehler (2006) preservice mathematics teachers should know not only the content but also the procedure that content can be changed by the application of technology. Cox (2008) sees TCK from a different standpoint by extending Koehler and Mishra's (2006) definition. Cox (2008) says that TCK is knowledge of the technologies which can be used in specific discipline (e.g. mathematics), and how the use of those technologies alters the subject matter for representation or generation of new concept. According to Cox (2008), TCK preservice mathematics teachers should not only integrate technology in content but also know the rationale for doing so, and they should select or transform technology in specific content. In this present research study, perceptions of preservice mathematics teachers' knowledge with technologies in mathematics have been measured. To give an example, item 51, "my knowledge about technologies that I can use for understanding and doing mathematics is" on the scale of poor to excellent measure respondent's perceptions related to technological content knowledge dimension of this study.

Technological Pedagogical Knowledge

Technological Pedagogical Knowledge (TPK) is the knowledge of how teaching and learning can change when specific technologies are used in specific ways. The intersection part of TK and PK constitutes the TPK (Koehler & Mishra, 2009). It is also defined as how to use digital tools for teaching more effectively. McCormick and Thomann (2007) describe TPK as the pedagogy of how to use and apply the technology. In brief, TPK is defined as preservice mathematics teachers' knowledge about how to use technology in their teaching. It covers having pedagogical knowledge and limiting the technological tools and resources to consider the pedagogical designs and strategies (Harris, et al., 2009). Additionally, Cox (2008) states that understanding technological tools, which are available for teaching, and their weaknesses and strengths are included in TPK. TPK is particularly important for preservice mathematics teachers, since most popular software programs are not designed for educational purposes such as Microsoft Office, blogs or podcasts. Therefore, technological tools should be adapted to education. Preservice mathematics teachers' TPK can determine the achievement of this adaptation (Koehler & Mishra, 2009). According to Koehler and Mishra (2008), TPK can develop creative flexibility with available tools in order to redesign these programs for specific pedagogical purposes. This study examined preservice mathematics teachers' perceptions on knowledge about identifying and choosing technologies in order to enhance teaching, attractions and drawbacks of those technologies, control the classroom and prepare the technology integrated activities while teaching. As an example, item 60, "my ability to choose technologies that enhance the teaching approaches for a lesson is" on the scale of poor to excellent, measures respondent's perceptions related to their technological pedagogical knowledge.

Technological Pedagogical Content Knowledge

Technological Pedagogical Content Knowledge (TPACK) refers to the complex interrelationship between technological, pedagogical and content knowledge (Mishra & Kohler, 2006). It is different from these three core knowledge domains in that it is the knowledge about how to use technology in a specific content area by using appropriate pedagogical methods and technologies (Schmidt, et al., 2009a). In other words, in TPACK, preservice mathematics teachers know how to use technology for helping students to learn a particular topic (Koehler & Mishra, 2008) when they find themselves on the teaching field. Mishra and Koehler (2006) defined TPACK as

> the basis of good teaching with technology and requires an understanding of the representation of concepts using technologies; pedagogical techniques that use technologies in constructive ways to teach content; knowledge of what makes concepts difficult or easy to learn and how technology can help address some of the problems that students face; knowledge of students' prior knowledge and theories of epistemology; and knowledge of how technologies can be used to build on existing knowledge and to develop new epistemologies or strengthen old ones (p. 1029).

Other researchers (e.g. Cox, 2008; Fath & Genalo, 2008; McCormick & Thomann, 2007; Niess, 2005) agree with Mishra and Koehler (2006) in terms of the structure of TPACK. Niess (2005) defines TPACK as how particular mathematics concepts can be taught in such a way that technology is used facilitating student comprehension. TPACK refers to integrating the appropriate pedagogy for teaching content and technology, and the appropriate technology for content (McCormick & Thomann, 2007). When preservice mathematics teachers are engaged in knowledge of technology, content and pedagogy in their instruction, TPACK occurs (Fath & Genalo, 2008). According to Cox (2008), TPACK is a way of thinking about the dynamic relationships between technology, pedagogy, and specific subject matter in order to help students better understand a particular topic. For instance, teaching triangles, solids, trigonometry and the characteristics of shapes in mathematics (the content) could be difficult when using just board and pen, and drawing. However, when a tool (the technology) such as GeoGebra, Geometer's Sketchpad, Excel, Otave, etc. are used for visual representations, or animations and videos (the pedagogy), the particular topic is more easily understood. The knowledge and application of this process refer to TPACK. In this present research study, perceptions of preservice mathematics teachers' knowledge about teaching mathematics with technology refer to their perceived TPACK knowledge about mathematics. To exemplify, item 68, "my ability to teach lesson that appropriately combined mathematics, technologies and teaching approaches is" on the scale of poor to excellent, measures participant's perceptions related to their technological pedagogical content knowledge.

Comparable frameworks have been developed both self-sufficiently and directly out of the TPACK framework, most based upon Shulman's (1986) model of Pedagogical Content

Knowledge (Koehler et al., 2014). The frameworks include (but are not limited to): *ICT – Related Pedagogical Content Knowledge* (ICT-Related PCK); *Knowledge of Educational Technology; Technological Content Knowledge; Electronic Pedagogical Content Knowledge* (ePCK); and *Technological Pedagogical Content Knowledge – Web* (TPCK-W) (Angeli & Valanides, 2005; Franklin, 2004; Lee & Tsai, 2010; Margerum-Lays & Marx, 2003; Rhonton & Shane, 2006; Slough & Connell, 2006). In the next five paragraphs, it is explained briefly why the other comparable frameworks significantly depart from the TPACK framework in terms of measuring preservice mathematics teachers perceived knowledge levels on TPACK and its components.

ICT – Related PCK is defined as an integrated understanding of four components: pedagogy, subject matter content, student characteristics, and the environmental context for learning. ICT – Related PCK is an instructional systems design model based on Shulman's (1986), and Cochran, Deruiter, and King's (1993) conceptualization of PCK. Specifically, according to Angeli and Valanides (2005), ICT-Related PCK comprises the body of knowledge and preservice teachers (including preservice mathematics teachers) must possess to teach with ICT, and consists of a combination of five components of preservice teachers' knowledge: pedagogical, subject area, students, environmental context, and ICT. According to Koehler et al. (2014), ICT-Related PCK is defined as knowing how to: (a) identify topics to be taught with ICT; (b) identify representations for transforming content; (c) identify teaching strategies that were difficult with traditional technology; (d) select ICT tools to support content and teaching strategies; and (e) infuse ICT activities in classrooms. ICT-Related PCK differs from TPACK in the sense that it conceptualizes the integration of technology into teaching as happening within the realm of PCK, and requiring additional types of knowledge within PCK (Koehler et al., 2014). Whereas the TPACK framework reflects technology knowledge as its own body of knowledge (see Figure 3), it should interact with other bodies of knowledge (CK, PK, and PCK) to form new types of knowledge (TCK, TPK, and TPACK) (Koehler et al., 2014).

Knowledge of Educational Technology (Margerum-Lays & Marx, 2003) view preservice mathematics teachers' understanding of educational technology through the lens of Shulman's (1986) conceptualization of preservice mathematics teachers' knowledge – content knowledge, pedagogical knowledge, and pedagogical content knowledge. Knowledge of Educational Technology is different from the TPACK framework, in the sense that the TPACK framework underscores the interactions between content, pedagogy, and technology and treating technology knowledge as separate but interacting with all other forms of preservice mathematics teachers' knowledge. In divergence, Knowledge of Educational Technology treats the integrated understanding of teaching with technology as understandable, for the most part, using the Shulman's existing framework of preservice mathematics teachers' knowledge (Koehler et al., 2014). Precisely, preservice mathematics teachers' knowledge of educational technology can be understood as three components: Content Knowledge of Educational Technology, Pedagogical Knowledge of Educational Technology, and Pedagogical Content Knowledge of Educational Technology.

Technological Content Knowledge is a theoretical framework which stress on the "total intersection" between technology and content (Slough & Connell, 2006). Slough and Connell (2006) use the analogy of lenses, one each for technology and content through which teaching and learning can be viewed, as such the two components, technology and content become one. Also, according to Slough and Connell (2006), the lenses serve to "magnify" teaching and learning by providing a more focused method for a preservice mathematics teacher. Slough and Connell (2006) offer the example of computer-generated visualizations such as 3-D graphs, as the total overlap of technology and content, offering a new way of building scientific understanding. The Technological Content Knowledge framework differs from the TPACK framework in the sense that the TPACK framework conceptualizes technology as a realm of knowledge separate from content or pedagogy and focuses on the areas of overlap between the three realms of necessary knowledge.

Electronic Pedagogical Content Knowledge (ePCK) comprises of knowledge that preservice mathematics teachers' must possess in order to successfully integrate technology into their classrooms (Franklin, 2004; Irving, 2006). ePCK is not a framework certainly but a specific type of preservice mathematics teacher's knowledge that exists alongside knowledge of content, pedagogy, and curriculum (Koehler et al., 2014). ePCK type of knowledge is distinctly different from basic technical knowledge and linked to preservice mathematics teacher's efficacy, a necessary component of technology integration (Becker, 2000; Dawson, 1998). Preservice mathematics teachers who possess ePCK are able to develop and implement a curriculum that includes methods and strategies for integrating technology in content areas in an effort to maximize student learning (Koehler et al., 2014). Electronic Pedagogical Content Knowledge differs from the TPACK framework as ePCK stresses on pedagogical practices specific to educational technology rather than conceptualizing technology as a distinct realm of knowledge (Koehler et al., 2014).

Technological Pedagogical Content Knowledge – Web (TPACK-W) consists of knowledge of TPACK components (content and pedagogy), and in place of general technology, the World Wide Web (Lee & Tsai, 2010). TPACK-W is identified as an extension of both Shulman's (1986) original framework and Mishra and Koehler's (2006) TPACK framework (Koehler et al., 2014). TPACK-W framework was precisely developed in response to the generality of technology in the TPACK framework and attempts to elaborate and clarify the more advanced knowledge necessary to teaching specifically on the Web (Koehler et al., 2014). The innovative Web constituent comprises of knowledge regarding all-purpose uses of the Web, specific Web tools, and advanced use of the Web. An example of TPACK-W is being able to select proper (desired content and pedagogy) existing Web-based courses to assist teaching (Koehler et al., 2014).

Although the comparable frameworks employ different labels, they are in broad agreement that the advent of new technologies requires preservice mathematics teachers to develop new forms of knowledge that connect the affordances (and constraints) of these new technologies to the transformation of content and pedagogy. Early research on TPACK focused on establishing and developing the underlying conceptual framework (Koehler & Mishra, 2005a, 2005b; Koehler & Mishra, 2006). As the TPACK framework has been increasingly adopted/adapted, research has turned to measuring TPACK as well as to test the effectiveness of various TPACK-based interventions (Graham, Tripp, & Wentworth, 2009; Guzey & Roehrig, 2009) of which this study did not do. This study looked at the preservice mathematics teachers' perceived knowledge levels on TPACK and its components in general because they have been trained in using technologies with approaches in teaching mathematical concepts every semester.

Theory of altruism

The term 'altruism' was introduced by Auguste Comte to describe devotion to the interests of others as an action-guiding principle or a behavior that describes a concern for other's welfare as a consequence of overcoming self-interest (Comte, 1967; Paul, Miller, & Paul, 1993). Defining altruism is problematic, with definitions often guiding how research is conducted (Sorrentino & Rushton, 1981). Altruism to some (e.g. Batson, 2011; Batson, Ahmad, & Stocks, 2011; Dovidio, Piliavin, Schroeder, & Penner, 2006; Penner, Dovidio, Piliavin, & Schroeder, 2005) is any behavior or any intended action that is designed to increase another person's welfare, and particularly those actions that do not seem to provide a direct reward to the person who performs them. According to Rushton (1980, p. 8), "altruism is defined as social behavior carried out to achieve positive outcomes for another rather than for the self". Bar-Tal (1986) defined altruism as helping behavior or an act which benefits others and no external rewards are promised a priori, in return.

Altruism's ultimate is increasing another's welfare (Batson, 1991; Batson, 2010; Batson, Duncan, Ackerman, Buckley, & Birch, 1981). Researchers (e.g. Bar-Tal, 1985; Bar-Tal, Sharabany, & Raviv, 1982; Batson, 1998; Berkowitz, 1972; Eisenberg & Miller, 1987; Krebs, 1970; Leeds, 1963; Smith, 2009; Staub, 1978) presenting altruistic approach arguments agree that the essential features of altruism include an act performed voluntarily and intentionally with the primary goal of benefitting another person. The theory of altruistic maintains that altruistic is necessary in all spheres of life (Sorokin, 1967) and that should not exclude the life of preservice mathematics teachers so that they can help their learners when they find themselves on the teaching field.

Altruism agree that altruistic behavior (a) must benefit another person, (b) must be performed voluntarily, (c) must be performed intentionally, (d) the benefit must be the goal by itself, and (e) must be performed without expecting any external reward (e.g., Bar-Tal, 1976; Berkowitz, 1972; Krebs, 1970; Leeds, 1963; Staub, 1978). Altruistic act is performed without expectations of possible future external rewards (Bar-Tal, 1976). Altruism traits are important factors within preservice teachers' desire to teach (Scott & Dinham, 1999). There is growing evidence that altruistic behavior has reinforcing properties, making the altruistic individuals feel better, and experience self-gratification (e.g. Baumann, Cialdini, & Kendrick, 1981; Cialdini & Kendrick, 1976; Weiss, Boyer, Lombardo, & Stitch, 1973). Onatir (2008) is of the view that the main criterion for altruism is the intention to help. Altruism is important factor of preservice teachers' future professional success (Scott & Dinham, 1999). Some researchers (e.g. Kohler & Fowler, 1985; Triliva & Chimienti, 2002) make the case persuasively that positive aspects of human behavior can and need to be included as part of the school curriculum. It is worthy to prepare preservice teachers who have the intention of showcasing altruistic behavior when they complete school (Pavenkov & Rubtcova, 2016). Most altruistic studies were conducted in Biology, Social Psychology, Special Education, Religion, inclusive education, etc. with scarce works in the area of preservice mathematics teachers' altruistic traits before they graduate.

From existing literature, one can begin to develop empirical investigations and theories and perhaps realise the complexity of the construct of altruism (Feigin, Owens, & Goodyear-Smith, 2018). It is very difficult to operationalize altruistic definitions behaviorally since expectations for internal rewards and moral reasoning can be determined only through verbal self-report (Bar-Tal, 1976). The problem of providing an operational definition of altruistic behavior is not an easy one (Bar-Tal, 1976). Bar-Tal (1976, p. 9) said that "studies show that the operationalization of altruistic act is possible". Additionally, Bar-Tal (1976, p. 9) is of the view that "the empirical evidence, although scarce, does show that altruistic behavior is a reality".

This study operationalised altruistic trait as altruistic to teach mathematics (AtTM) and defined it as preservice mathematics teachers perceived intent traits of teaching mathematics (especially core mathematics) after graduation and also their selfless desire of helping SHS learners to learn mathematical concepts. Having a desire to improve the learning of mathematics of SHS learners as a preservice mathematics teacher means the altruist/the preservice mathematics teacher will derive pleasure from improvements in the success of his/her learners (Batson & Weeks, 1996).

Some researches (e.g. Hisnanick & Coddington, 2000; Kahana et al., 2004) of western have focused on the relationship between altruism and wellbeing. From the extant literature, pedagogy approaches relate to altruism (Marchel, 2003; Laohasongkram, 2017). For instance, service-learning which is a pedagogy was found by Marchel (2003) to relate to altruism. Similarly, technology has shown in the literature to relate to altruism (Chan & Ma, 2014; Klisanin, 2011; Kuznetsov, 2006; Pee, 2018; Prasarnphanich & Wagner, 2009; Rafaeli & Ariel, 2008; Xu & Li, 2015). For example, in Kuznetsov (2006), Prasarnphanich and Wagner (2009), Rafaeli and Ariel (2008) and Xu and Li (2015) works, knowledge sharing on Wikipedia (technology) positively related to Altruism. Similarly, Klisanin (2011) found that the internet (technology) is helping people have altruistic traits of sharing learning resources without any reward.

From the immediate above paragraph, it shows clearly that PK and TK which are some components of TPACK relates to altruism (AtTM). This research thence hypothesised that the perceived knowledge levels of preservice mathematics teachers on TPACK and its components relates to their perceived AtTM.

Appraisal of education in schools

People are the lifeblood of universities (Flaniken, 2009). If there are no students/preservice mathematics teachers applying to read mathematics education programme in a university, the programme would naturally die off. Due to the paramount importance of students/preservice mathematics teachers who are in higher education (Flaniken, 2009), it is vital to let them appraise the kind of courses they take.

In higher education, the conventional ideas of performance, assessment, and appraisal are most often applied to the preservice teachers (Flaniken, 2009) concerning the courses they have taken in a particular semester. Most often, questions are asked concerning how preservice teachers are performing academically in their studies as well as how well they are acclimatising to their new social environment in higher education (Creamer & Winston, 1999). The academic accomplishment of preservice teachers is typically measured by grade point averages, while preservice teachers' adaptation to their new social environment is measured through such things as retention rates and graduation rates (Flaniken, 2009).

A review of the literature found limited studies focusing on how preservice mathematics teachers appraise the kind of courses they take and how the courses are also structured especially in terms of which course should come first and whether the courses have met their needs. An effective performance appraisal system is one of many methods that are useful for assessing and improving a system (Mani, 2002) so if always departments are allowed to restructure courses, then it would not inure to the benefit of preservice mathematics teachers or the courses may not actually address the needs of preservice teachers. According to Demir (2019), preservice mathematics teachers should be able to choose what they want to learn. Also, Demir (2019) said grades are irrelevant in terms of training of preservice mathematics teachers and that only self-evaluation of courses is meaningful.

Most appraisals in education are done on: staff; institutions; common standards; students'/preservice teachers' academic performance; achievement among institutions; the relationships between inputs, processes and, to some extent, outputs; public educational resources; etc. (Atkinson, 2005; Caldwell, Jim, & Spinks, 1998; Dixit, 2002; Figlio & Ladd, 2007; Figlio & Loeb, 2011; Glenn & de Groof, 2005; Gorard, Fitz, & Taylor, 2001; Hart & Figlio, 2015; Hoxby, 2003; Justine & Weinstein, 2008; Ladd, 2012; Mante & O'Brien, 2002; Organization for Economic Cooperation and Development (OECD), 2005; OECD, 2006a; OECD, 2007; OECD, 2008a; OECD, 2008d; van de Grift & Houtveen, 2006). For instance, van de Grift and Houtveen (2006) are of the view that school appraisal with a view to school improvement may focus on providing useful information for making and monitoring improvements and can support school principals and teachers. It is high time that we have literature on how preservice mathematics teachers appraise courses they have taken in relation to their cognitive needs.

The needs of preservice mathematics teachers

Preparation of preservice mathematics teachers is a continuous process. It begins with the selection of an aspirant mathematics teacher and includes initial preparation induction. The formulation of policy and design of mathematics teacher reparation should optimally take into account the whole spectrum of teacher learning (Rothenberg, McDermott, & Gormley, 1997). The spectrums could be a whole lot of needs that would make a preservice mathematics teacher ready to go and teach after graduation.

Preservice mathematics teacher education programme needs to allow the space where preservice teacher could appraise courses been offered to him/her and capable of analysing his or her own life in the process of education at school so that after becoming a mathematics teacher, he/she becomes an agent of change (Whitworth, 1996). The coursework required of preservice mathematics teachers has been discussed extensively within the mathematics education community (Cox et al., 2013). Typically, mathematics teacher education programmes require preservice mathematics teachers to complete a mathematics major, or the equivalent (Artzt, Sultan, Curcio, & Gurl 2011; Conference Board of the Mathematical Sciences (CBMS), 2012). Such training allows preservice mathematics teachers to engage deeply with mathematical content, which is considered essential for mathematics teaching (Masters, 2009; Miller & Davidson, 2006; Norton, 2010).

Also discussed widely is the quality of pedagogical coursework offered within teacher education programmess (Cox et al., 2013), where preservice mathematics teachers learn a variety of ways to represent mathematical content and to assist students in deepening their understanding (Ma, 1999; Shulman, 1987, 1999; Silvernam & Thomson, 2008). In addition, pre-internship (or pre-practicum experience) is an integral aspect of teacher education programmes where preservice teachers undertake the activity of learning peer teaching (Cox et al., 2013; Putnam & Borko, 2000). Although there is a lack of understanding of how best preservice mathematics teachers can appraise the courses that meet their needs (Boyd et al., 2009), an investigation of preservice level 300 mathematics teachers' appraisal of courses they have taken may be insightful for future efforts in mathematics teacher formation. According to Shulman (1987), preservice mathematics teachers need to understand subject matter deeply and flexibly, so that they can help SHS students create useful cognitive maps, relate ideas to one another, and address misconceptions in mathematics. Shulman (1987) further stated that, preservice mathematics teachers need to see how ideas connect across fields and to everyday life.

Preservice mathematics teachers need several kinds of knowledge about mathematics learning. Preservice mathematics teachers need to think about what it means to learn different kinds of concepts and theories for different purposes and how to decide which kinds of learning are most necessary in different contexts (Grimmett & MacKinnon, 1992). Preservice mathematics teachers need to know about curriculum resources and technologies to connect their learners with sources of information and knowledge that allow them to explore ideas, acquire and synthesize information, and frame and solve mathematical problems (Pacific Policy Research Center, 2010). Again, preservice mathematics teachers need to know about collaboration that is, how to structure interactions among learners so that more powerful shared learning can occur; how to collaborate with other preservice mathematics teachers; and how to work with parents to learn more about their children and to shape supportive experiences at school and home (Shulman 1987). Shulman (1987) asserted that, preservice mathematics teachers need to be able to analyse and reflect on what they have been taught. Shulman (1987) identified seven categories of essential knowledge needs for preservice mathematics teachers as follows:

- content knowledge
- general pedagogical knowledge
- pedagogical content knowledge
- curriculum knowledge
- knowledge of educational contexts
- knowledge of learners and their characteristics
- knowledge of educational goals.

Lewin and Stuart (2003) and Stuart (1999) (cited in Keith, 2004, p. 7) also identified a range of needs in preservice teacher education and they include:

- Subject Content: knowledge and understanding of school subjects in the curriculum.
- Pedagogical Content Knowledge: teaching methods and ways of assessing learning related to specific subject areas and matched to the capabilities of learners (cf. Shulman, 1987).
- Professional Studies/Education Studies: understanding of how students learn and how cognitive, affective, psychomotor, and social development take place, knowledge and skill in classroom management and pastoral care, craft knowledge of effective techniques to promote learning, acquisition of professional identities as a teacher, awareness of relevant educational history, psychology, sociology, philosophy, legislation, responsibilities, etc.
- Teaching Practice/Practicum: in school and in college opportunities to practice teaching under supervision with support from experienced mentor teachers.

Categories of needs (Keith, 2004; Shulman, 1987) have been widely adopted in preservice mathematics teacher education programmes. They are commonly used as the basis for describing essential knowledge at all subsequent stages of preservice mathematics teacher development. da Ponte and Chapman (2008) stated that preservice mathematics teacher education is a complex process in which many needs interact. They said these needs include the kinds of knowledge, competencies, attitudes and values that teacher candidates should acquire or develop, where learning takes place (university, school, and other settings), and the roles, interests and characteristics of the participants in the process (preservice teachers, university instructors, classroom teachers/mentors, and students). They also pointed out that the needs include program options and conditions such as pedagogical approaches, ways of working emphasized, relationship of preservice teachers and instructors, access to resources, and use of information and communication technology.

Preservice mathematics teachers' needs are enormous. The extant literature (e.g. Cox et al., 2013; Grimmett & MacKinnon, 1992; Keith, 2004; Putnam & Borko, 2000) shows that there are so many needs of preservice mathematics teachers that need to be addressed before they finally graduate and go to teach especially at the SHS. If preservice mathematics teachers' needs (especially content, pedagogy, and ICT needs) are addressed to a very large extent, they would have a very high confidence in teaching (Boyd et al., 2009; da Ponte & Chapman, 2008; Cox et al., 2013; Silvernam & Thomson, 2008). In this study, preservice mathematics teachers' cognitive needs in terms of content, pedagogy and technology/ICT courses were investigated.

Mathematical knowledge needs of preservice mathematics teachers

According to Shulman (1987), content knowledge (CK) is the preservice mathematics teacher's knowledge about the subject matter that students will learn and later teach when they find themselves on the teaching field. It includes knowledge of concepts, theories, ideas, organisational framework, and evidence and proof, as well as the practices and approaches that lead to developing such knowledge (Shulman, 1987). Fennema and Franke (1992) determined the components of preservice mathematics teachers' knowledge as:

1. Knowledge of mathematics
    - Content Knowledge
        - The nature of Mathematics
        - The mental organization knowledge.
2. Knowledge of mathematical representations
3. Knowledge of students they would be teaching
    - Knowledge of SHS students' cognitions
4. Knowledge of teaching and decision making.

The knowledge needed for preservice mathematics teachers to be successful after graduation is defined by Leikin (2006) as Subject Matter Knowledge, Pedagogical content Knowledge, and Curriculum Knowledge, etc. Hill et al. (2008) in their study also categorized the mathematical knowledge preservice mathematics teacher need to be effective after leaving school as Mathematical Knowledge for Teaching (MKT) which is similar to Shulman's (1987) PCK.

Mathematical knowledge includes knowledge of mathematical facts, concepts, procedures, and the relationships among them (Hill et al., 2008). Mathematical knowledge also comprises knowledge of the ways that mathematical ideas can be represented and knowledge of mathematics as a discipline in particular, how mathematical knowledge is produced, the nature of discourse in mathematics and the norms and standards of evidence that guide argument and proof (National Research Council, 2001). A preservice mathematics teacher must understand the syntax or rules of a particular topic, and must also explain why these are worth knowing, and how they relate to other topics within a mathematics curriculum (Shulman, 1986). An example of content knowledge in mathematics that a preservice mathematics teacher needs to know would be that: dividing fractions (the rule), and additionally understands why division of fractions is possible and how it is related to subtraction and multiplication of fractions (Shulman, 1986).

Shulman (1986) explained that preservice mathematics teachers need not only understand that something is so; s/he must further understand why it is so, on what grounds its warrant can be asserted, and under what circumstances our belief in its justification can be weakened and even denied. Most of the mathematical content knowledge a preservice mathematics teacher needs to grasp before going on an internship at a SHS or before leaving school all depends on the content courses s/he has taken. When preservice mathematics teachers are able to appraise the content courses and realise that most of the courses have addressed their needs to an extent then they are likely to have confidence in teaching mathematics (especially core mathematics).

Pedagogical knowledge needs of preservice mathematics teachers

The relationship between preservice mathematics teachers' mathematical content knowledge and their ability to teach after graduation has been well researched and there is clear evidence on the positive relationship between them (Ball, Hill, & Bass, 2005; Darling-Hammond, 1997; Harris & Jensz, 2006; Ma, 1999; Norton, 2010; Shulman, 1987, 1999). Pedagogical Knowledge (PK) describes the general-purpose knowledge unique to teaching (Koehler & Mishra, 2009). PK is the set of skills that preservice mathematics teachers must develop in order to manage and organize teaching and learning activities for intended learning outcomes when found on the field. Also, PK involves but not limited to an understanding of classroom management activities, the role of student motivation, lesson planning, and assessment of learning which a preservice mathematics teacher could acquire from pedagogical and its related courses. PK may also describe knowledge of different mathematics teaching methods, such as knowing how to organize activities in a way conducive to students' constructive building of knowledge.

Koehler and Mishra (2009) stated that PK is the preservice mathematics teacher's deep understanding of the processes and practices or method of teaching and learning mathematics. It includes:

- understanding the nature of the students they would be teaching
- having strategies for evaluating the students when they are on the field
- understanding the cognitive, social and developmental theories of learning and how they apply to the students in the mathematics classroom (Koehler & Mishra, 2009) when on teaching practice or found on the teaching field.

For preservice mathematics teachers to be able to say that their PK needs are met during training, they have to appraise the pedagogy courses related to mathematics (Emerick, et al., 2003; Miller & Davidson, 2006; Teacher Education Ministerial Advisory Group

[TEMAG], 2014) and once their PK needs have been addressed to some extent, it is likely they would be able to transmit mathematical concepts to learners.

Technological knowledge needs of preservice mathematics teachers

The preparation of preservice mathematics teachers to use technology/ICT is one of the most critical issues facing mathematics teacher education programmes (Powers & Blubaugh, 2016; Kaput, 1992; Waits & Demana, 2000). In response to the growing need for technological literacy, the department of mathematics education of the University of Education, Winneba introduced ICT courses for preservice mathematics teachers to study as cognate courses. The aims of the ICT courses include: (a) providing trainees with the opportunity to learn specific technological resources in mathematical contexts, (b) focusing trainee attention on how and when to use technology appropriately in mathematics classrooms, and (c) giving opportunities for trainees to apply their knowledge of technology and its uses with appropriate methodology in the teaching and learning of mathematics.

Appropriate and integrated use of technology/ICT impacts every aspect of mathematics education: what mathematics is taught, how mathematics is taught and learned, and how mathematics is assessed (NCTM, 2000). Preservice mathematics teachers would use technology appropriately and effectively in their mathematics classrooms if they are familiar and comfortable with the technology and, especially, if they have had successful experiences with the technology/ICT in an instructional environment during training (Powers & Blubaugh, 2016). Powers and Blubaugh (2016) are of the view that preservice mathematics teachers who are able to use today's technology/ICT during training would be prepared to learn and utilize tomorrow's technology/ICT in the classroom after graduation.

Upcoming mathematics teachers need to be well experienced in the matters and applications of technology/ICT. One way to close the gap and bring mathematics education into the 21st century is by preparing preservice mathematics teachers to utilize instructional tools such as graphing calculators and computers for their future practice (Powers & Blubaugh, 2016). Upon completion, future mathematics teachers should not only be knowledgeable as to which mathematics concepts are best learned through technology, but also would have had many successful experiences in developing and carrying out lesson plans that involve a variety of different technologies. Since the introduction of the ICT courses in the department of mathematics education of the University of Education, Winneba, can one say that the ICT courses have adequately addressed the needs of many preservice teachers to be competent at integrating ICT tools for teaching and learning mathematics? Powers and Blubaugh, (2016) opined that if preservice mathematics teachers perceived that technology/ICT related coursed have addressed their needs to a very large extent, then they would be able to integrate ICTs in their teaching after graduation.

Research studies on Preservice Teachers' perceived TPACK

When the literature is reviewed, it can be seen that most of the TPACK studies have been conducted with preservice teachers. For instance, Schmidt et al. (2009a) have measured preservice teachers' TPACK for content areas of mathematics, social studies, science and literacy by using 75-item TPACK survey. The aim of Schmidt et al.'s (2009a) study is to develop and validate an instrument to assess preservice teachers' TPACK. Schmidt et al.

(2009a) reviewed the relevant literature and existing survey studies in generating process of their instrument. Besides, their instrument has been prepared as 5-point Likert scale, ranging from "strongly disagree" to "strongly agree". Schmidt et al. (2009a) also used Koehler and Mishra's (2005) TPACK questionnaire in developing of their survey instrument. One hundred twenty-four preservice teachers participated in Schmidt et al.'s (2009a) study, and the results of their study have shown that factor analysis (between .65 and .92) and reliability analysis (between .80 and .90) were good (Schmidt, et al., 2009a). Some items were deleted or modified, and the instrument has become a reliable and valid instrument; therefore, it provides adequate information for determining and examining preservice mathematics teachers' perceived TPACK and its components levels (Schmidt, et al., 2009a). The survey instrument of Schmidt et al.'s (2009a) has been used in another study in order to examine the changes in perceived knowledge in TPACK components (Schmidt, Baran, Thompson, Mishra, Koehler, & Shin, 2009b). Schmidt et al. (2009b) stated that the participants of the study have been 87 preservice teachers, and pretest-posttest have been conducted in an introductory instructional technology course. Furthermore, a series of paired samples t-tests have been conducted, and changes in all measured variables have found a statistically significant difference. The results of the Schmidt et al.'s (2009b) study indicated that the change is a higher degree of perceived knowledge at the end of the course. Furthermore, the largest differences have been found in TK, TCK, and TPACK dimensions.

Another study conducted with preservice teachers is Niess's (2005) study. Niess (2005) worked with 22 preservice science and mathematics teachers in science and mathematics content. The development of these preservice teachers' TPACK has been assessed by using qualitative research methodology. Niess (2005) says that all classes of the participants and all assignments have been observed throughout one year and analyzed; firstly, technology courses have been examined, and then microteaching courses and lastly pedagogy courses have been examined. According to Niess (2005), in technology courses part, preservice teachers have learned using various technologies in addition to pedagogical considerations with these technologies and teaching/learning with these technologies. In microteaching courses, preservice teachers have gained teaching experience about four instructional methods; demonstrations, hands on, inductive and deductive modes. In pedagogical courses, preservice teachers have practiced what they have learned (Niess, 2005). The content knowledge of her study is both scientific and mathematical. Niess (2005) reports that due to the courses, 14 of the 22 students have had a great improvement in their TPACK, and the remaining eight students still need more work to reach high TPACK levels.

Additionally, Agyei and Voogt (2012) designed their study to explore how preservice mathematics teachers incorporated the developed technology-enhanced lesson materials into their teaching and how they learned the TPACK development on the concept of quadratic equations. Agyei and Voogt (2012) specifically used Schmidt et al. (2009a) questionnaire that included items that addressed the experimental preservice mathematics teachers' self-assessment toward TPACK. The questionnaire was applied two times as pre- and post-surveys. Agyei and Voogt (2012) used the pre- and post-surveys to evaluate their understanding and use of spreadsheets (e.g. Excel) (as their TK), possibilities for teaching and learning with spreadsheets (as their TPK), how they use spreadsheets to improve understanding of the concepts (as their TCK), and how they understand the changes based on teaching and learning mathematics with the application of spreadsheets (as their

TPACK). Based on the preservice mathematics teachers' responses, Agyei and Voogt (2012) calculated pre- and post-test mean score of participants' TPACK subscales. Agyei and Voogt (2012) suggested that the method they used could be considered to determine preservice mathematics teachers' development of TPACK knowledge.

Combing the literature, it was realised that most studies (e.g. Agyei & Voogt, 2012; Bowers & Stephens, 2011; Haciomeroglu, Bu, Schoen, & Hohenwarter, 2011; Hahkioniemi & Leppaaho, 2012; Hardy, 2010; Larkin, Jamieson-Proctor, & Finger, 2012; Lee & Hollebrands, 2008; Meagher, Ozgun-Koca, & Edwards, 2011; Niess, 2005; Niess et al., 2009; Özgün-Koca et al., 2010; Ozmantar, Akkoc, Bingolbali, Demir, & Ergene, 2010) measure preservice teachers' perceived knowledge levels on TPACK and its subscales after a technology course interspersed with pedagogies in teaching concepts or after introducing a technological tool with a methodology in teaching a concept or measuring their perceived knowledge levels before taking preservice teachers through activities that include a technological tool and a method and after that measure their perceived knowledge levels on TPACK and its components. As of now, there are limited studies on measuring preservice teachers' perceived knowledge levels on TPACK and its components for preservice teachers who are been trained in using various technologies and different teaching approaches in teaching concepts. This present study investigated the perceived knowledge levels on TPACK and its components of preservice mathematics teachers who have been trained for a period of 3-years in integrating technologies with methods in teaching mathematics concepts.

The perceived knowledge level of preservice mathematics teachers in relation to TPACK and its components

Every innovation brings along an integration process that takes a long time, especially in social disciplines. Supporting technology integration in schools has become an important issue on the agenda of countries over the past two decades (Chen & Jang, 2014). In particular, the introduction of more technologies into everyday life has increased the pressure on preservice teachers on how to use such technological tools and devices in line with instructional purposes they complete. In 2005, Koehler and Mishra (2005b) introduced the term technological pedagogical content knowledge (TPCK) as a conceptual framework to describe the knowledge base for teachers to effectively teach with technology. The claim by Agyei and Voogt (2012, p. 547) that "although many studies have shown the need to pay attention to teachers' preparation for the integration of technology in classroom practice, most teachers in Ghana have not had any preparation that develops their technological pedagogical content knowledge (TPCK)" is due to the fact that the participants in their case study did not go through any training in how to use an appropriate technology with an appropriate methodology to teaching a concept. In this study, the preservice mathematics teachers have undergone tutelage in how to use technologies and approaches in teaching concepts so their perceived knowledge level in terms of TPACK and its components were investigated.

TPACK stands for Technological Pedagogical Content Knowledge and was announced as the 'Total PACKage" for effectively teaching with technology (Thompson & Mishra, 2007). According to Thompson and Mishra (2007), TPACK better reflected the interdependence of the three contributing knowledge domains (i.e. CK, PK and TK). Since the introduction of TPACK in 2005, it has been rapidly extended across the fields of professional development and technology integration (Voogt, Fisser, Pareja, Tondeur, & van Braak, 2013). The increasing number of studies that refers to TPACK calls for a systematic synthesis of both the evolution of TPACK as a concept and its practical applications.

In the mind of a preservice mathematics teacher, perceived knowledge and beliefs are intertwined, and therefore, both are often conceived as an inherent part of preservice mathematics teachers' knowledge (Verloop, Van Driel, & Meijer, 2001). Some preservice mathematics teachers' beliefs on TPACK were discussed from two perspectives: beliefs about technology (Abbitt, 2011a; Niess, 2005; Özgün-Koca, et al., 2010) and pedagogical beliefs (Manfra & Hammond, 2008; Niess, 2005; So & Kim 2009; Valtonen et al., 2013). Abbit (2011) demonstrated that preservice mathematics teachers' TK was a stable predictor of teachers' self-efficacy beliefs towards technology. Similarly, Özgün-Koca et al. (2010) found that beliefs about the functionality of specific technologies affect the way in which preservice teachers will integrate technology in their teaching. Further evidence about the influence of preservice mathematics teachers' beliefs is provided by Niess' (2005) study, showing that one of the preservice mathematics students participating in an educational technology course felt hindered to apply what she had learned in the program to her teaching practice because of her view of technology. In the same study, Niess (2005) also described a preservice mathematics teacher who did not feel comfortable with the technology herself but whose pedagogical beliefs facilitated the use of the technology because she believed that her students will be able to see and understand some concepts better with technology. Manfra and Hammond (2008) argued that preservice mathematics teachers' decisions during lesson preparation and execution are based on their pedagogical beliefs about content and technology and not guided by the affordances of technology. Moreover, Valtonen et al. (2013) found that the majority of preservice mathematics teachers who designed online courses opted for the design of teacher-centred courses.

Saltan and Arslan (2017) did a study on preservice mathematics teachers perceived knowledge in technological, pedagogical and content knowledge and their findings show that preservice mathematics teachers' ratings on technology use was not high. One may think that preservice mathematics teachers who use technology would have a significantly higher TPACK score, especially on the TK domain. In their study, Jang and Tsai (2012) found that preservice mathematics teachers' ratings were high on pedagogy, content, and pedagogical content. Another study exposed that the TPACK scores of preservice mathematics teachers who use ICT were significantly higher than those who did not use ICT (Yurdakul & Coklar, 2014). In Yurdakul and Coklar's (2014) study, the preservice mathematics teachers have taken ICT courses so their perceived knowledge level in relation to TPACK and its components were investigated. In their study, Saltan and Arslan (2017) found that preservice mathematics teachers have low ratings on TK as compared with CK, PK and PCK and their findings were similar to the findings of Özgün-Koca et al. (2010) and Tokmak, Incikabi, and Ozgelen (2013). Chuang and Ho (2011) stated that in their study, preservice mathematics teachers had higher-level perceptions on some TPACK sub-domains. Considering the educational programmes variable, Erdogan and Sahin (2010) concluded that preservice elementary mathematics teacher candidates had significantly higher TPACK ratings than preservice secondary mathematics teacher candidates. They explained that one of the reasons why preservice mathematics elementary teachers had significantly higher TPACK ratings might be because the Department of Elementary Mathematics Education offers more information on TPACK because of its selective courses and curriculum.

Archambault and Crippen (2009) studied the perceived knowledge level of 596 preservice mathematics teachers in terms of technological and pedagogical content knowledge. The results of Archambault and Crippen's (2009) suggested that knowledge ratings are highest among the domains of pedagogy, content, and pedagogical content, indicating that responding preservice mathematics teachers felt very good or have high levels about their knowledge related to these domains (PK, CK, & PCK). In a study, Koh and Chai (2011) focused on the perceptions of preservice mathematics teachers in accordance with the seven components of TPACK. The results of Koh and Chai's (2011) research suggested that TPACK components had significant effect on preservice mathematics teachers' perceptions on TPACK. In addition, Koh and Chai (2011) claimed that among TPACK components, TPK and TCK were the determiners of TPACK.

Quantitative results from a research by Doering, Veletsianos, Scharber, and Miller (2009) indicated a general tendency of TPACK to shift across time. Approximately 59% of preservice teachers' ratings were different between the pre- and the post-survey, indicating that teachers' perception of their perceived knowledge domains in terms of TPACK changed over the duration of a programme (Doering et al., 2009). Besides, it appears that the preservice teachers perceived a largely positive change in their technological, pedagogical, and content knowledge after engaging with the designed programme as indicated by the fact that out of the 14 ratings that did change between the pre- and the post-survey, 11 were positive while just 3 were negative (Doering et al., 2009). In addition, Doering et al. (2009) stated that: (a) the most positive change occurred in the technology knowledge category with five out of eight teachers indicating that their technology knowledge increased; (b) the technology and content knowledge components exhibited only positive changes; and (c) five out of eight teachers indicated that their knowledge increased in at least one of the three knowledge components. The pedagogy knowledge component exhibited mixed results: three preservice teachers perceived an increase in their pedagogy knowledge; and two felt that their pedagogy knowledge remained unchanged (Doering et al., 2009). Findings have also shown interrelatedness between data collected through TPACK survey and those of observation checklist. From TPACK survey it has been revealed that before intervention, preservice teachers had perceived their knowledge on technology related components to be more limited compared to the knowledge of pedagogy, content and pedagogical content (Kafyulilo, Fisser, & Voogt, 2013). Similarly, in the observation results, Kafyulilo et al. (2013) stated that preservice teachers' technology related components of TPACK were rated low during the pre-intervention assessment. However, Kafyulilo et al. (2013) opined that both post intervention perceived and observed results were significantly high during the post-intervention assessment. Pre and post intervention results indicate an agreement between preservice teachers perceived and observed TPACK (Kafyulilo et al., 2013). Findings of Kafyulilo et al. (2013) is different from the findings of Alayyar (2011) which indicated a difference between self-reported and observed data. However, in Kafyulilo et al. (2013 case, the use of logbook was found important in noting down some important features of technology integration that could not be observed through the observation checklist. The logbook provided a summary of the difficulties that preservice teachers were experiencing during the lesson preparation process and classroom teaching, thus providing the basis for improvement of the preservice teachers' training on the use of technology (Kafyulilo et al., 2013). In this current study, there was no design activities on TPACK but rather, the preservice mathematics teachers responded to a survey instrument.

The relationship between TPACK and its components

Studies (Agyei & Voogt, 2011; Department of Education and Science, 2008; Mooij, 2007; Noor-Ul-Amin, n.d.; UNESCO, 2004) have shown that the incorporation or integration of Information Communication Technology (ICT) in education has the potential of enhancing and improving teaching and learning especially in the areas of science and mathematics. If ICT can improve the teaching and learning of mathematics, then examining the interaction between TPACK and its components of preservice mathematics teachers is worthwhile. As of now, the best prevailing situation of technology integration available for the Ghanaian context mostly is illustrated in Figure 4. From Figure 4, there is much interactions between PK and PCK and PCK and CK. The illustration in Figure 4 clearly indicated that in most classrooms in Ghana, TK is a stand-alone knowledge that has no interaction with the other knowledge domains. Notwithstanding the prevailing situation in terms of technology integration in education in Ghana, if preservice mathematics teachers who are trained in how to use the appropriate technologies with a suitable methodology in teaching mathematical concepts find themselves in SHSs in Ghana, they will be able to integrate technologies into the teaching process.

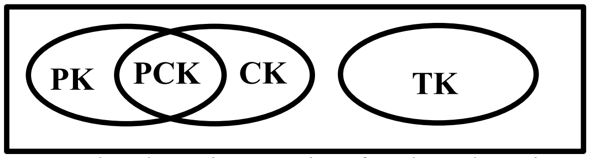

Figure 4. Technology integration for the Ghanaian context mostly.

Since preservice mathematics teachers in this study have been trained in how to integrate technologies with methodologies in teaching concepts, this study looked into detail the relationship between TPACK and the other domains. The interaction between TPACK and its domain, both theoretically and in practice, produces the types of flexible knowledge needed to successfully integrate technology use into mathematics teaching and learning (Koehler & Mishra, 2008). Teaching is an example of an ill-structured discipline, requiring preservice mathematics teachers to apply complex knowledge structures across different cases and contexts when they complete school (Mishra, Spiro, & Feltovich, 1996; Spiro & Jehng, 1990).

Based upon the existing literature about examining preservice mathematics teachers' TPACK, regardless of the rarity, methods are emerging especially at the higher institutions (Angeli & Valanides, 2009; Koehler, Shine, & Mishra, 2012; Yigit, 2014). As the preservice mathematics teacher is the unit of change, in measuring the perceived relationships between TPACK and its components (Kahveci, Gilmer, & Southerland, 2008), it makes sense to examine the said relationship. In a study by Archambault and Crippen (2009), they found that the correlations among each of the domains within the TPACK framework revealed a small relationship between the domains of technology and pedagogy, as well as technology and content (.289 and .323, respectively). However, Archambault and Crippen (2009) claimed that there was a large correlation between pedagogy and content (.690), and stated that this is calling into question the distinctiveness of these domains. Archambault and Crippen (2009) also found high correlations between technological content and technological pedagogy (.743), and technological pedagogical content and both technological pedagogy (.787) and technological content (.733), pedagogical content and content (.713) and pedagogical content and pedagogy (.782). In their studies (Koehler & Mishra, 2005; Koehler, Mishra, & Yahya, 2007), they found relationships between content, pedagogy and technology. Schmidt et al. (2009, p. 135) also stated in their study that "The highest correlations were between TPACK and TPK ($r = 0.71$), TPACK and TCK ($r = 0.49$), and TPACK and PCK ($r = 0.49$)". According to Koehler et al. (2014), "Similar high degrees of correlation exist across studies, although which of the seven sub-scales of TPACK are most strongly correlated differs from study to study" (p. 106). Most of the studies on investigating the relationship between TPACK and its components were conducted in settings whereby the respondents/participants were taken through a technology course or taken through a software with a methodology in teaching a specific concept. This study's setting took into consideration preservice mathematics teachers who were trained for 3-years in how to use technologies with different methodologies in teaching mathematical concepts.

Preservice mathematics teachers perceived altruistic to teach mathematics

Within the preservice teacher education literature, numerous positive factors have been noted as influencing preservice teachers' decision to pursue a career in teaching or their desire to teach after leaving school or their intent traits of teaching after graduation (Yüce, . ahin, Koçer, & Kana, 2013) and altruistic behaviour is one of them. From the extant literature, preservice teachers' altruistic have been investigated in general but study on preservice mathematics teachers altruistic to teach mathematics is rare. Also, whereas there have been several studies (Bruinsma & Canrinus, 2012; Lin, Shi, Wang, Zhang, & Hui, 2012; Low, Lim, Ch'ng, & Goh, 2011; Pop & Tunner, 2009; Richardson & Watt, 2006; Unwin, 1990; Yong, 1995) examining preservice teachers' motives in developed countries like the United States of America, United Kingdom, some European Countries, Asia Countries or Australia and based on search of internet resources, abstracts and databases including ERIC, academic Search Elite, Libris, google scholar, and journal sources such as Emerald, Sage, Science Direct, etc. there is limited research effort devoted to preservice mathematics teachers' altruistic in Africa and Ghana in particular. This current study fills the gap of preservice mathematics teachers' altruistic to teach mathematics literature. In order to recruit and retain preservice mathematics teachers (Yüce et al., 2013), their altruistic traits need to be investigated during their training so that stakeholders and academic leaders in education would be aware of whether preservice mathematics teachers recruited after their training have some altruistic traits to teach especially core mathematics or not.

Altruistic is defined as thinking or behaving in a way that shows you care or you would care about other people and their interests more than you care about yourself (Cambridge University Press, 2019). Altruistic has been described as an internal drive, driving force, feeling and desire a person has to perform a specific activity (Brown, 2001) such as the teaching of mathematics. Preservice mathematics teachers are persons who are yet to or about to enter full-time service as mathematics teachers and it is worthwhile to determine whether they have the desire to teach mathematics after graduation. Altruistic reasons for teaching, according to Low et al. (2011), Moran, Kilpatrick, Abbot, Dallat, and McClune (2001), Mukminin, Kamil, Muazza, and Haryanto (2017) and Mukminin, Rohayati, Putra, Habibi, and Aina (2017), imply preservice mathematics teachers having the perception of going beyond any tangible benefits that the teaching profession have to offer before they leave school. Mathematics teaching is an important profession contributing to the betterment of society (Lin et al., 2012; Unwin, 1990; Yong, 1995). Perceived altruistic traits refer to the reasons outside any obvious benefits that the teaching profession has to offer (Low et al., 2011; Moran et al., 2001;) or altruistic motives refer to the view that teaching is a vital job that impacts on the betterment of society (Yong, 1995). In essence, altruistic has to do with selflessness, self-sacrifice, generosity and the likes. In this current study, altruistic was viewed mainly as the perceived altruistic traits preservice mathematics teachers have to teaching especially core mathematics at the SHS level after graduation. Preservice mathematics teachers who choose altruistic traits as influencing them in choosing teacher education programme absolutely have a deep passion for teaching and see teaching as a socially worthwhile and important job, such as love to work with learners, desire to help leaners succeed, shape future of leaners, enhance social equity, a desire to contribute to society, a socially worthwhile job, to fulfil a mission, and to answer a calling (Mukminin., Rosmiati, & Ariyanti, 2016).

Assay/analysis of the extant literature shows that items that were used in measuring the perceived preservice teachers altruistic to teach inter alia include: love for children or young people, a desire to work with and benefit students, a ‘calling’ to teach, a love of teaching a particular subject or a desire to impart knowledge, teaching as a socially important and worthwhile job, desire to help and support learners to understand, succeed, and enjoy mathematics, love for teaching or a passion for their specific subject expertise, loving and wanting to teach others, being in service of people, teaching is sacred, desire to help others, shaping the future of learners, love to work with leaners, desire to help others, interest to work with learners, meaningful job nature, helping society become better in future, helping rural and remote areas, shaping future educated generation, loving to work with young generation, teaching is intellectually stimulating, etc. (Chan, 2006; Keow, n.d.; Kyrıacou, Hultgren, & Stephens, 2003; Manuel & Hughes, 2006; Mukminin et al., 2017; Mukminin et al., 2017; Ngoepe, 2014; Nyaumwe, Brown, & Dhliwayo, 2004; Pop & Turner, 2009; Sinclair, 2008; Stokes, 2007; Yüce et al., 2013). For instance, the 'desire to help others' came as a strong item in Stokes's (2007) study. Also, Mukminin et al. (2017, p. 40) reported that "96.1% of 285 student teachers' agreed that the main motive that they will teach was 'it has a socially worthwhile job (ranked first)'". In this current study, similar items were investigated with teaching of mathematics especially core mathematics at the SHS in perspective.

Altruism is the hallmark of preservice teachers (Yüce et al., 2013). No preservice mathematics teacher, or in general, preservice teacher, will ever leave a lasting impact on his/her learners and for that matter, the society, if he/she is not moved by fundamental altruistic impetus when s/he finds herself/himself on the teaching field (Ngoepe, 2014; Pop & Turner, 2009). Altruistically, driven preservice mathematics teachers have an inner passion for their work (Nyaumwe et al., 2004; Stokes, 2007).

How TPACK and its components relate to preservice mathematics teachers' altruistic to teach mathematics

Technology, pedagogy, and content knowledge known in short as "TPACK" is an approach which builds preservice teachers' knowledge and demonstrate the usefulness of technology as a pedagogical strategy to meet authentic curriculum learning goals as well as how to integrate technology in content areas such as mathematics (Harris et al., 2009; Koehler et al., 2014; Messina & Tabone, 2012; Walker, Robertshaw, & Recker, 2010). Technology is perceived as useful tool which enhances job performance and easy to use and requires the least amount of effort (Harris et al., 2009). In line with computer use to disseminate knowledge came with the term technological, pedagogical and content knowledge (TPACK) which was introduced to the educational research field as a theoretical framework for understanding preservice teacher knowledge required for effective technology integration and also derived stepwise regression models to describe variables significant for TPACK formation (Mishra & Koehler, 2006). In finding out how TPACK and its components relates/predicts other latent variables/constructs, and how TPACK components predict TPACK, some studies (Abbitt, 2011a; Apeanti, 2010; Horzum, 2013) have used regression analysis. In Abbitt's (2011) study, it was reported that "…at the beginning of the academic term, only two independent variables (TK and TPACK) were found to be significant predictors of self-efficacy beliefs ($R^2 = .76$)" (p. 140). Abbitt's (2011b, p. 140) report further stated that "At the end of the academic term, however, a slightly stronger predictive model was found in which TK, PK, PCK, and TPK were significant predictors of self-efficacy beliefs ($R^2 = .83$)" Besides, in Apeanti's (2010) study, it was found that TPACK, Perception of the effectiveness of ICT in teaching and learning and Perception of the Barriers in ICT integration were significant factors that contributed to preservice mathematics teachers' perceived e-readiness. A study also reported that "…technological knowledge, technological content knowledge, and technological pedagogical knowledge accounted for 82% of the variance in technological pedagogical content knowledge" (Horzum, 2013, p. 308).

Based on search of internet resources, abstracts and databases, it was found that TK and PK which are components of TPACK relate to altruism (Klisanin, 2011; Laohasongkram, 2017; Ma & Chan, 2014; Marchel, 2003; Olitalia et al., 2013; Pee, 2018; Palta, 2019; Prasarnphnich & Wagner, 2009). This study shed light on how TPACK and its components relate to preservice mathematics teachers' altruistic to teach mathematics (especially core mathematics). There are researches which points out that preservice teachers are shaped by many different elements of beliefs that they hold (Koehler & Mishra, 2006; Chai, Chin, Koh, & Tan, 2013c). The TPACK framework has been thus far focused exclusively on accounting for the knowledge that preservice mathematics teachers need to integrate technology/ICT into the classroom (Harris, Mishra, & Koehler, 2009; Koehler & Mishra, 2006). It is therefore necessary to further unpack the relationship between preservice teachers' TPACK and associated perceived beliefs (Chai et al., 2013c) on other concepts such as altruistic to teach mathematics. There are currently few studies that explicitly examine both preservice teachers' TPACK components and how it relates to other constructs (Chai et al., 2013c). Most studies dwell on the correlation among the TPACK components (Chai et al., 2013c). The idea of TPACK has emerged as a generally accepted training to provide explanation of how ready preservice mathematics teachers are in integrating Information and Communication Technologies (ICTs) into classroom discourse (Cox & Graham, 2009; Koehler et al., 2014; Koehler & Mishra, 2006) and if they are ready, how ready are they in relation to their altruistic to teach mathematics? Given that preservice teacher education has good potential to influence teachers' future use of ICT (Hammond et al., 2009; Horzum, 2013), it is clear that teacher educators have to constantly design, evaluate and redesign preservice education for effective ICT integration (Goktas, Yildirim, & Yildirim, 2009) and make sure that preservice teachers have the altruistic to teach especially mathematics.

Summary

This study was based on the Maslow's hierarchy of needs theory, theory of TPACK and theory of altruism. Appraisal in education was reviewed extensively by looking at the works of Atkinson (2005), Creamer and Winston (1999), Flaniken (2009), Mani (2002) among other works. In every training, the needs/perceived needs of trainees need to be ascertained and this study looked at the works of Artzt et al. (2011), Cox et al. (2013), Lewin and Stuart (2003) (cited in Keith, 2004), Rothenberg et al. (1997), Whitworth (1996) among other works. Preservice mathematics teachers' perceived knowledge level in terms of TPACK and its constituents' levels were reviewed as well as the relationship between TPACK and its components. In order to teach and teach very well after graduation, preservice mathematics educators' altruistic to teach mathematics (especially core mathematics) was also reviewed. Finally, how TPACK and its components relate to preservice mathematics teachers' altruistic to teach mathematics was reviewed having it that the TPACK and its components relates to other constructs but not altruistic to teach mathematics.

CHAPTER THREE

METHODOLOGY

Overview

This chapter comprised of research design, population, samples and sampling procedures, instrumentation, validity and reliability of the instruments, data collection procedures, data analysis procedures, ethical concerns/considerations and summary. The following research questions guided the study.

1. How do content, pedagogy and ICT courses address the cognitive needs of preservice mathematics teachers?
2. What are the levels of preservice mathematics teachers' perceptions on their TPACK in the field of mathematics?
3. What are the relationships among perceptions of preservice mathematics teachers' TK, PK, CK, PCK, TCK, TPK and TPACK?
4. To what extent will preservice mathematics teachers have the altruistic to teach mathematics after they have graduated (before internship)?
5. How do the following factors: TK, PK, CK, PCK, TCK, TPK and TPACK relate to preservice mathematics teachers' altruistic to teach mathematics (especially core mathematics)?

Research design

According to Creswell (2012),

> You decide to collect both quantitative data (i.e., quantifiable data) and qualitative data (i.e., text or images). The core argument for a mixed methods design is that the combination of both forms of data provides a better understanding of a research

> problem than either quantitative or qualitative data by itself. Mixed methods designs are procedures for collecting, analyzing, and mixing both quantitative and qualitative data in a single study or in a multiphase series of studies. In this process, you need to decide on the emphasis you will give to each form of data (priority), which form of data you will collect first (concurrent or sequential), how you will "mix" the data (integrating or connecting), and whether you will use theory to guide the study (e.g., advocacy or social science theory). (p. 22)

A fixed mixed methods design (Choosing a mixed methods design, n.d.) with emphasis on the explanatory sequential or sequential explanatory design was used in this study. Fixed mixed methods designs are mixed methods researches where the use of quantitative and qualitative methods is predetermined and planned at the start of the research process, and the procedures are implemented as planned (Choosing a mixed methods design, n.d.). An explanatory sequential mixed methods design (also called a two-phase model; Creswell & Plano Clark, 2011) consists of first collecting quantitative data and then collecting qualitative data to help explain or elaborate on the quantitative results (Creswell, 2012). The sequential explanatory enabled the researcher to use both quantitative and qualitative approaches to generate enough data for the study, validate and interpret using systematic principles (Johnson & Christensen, 2008).

Generally, mixed methods present a better understanding of the research problem than either quantitative or qualitative methods (Creswell, 2012), and that is why this study employed the explanatory sequential or sequential explanatory design. In addition, this study sought to explain in more detail through qualitative research the initial quantitative statistical data that were collected first in some cases. Furthermore, the design was used because the survey instruments were available and the interviewees were also available for the second data collection (Fischler, n.d.). The sequential explanatory research followed the design (see Figure 3) in this study.

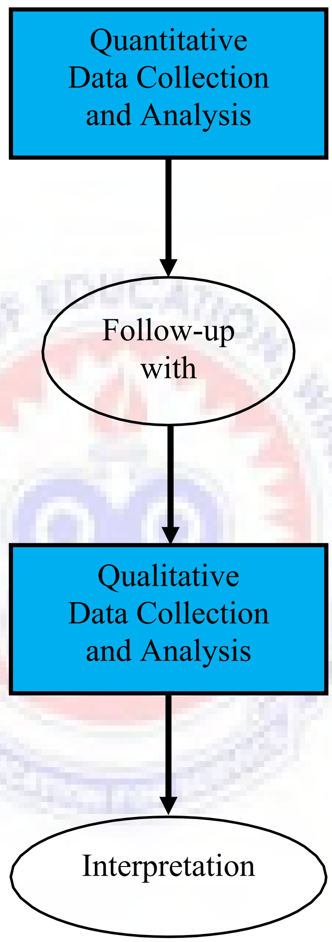

Figure 5. The design framework for the study.

The use of mixed methods has slowly gained acceptance in educational research after argumentative debate among researchers on the advantages and disadvantages of using either quantitative or qualitative methods. According to Creswell and Plano Clark (2011), the main paradigms or worldviews that traditionally were opposed to the acceptance of mixed methods research are positivism and interpretivism. The positivism idea of discovering a singular reality in an objective and unbiased inquiry is common in quantitative research methods. The interpretivist on the other hand, holds that there is no such thing as a single objective reality, but subjective inquiry offers a far more informative approach to better understand research (Creswell & Plano Clark, 2011). Notwithstanding the challenges and opposition of these paradigms, they still dominate methodological research and epistemological debates in the social sciences and education (Hughes & Sharrock, 2007; Teddlie & Tashakkori, 2009).

Advocates of mixed methods research use a combination of quantitative and qualitative research approaches. Thus, a mixed methods method does not fall comfortably within either of the two worldviews or paradigms, but is created or constructed as an alternative framework that accommodates the diverse nature of such research (Creswell & Plano-Clark, 2011). Pragmatism which is related to mixed methods research offers an alternative worldview to those of positivism and constructivism/interpretivism, and focuses on the problem to be researched and the consequences of the research (Creswell & Plano Clark, 2011; Miller, 2006; Tashakkori & Teddlie, 2003; Teddlie & Tashakkori, 2009). Pragmatism holds that there are singular and multiple realities that are open to empirical inquiry and orients itself toward solving practical problems in the "real world" (Creswell & Plano Clark, 2011; Rorty,1999). Hence, pragmatism allows the researcher to be free of the mental and practical constraints imposed by the "forced choice dichotomy between positivism and constructivism" (Creswell & Plano Clark, 2011, p. 27).

Population

The population of a study is the group of people around whom a researcher would like to generalize the findings of a study. The population for this study was preservice mathematics teachers at the UEW of Ghana. All the preservice mathematics teachers of UEW on the four-year programme constituted the targeted population for the study. The four-year programme is a teacher training programme that allows preservice mathematics teachers to teach mainly at SHS when they graduate. In all, there are four different year groups which are level 100 students, level 200 students, level 300 students and level 400 students. The preservice mathematics teachers formed the targeted population because from level 100 to 300, they are trained in how to integrate technologies with eclectic teaching approaches in teaching concepts unlike the other preservice mathematics teachers in other higher institutions in Ghana. For instance, in a study by Agyei and Voogt (2014, p. 7), they stated that the preservice mathematics teachers of the University of Cape Coast in Ghana "… are novices regarding the use of technology to teach or learn mathematics" and preservice mathematics teachers of UEW are not in that regard.

Samples and Sampling Procedures

Sampling refers to the process of selecting a portion of the population to represent the entire population (Alhassan, 2006; Fraenkel & Wallen, 2003; Muijs, 2004). The researcher employed the purposive sampling technique specifically homogeneous sampling technique (Alvi, 2016; Necessary knowledge to conduct a business research, 2018; Palys, 2008) to select level 300 mathematics teachers from the department of mathematics education of the UEW. Creswell (2012) intimated that purposeful sampling is when a researcher "intentionally selects participants who have experience with the central phenomenon or the key concept being explored" (p. 112). With this particular study the central theme bothers on cognitive needs, TPACK and altruistic to teach mathematics. Also, by 300, the preservice mathematics teachers would have gone through 17 mathematics content courses, 6 mathematics pedagogy courses and 6 ICT courses and are ready to go for internship programme and they were suitable for the study. In all, there were 183 level 300 students.

Tools like the sample size software (e.g. sample size calculator) allow you to work out the sample size you need from your desired confidence level, confidence interval and size of your target population (Austin Research, 2014). Sample size software tool was used to determine a sample size of 125 for the study with 5% margin of error, 95% confidence level and 50% response distribution (Raosoft, 2004 cited in Apawu, 2014). After the determination of the sample size, simple random sampling technique was used in selecting the respondents for the study. That is, 183 level 300 students index numbers were inputted into the International Business Machine Statistical Package for the Social Sciences (IBMSPSS) version 26.0 and was used in selecting a sample of 125 respondents (Data → Select Cases… → Random Sample of Cases → Sample… → Exactly → 125 cases from the first 183 cases → Continue → Copy selected cases to a new dataset → Dataset name: → OK) from a population of 183. Simple random sampling was employed because all the respondents in the population have equal chance of been selected (DePersio, 2015; Meeden, 2012). Also, a simple random sample gives an accurate representation of the larger population (DePersio, 2015). The remaining 58 students who were not in the sample took part in the think aloud process and pretesting. In the first phase of the study, the entire 125 respondents making the sample size took part in the quantitative data collection whilst in the second phase, 6 selected respondents who agreed to be interviewed took part in the qualitative data collection.

In a nutshell, a sample relationship criterion with emphasis on nested sequential sample relation (Johnson & Christensen, 2008) was employed in this study. According to Johnson and Christensen (2008), a nested sequential sample relation means that the respondents that were selected for one phase of a study represent a subset of those respondents who were selected for the other phase of the same study. In this study, the 6 respondents who agreed to take part in the qualitative data collection were also part of the 125 respondents who took part in the quantitative data collection. Out of the 125 respondents who indicated their gender, 118(94.4%) were males and 7(5.6%) were females. The age of the respondents ranged from 18 to 34 and above. The frequency and percentage distribution in each age band was: 18-22(12, 9.6%), 23-27(94, 75.2%), 28-33(18, 14.4%), and 34 and above (1, .8%).

Instrumentation

With the lens of Maslow's theory of hierarchy of needs, PSMTCN framework, TPACK framework, and theory of altruism and from the research literature, and expert judgment, questionnaire and interview protocol were chosen to gather data for this study. The common benefits of a questionnaire which include uniformity of presentation of items to the respondents, the guarantee of anonymity for the respondents and the less time it takes to administer items (Fraenkel & Wallen, 2000; Muijs, 2004) made it appropriate for this study which was time bound to use questionnaire as one of the instruments. Questionnaire was also found to be appropriate for the study because the study employed a sequential explanatory mixed-methods design (Fraenkel & Wallem, 2000) and also it is the most common data collection instrument used in educational research which is more familiar to respondents (Muijs, 2004). Nonetheless, questionnaire often have low response rates and cannot probe deeply into respondents' opinions and feelings (Alhassan, 2006; Fraenkel & Wallen, 2000; Muijs, 2004) and the interview have taken care of the disadvantages to some extent.

With granted permissions (see Appendix O), survey instruments by Schmidt et al. (2010) and Landry (2010) were adapted in addition to other items developed by the researcher for the study. Fisser et al. (2015) stated that researchers have adapted the TPACK items because most studies show reliable outcomes when the TPACK items were used. Similarly, Yurdakul and Coklar (2014, p. 364) claimed that "in TPACK-related literature, it is generally seen that various studies on the development of surveys and scales were conducted with preservice teachers" and in this study, preservice mathematics teachers were respondents.

Besides, a self-developed interview protocol was designed to collect qualitative data taking into consideration the items from the questionnaire. The questionnaire (which comprised of items adapted from Schmidt et al. (2010) and Landry (2010) instruments and other items) and the interview protocol helped in either results corroboration or not and they were used sequentially. All items were generated taking into consideration the research questions. The questionnaire consisted of mainly close ended-ended items which demanded respondents to tick responses that best apply to them. It was anticipated that the calibre of respondents supplied true, genuine and reliable responses devoid of extraneous influence. The close-ended items were also aimed at ensuring uniformity in the responses and therebypreventing subjectivity of any kind. The questionnaire items were in the Likert-type scale. The questionnaire was made up of four sections as follows: Section A:

Demographic information of respondents, Section B: perceived cognitive needs via courses, Section C: Perceived knowledge level in relation to TPACK and its components, Section D: Perceived altruistic to teach mathematics. The items on the questionnaire were positively and negatively worded in order to minimize participant satisficing responses. The interview protocol was a semi- structured interview protocol structured around the research questions and the study constructs. The semi-structured interview protocol allowed clear differences and similarities that emerged between respondents but was also flexible enough to allow further probing, through the use of appropriate prompts, of interesting points or areas where information was difficult to elicit (Prescott, 2011). There were seven questions on the semi-structured interview protocol.

Scoring of the questionnaire items

The questionnaire items are on a Likert-type scale with five response choices, including "1 = strongly disagree", "2 = disagree", "3 = neutral", "4 = agree" and "5 = strongly agree" for sections B and D items which comprised of 32 items (i.e. items 3-34) and 4 items (i.e. items 71-74) respectively and "1 = poor", "2 = fair", "3 = good", "4 = very good" and "5 = excellent" for section C items which comprised of 36 items (i.e. items 35-70). That is each item response is scored with a value of 1 all the way to a value of 5. For some of the constructs, the respondent's responses were averaged (Schmidt et al., 2009). For example, the 7 questions/items under PK were averaged to produce one PK Score. According to Blaikie (2003), the Likert scale (e.g. strongly agree to strongly disagree) illustrates a scale with theoretically equal intervals among responses. However, Creswell (2012) is of the view that there is no guarantee of equal interval so Likert scale should be treated as both ordinal and interval data in educational research and should be referred to as quasi-interval.

In this study, the Likert scales were treated as interval data. Likert-type scale is easier to construct, interpret and also provide the opportunity to compute frequencies and percentages as well as statistics such as the mean and standard deviation of scores (Muijs, 2004). Likert-type scale also allows for a more sophisticated statistical analysis such as Analysis of Variance (ANOVA), T-test and regression analysis (Fraenkel & Wallen, 2000; Muijs, 2004). Moreover, Likert-type scales are often found to provide data with relatively high reliability (Gable & Wolf, 1993; Fraenkel & Wallen, 2000; Oppenheim, 1992).

Validity and reliability of the instruments

According to Dikko (2016, p. 521), "with every research design, instruments chosen for the collection of data must pass the tests of validity and reliability before they can be considered good measures". The questions of reliability and validity are essential in any research as the credibility of a research study depends on the reliability of the data, methods of data collection and also on the validity of the findings (Cohen, Manion, & Morrison, 2007; Lecompte & Preissle, 1994; Seale, 1999). The reliability of items is achieved when it consistently, and without bias, measure the concepts/constructs it is supposed to measure (Sekaran, 2003). Also, according to Czaja and Blair (2005), the reliability of data obtained through for instance questionnaire rests, in large part, on the uniform administration of questions and their uniform interpretation by respondents. Fraenkel and Wallen (2000) cautioned that it is possible to design a questionnaire that is reliable because the responses are consistent, but may be invalid because it fails to measure the concept it intended to measure. Reliability and validity in educational researches help in achieving triangulation of data collection methods (Patton, 1990, cited in Owen & Demb, 2004) and in this study, the methods of data collection were through questionnaire and interview.

Validity of an instrument is the extent to which the items in an instrument measure what they are set out to measure, while reliability on the other hand, is the extent to which items in an instrument generate consistent responses over several trials with different respondents in the same setting or circumstance (Cohen et al., 2007; Fraenkel & Wallen, 2003; Gall, Gall, & Borg, 2003; Lecompte & Preissle, 1994; Miles & Huberman, 1994; Seale, 1999). Validity is aimed at ensuring that the instrument of measurement has tapped the concept it sets out to measure by including an adequate representation of items that operationalize the concept (content validity), differentiates items on an adequate criterion (criterion-related validity) and ensures that the measure used fits around the theories for which the items are created (Construct validity) (Ghauri & Gronhaug, 2010; Sekaran, 2003) though Mouton and Marais (1996) argued that validation is not a necessity with qualitative research instrument as concepts already reflect the world of the object of study. One way to guarantee that validity is achieved in any research is to conduct a pilot study of research instruments (Dikko, 2016).

Following Dillman's (2007) methodology, the researcher's supervisors (who are experts) in addition to two (2) experts in the field of ICT integration and mathematics education at the Department of Mathematics Education in the UEW evaluated the questionnaire items as well as the semi- structured interview questions for content and construct as well as face validity. A number of discussions took place regarding the questionnaire items, both at the inception and throughout the revision of the questionnaire instrument. Based on feedback from the experts, several changes were made to the questionnaire instrument. In particular, items 43 and 44 were the same so item 44 was deleted accordingly and ICTD 361: Web Technologies for Mathematics Teachers item was initially not included and was accordingly added. Initially, there were 74 items and after expert review, it remained 74 items after an item was deleted and another item was added. Having experts review the questionnaire instrument to confirm that the items were complete, relevant, and arranged in a suitable format was important to establish an adequate level of content validity (Archambault & Crippen, 2009).

According to Archambault and Crippen (2009), validity necessitates that the items adequately measure the proposed constructs and that respondents correctly interpret what each item is asking, so piloting of the instruments was essential. A pilot study is a small type of a research or a trial run conducted in preparation of a full-scale study and may be conducted specifically to pre-test a research instrument (Teijlingen & Hundley, 2001) and Tashakkori and Teddlie (2003) have established that pilot studies are useful in both quantitative and qualitative research. Various authors (e.g. Teijlingen & Hundley, 2001; Watson, Atkinson, & Rose, 2007) have highlighted the importance of the conduct of a pilot study as fundamental to any research as it serves the function of helping to detect possible flaws in the measurement instrument and whether concepts have been adequately operationalized. Piloting is achieved by pre-testing the instrument on a small number of participants having the same characteristics as those in the main study. Sekaran (2003) argued that interviewees can bias data collected if they do not understand the questions put to them and according to Calitz (2009) a pilot test of questions helps to identify unclear or ambiguous statements in the research protocol while van Wijk and Harrison (2013) believe that pilot studies can add value and credibility to the entire research project. In essence, a pilot study helps to determine how well a research instrument will work in the real study by detecting possible problems and areas that may require modifications (Dikko, 2016).

Piloting of the instruments were conducted on 58 preservice mathematics teachers who did not take part in the main study. Out of the 58 preservice mathematics teachers, 3 took part in the think-aloud pilot but did not take part in the semi-structured interview schedule/protocol pilot study and the questionnaire pilot study. The remaining 55 preservice mathematics teachers took part in the questionnaire pilot study and 3 from the 55 also took part in the semi-structured interview schedule pilot study. The following sections describe the piloting processes the study went through.

Think-aloud pilot

Though content, construct and face validity can be confirmed by having instruments reviewed by experts, construct validity can also start to be verified by means of a think-aloud approach by allowing respondents (who would not take part in the main study) to verbalize their thought and perception about research instruments (Clement, 2000; Dillman, 2007; Fowler, 2002; Johnson & Christensen, 2008; Koichu & Harel, 2007). According to Johnson and Christensen (2008), in think-aloud technique, respondents are allowed and asked to verbalize their thoughts and perceptions about the research instrument(s) and the researcher would write down every single thing about respondents' opinions. The think-aloud technique helped the researcher to determine if the respondents get the same interpretation about the items in the questionnaire and the interview schedule. In this study, through the think-aloud approach, three preservice mathematics teachers who were not part of the sample were allowed and asked to verbalize their thoughts and perceptions about items on the questionnaire and the questions on the interview schedule and the researcher penned down every single thing about the respondents' opinions. Responses from the respondents were compared from one person to the other to make sure that the questions are being interpreted in the same way, are easy to understand, and are arranged in a logical sequence (Archambault & Crippen, 2009). After the think-aloud technique, there were some changes made to the questionnaire and the interview schedule. Preservice mathematics teachers who participated in the think-aloud understood the questionnaire instrument formatting, but had a difficult time understanding what they were being asked to rate in Section C of the questionnaire. Consequently, the Section C items on the questionnaire (items 35-70) were reframed for clarity because of the rating scale. For instance, "I know how to assess student performance in a classroom" item was changed to "My knowledge of how to assess student performance in a classroom is", "I know how to solve my own technical Problems" item was modified to "My knowledge of how to solve my own technical problems is", "I have sufficient knowledge about mathematics" item was modified to "My sufficient knowledge about mathematics is", etc. Besides, the three preservice mathematics teachers who took part in the think-aloud process agreed that "Questions concerning some of the items you have responded to in the questionnaire may be asked again" should be added to the interview schedule. The final version of the questionnaire can be found on the Appendix A page.

Pilot testing of the semi-structured interview schedule

Piloting an interview schedule is rare and sometimes not necessary (Beebe, 2007; Campell, 2017; Marshall & Rossman, 2006). Despite the uncommon piloting of an interview schedule, if a pilot study is conducted on an interview schedule, it can be helpful in the schedule refining. In addition, where an interview schedule is used as the research instrument, a pilot study helps to do the following:

i. Highlight ambiguities and difficult and unnecessary questions and discard or modify same (Campell, 2017).
ii. Record the time taken to complete the interview to determine whether it is reasonable (Dikko, 2016).
iii. Determine whether each question elicits an adequate response (Campell, 2017).
iv. Establish whether replies can be properly interpreted in relation to the information required (Teijlingen & Hundley, 2001).
v. Determine whether the researcher has incorporated all the questions necessary to measure all concepts (Berg, 2004).
vi. Allow the researcher to practice and perfect interviewing techniques (Berg, 2004).

Owing to the positives of pilot testing an interview schedule, a pilot study was conducted with three preservice mathematics teachers who were not included as respondents in the main study. The pilot testing of the semi-structured interview schedule helped the researcher to construct the questions appropriately and to remove some of the questions that did not seem to serve a purpose at all. It also ensured that there was a flow in the way questions were asked. In the conduct of the pilot testing, determinations were made by the researcher to ensure the setting, choice of respondents and interview methods were as close as those intended in the main study as possible. The pilot interview lasted for 22 minutes on the average. After the piloting of the semi-structured interview schedule, questions one and three were modified to “Have the content courses addressed your needs as preservice mathematics teacher?” and “Have the pedagogy courses addressed your needs as preservice mathematics teacher?” from “Have the content courses learned so far addressed your needs as preservice mathematics teacher?” and “Have the pedagogy courses learned so far addressed your needs as preservice mathematics teacher?” respectively. The final version of the interview schedule can be found on the Appendix B page. The piloting of the semi-structured interview schedule was not intended to produce results (Dikko, 2016) but to fine tune the interview schedule so the researcher took note of the necessary responses without audio taping and transcribing verbatim.

Pilot testing of the questionnaire instrument

Pilot testing of a questionnaire on 25-75 respondents is reasonable (Converse & Presser, 1986). According to Converse and Presser (1986), 25-75 are normally valuable pilot testing range which can vary first with the experience and the talent of the researcher. In this study, the questionnaire was tested by distributing it to a group of fifty-five (55) preservice mathematics teachers who were not part of the main study. The response rate for the questionnaire pilot study was 100% (55 respondents). The testing of the questionnaire was to check for internal consistency. Scales and tests that involve summing items are evaluated for internal consistency (Polit & Beck, 2004). The most widely approach used in checking the internal consistency of a questionnaire is the calculation of the coefficient alpha or Cronbach’s alpha (Polit & Beck, 2004). Cronbach’s alpha is mostly used when the research being carried out has multiple-items measuring a concept (How2Statsa, 2015; Tavakol & Dennick, 2011). In this study, Cronbach’s alpha (α) (or coefficient alpha) was used, based on the feedback of the pilot group, to measure the internal consistency and reliability of the questionnaire. Cronbach’s alpha is interpreted as the percentage of variance an observed scale would explain the hypothetical true scale composed of all possible items in the universe. Unidimensionality which is a fundamental assumption of Cronbach's alpha that assumes the questions are only measuring one latent variable or dimension was taken into consideration before the coefficient alphas were calculated. Cronbach's alpha usually expressed as a number between 0.0 and 1.0 (How2Statsa, 2015; Tavakol & Dennick, 2011). When α equals 0.0, the true result (score) is not measured at all and there is only an error component or a value of 0.0 means no consistency in measurement (How2Statsb, 2015). When $\alpha = 1.0$, all items measure only the true score and there is no error component or a value of 1.0 indicates perfect consistency in measurement (How2Statsb, 2015). Therefore, the closer α is to 1, the greater the internal consistency of the items. Coefficient alpha can be written as a function of number of items and the average inter- correlation among the items. The formula used to calculate the standardized Cronbach's alpha is: $\alpha = \frac{N.\bar{c}}{\bar{v}+(N-1).\bar{c}}$, where N is the numbers of items, $\bar{c}$ the average covariance between item-pairs, and $\bar{v}$ is the average variance (Statistics How To, 2017). From the Cronbach's alpha formula, if the number of items increases, Cronbach's alpha increases. As the average inter-item correlation is low, coefficient alpha will be low. As the average inter-item correlation increases, coefficient alpha increases as well (Statistics How To, 2017). Intuitively, if the inter-item correlations are high, then there is evidence that the items are measuring the same underlying construct or latent variable (How2Statsb, 2015). The value one gets for α usually indicates the percentage of the reliable variance. For instance, if one gets a value of .70, it means that 70% of the variance in the scores is reliable variance, which means that 30% is error variance (How2Statsb, 2015). The acceptable range is between 0.70 and 0.90 or higher depending on the type of research (How2Statsc, 2015). Similarly, George and Mallery (2003) provide the following rules: "($\alpha > 0.9$ (Excellent), $\alpha > 0.8$ (Good), $\alpha > 0.7$

(Acceptable), $\alpha > 0.6$ (Questionable), $\alpha > 0.5$ (Poor), and $\alpha < 0.5$ (Unacceptable)" (p. 231). Also, a rule of thumb for interpreting alpha for Likert scale questions is: $\alpha \geq 0.9$ (Excellent). $0.9 > \alpha \geq 0.8$ (Good), $0.8 > \alpha \geq 0.7$ (Acceptable), $0.7 > \alpha \geq 0.6$ (Questionable), $0.6 > \alpha \geq 0.5$ (Poor), $0.5 > \alpha$ (Unacceptable) (Statistics How To, 2017). There is still debate among researchers as to where the appropriate cut-off points are for coefficient alpha. Combing the literature, Hinton, Brownlow, McMurray, and Cozens (2004) also have the following guide: 0.90 and above shows excellent reliability, 0.70 to 0.90 show high reliability, 0.5 to 0.79 shows moderate reliability and 0.50 and below shows low reliability.

In this study, the Cronbach's alpha for all the 72 items was 0.961 (see Appendix C) indicating that the internal consistency and reliability of the questionnaire was excellent (George & Mallery, 2003; Hinton, Brownlow et al., 2004; Statistics How To, 2017). Coefficient alpha was also computed for each latent variable (see Appendix C). For items perceived content needs provided by mathematics content courses (questions 3 – 20), Cronbach's Alpha was 0.892. For items addressing perceived pedagogy needs provided by mathematics pedagogy courses (questions 21 – 27), Cronbach's Alpha was 0.917. For items addressing perceived technology needs provided by ICT courses (questions 28 – 34), Cronbach's Alpha was 0.834. For items addressing PK (questions 35 – 41), Cronbach's Alpha was 0.876. For items addressing TK (questions 42 – 47), Cronbach's Alpha was 0.924. For items addressing CK (questions 48 – 50), Cronbach's Alpha was 0.883. For items addressing TCK (questions 51 – 54), Cronbach's Alpha was 0.917. For items addressing PCK (questions 55 – 59), Cronbach's Alpha was 0.845. For items addressing TPK (questions 60 – 67), Cronbach's Alpha was 0.960. For items addressing TPACK (questions 68 – 70), Cronbach's Alpha was 0.860. Finally, for items addressing altruistic to teach mathematics (questions 71 – 74), Cronbach's Alpha was 0.662. Also, when Cronbach's Alpha was computed for individual items, the coefficient alphas were in the range of 0.960-0.963. The Cronbach's alphas were computed with the help of the IBMSPSS version 26.0. Reverse scoring was done in the IBMSPSS 26.0 before the alphas of the items, constructs alphas and the overall alpha were computed.

Data Collection Procedures

After the consent form was read to the four (4) groups of the third year Mathematics Education students (2016/2017 level 300 batch) by their class representatives and the class representatives duly signed the consent form, the questionnaire was administered to the selected sample personally with the help of the class representatives and a colleague. The questionnaire was administered personally to help improve the collection and response rate of the questionnaire. The questionnaire was collected as soon as it was filled by the respondents and no communication between respondents was allowed during the filling of the questionnaire. The responses were provided individually by the selected sample. The questionnaire response rate was 125 (100%).

Semi-structured interviews were also conducted with a small sample of six (6) preservice mathematics teachers who agreed to be interviewed. The interviewees were Student A, Student B, Student C, Student D, Student E, and Student F (pseudonyms for the interviewees). The interview was to supplement the findings of some aspects of the questionnaire. When using an interview as a research instrument, particularly face-to-face interviews, Jacob and Furgerson (2012) suggested using a setting that provides the most comfort to the participant. Participants were interviewed individually by the researcher in the researcher's office on campus. On the average, each interview lasted for 25 minutes. With the permission of participants, the interviews were audio recorded. The interview data also played the role of validity check of some of the questionnaire responses (Schuman, 1970) to some extent.

Data analysis procedures

The questionnaire data and the interview data were analysed sequentially by taking the research questions into consideration and also through the lens of the theories that guided this study. Analyses of the questionnaire data were performed using both descriptive and inferential statistics. The following subsections are on the procedures used in analysing the questionnaire data and the interview data.

Preparing the questionnaire data

The first phase of data analysis in this study was to serially number the filled questionnaire. The responses from the filled questionnaire were coded and scored. In preparing the questionnaire data in IBMSPSS, frequencies were generated to check whether there are no inaccuracies in the data. After generating the frequencies, it was detected that items 71 to 74 values were not coded and they were later coded accordingly. The label for item 74 was also changed from "To a very large extent:" to "To a very large extent: I would be more comfortable as a mathematics teacher after graduation".

Recoding variables and creating averages

To ensure that all the items were measured in the same way, items 21 to 27 and 73 were re- coded in IBMSPSS because they were worded negatively whilst the rest were worded positively (Ntoumanis, 2013). In reverse scoring, the 5 becomes 1, 4 becomes 2, 3 stays the same, 2 becomes 4 and 1 becomes 5. Averages were computed for some of the latent variables (PK, TK CK, TCK, PCK, TPK, TPACK, and AtTM).

Descriptive statistics

The IBMSPSS version 26.0 was used to generate frequencies and percentages to answer research question one. The research question one was on finding out cognitive needs via content, mathematics pedagogy and ICT courses. The frequencies and the percentages generated helped in creating frequency tables. Similarly, frequencies and percentages were generated to answer research question four. Descriptive measures including mean and standard deviation for items under the PK, TK CK, TCK, PCK, TPK, and TPACK constructs as well as descriptive statistics of TPACK and its component constructs were calculated/generated using IBMSPSS to answer research question two.

Pearson's product-moment correlation analysis

In order to answer research question three, the Pearson's product-moment correlation was used to determine the relationship among preservice mathematics teachers' ratings of their knowledge levels along the TPACK framework.

Multiple linear regression analysis

In a multiple linear regression model, we have two or more independent/predictor variables and want to determine their contribution to a single dependent/criterion/outcome/response variable (Grande, 2015; Ntoumanis, 2013). Multiple linear regression analysis was employed in this study to find out how preservice mathematics teachers' TPACK and its components relate to their perceived AtTM. In this study, the dependent variable (DV) was

AtTM and the predictor variables (PVs) variables were PK, TK CK, TCK, PCK, TPK and TPACK.

Analysis of interview responses

According to Fontana and Frey (2008), individual, face-to-face verbal interviewing is one of the most common ways to try to understand people. They suggested that semi-structured interviews provide greater breadth of understanding a phenomenon. Student A, Student B, Student C, Student D, Student E and Student F (pseudonyms for the students) were interviewed individually using face-to-face interview approach.

The interview data were analysed qualitatively based on the research questions one and four formulated for this study. In general, interview data analysis allows readers to understand the meaning of what people experience and how they make sense of it (Merriam, 2009). In this study, the process of interview data analysis involves contextualization, where research findings were interpreted with reference to data gotten from interviews (Mertler & Charles, 2011). Miles, Huberman and Saldana (2014) propose that coding where the researcher mark passages of text and write accompany explanation of what the selected passages have in common can be employed in interview data analysis. The researcher read through all the transcribed interviews several times and coded them thematically. In the course of interpreting the interview data, in order to arrive at useful findings, the researcher employed the hermeneutics approach of qualitative data analysis by reviewing the data set of the interviews intensively. Hermeneutics, a method of interpretivism, is an approach to analysis of texts that stresses how previous understandings and preconceptions shape the interpretive process (Denzin & Lincoln, 2011; Moon, 2014; Zimmermann, 2016). Data collected were also analysed by "thick description" after the researcher had read the transcribed interviews (see Appendices H, I, J, K, L, & M) and identified categories of responses that answered the research questions one and four. The researcher reported all events that emanated from the study by describing and interpreting the outcomes. Hittleman and Simon (2006, p.38) stated that the basic interview data analysis purposes are to "...describe, interpret, verify and evaluate" and further elaborated that "... in interpretive analysis, the researcher explains or creates generalizations". In this study, patterns that emerged from the interview data were summarised and described so that one can make meaning from the transcribed data.

Ethical concerns/considerations

Permission was obtained from the students of the department of mathematics education of UEW before the commencement of the study and anonymity of the respondents was protected. The purpose of the study was also communicated to the respondents after which each group representative signed a consent form (see Appendix N) on behalf of each group. In all, four representatives signed the consent form. The researcher was responsible for maintaining confidentiality (O'Brien, 2001; O'Brien, 2010). The confidentiality of information provided by all respondents were protected by reporting only group data without any major form of identification.

Summary

The study involved 125 preservice mathematics teachers of UEW. The UEW site was chosen because preservice mathematics teachers of UEW have been trained in how to use technologies with appropriate methodologies in teaching concepts. Data collected from the questionnaire were analysed using descriptive statistics, Pearson's product moment correlation and multiple linear regression. In addition, individual interviews were conducted to supplement some of the quantitative findings. Ethical issues were also taken into consideration. The next chapter presents the results obtained and the discussion of the results thereof.

CHAPTER FOUR

RESULTS AND DISCUSSION

Overview

The study sought to examine preservice mathematics teachers' cognitive needs, TPACK levels and their altruistic to teach mathematics and to also find out how TPACK and its components relate to preservice mathematics teachers' altruistic to teach mathematics (especially core mathematics). Five research questions guided the study. These questions are:

1. How do content, pedagogy and ICT courses address the cognitive needs of preservice mathematics teachers?
2. What are the levels of preservice mathematics teachers' perceptions on their TPACK in the field of mathematics?
3. What are the relationships among perceptions of preservice mathematics teachers' TK, PK, CK, PCK, TCK, TPK and TPACK?
4. To what extent will preservice mathematics teachers have the altruistic to teach mathematics after they have graduated (before internship)?
5. How do the following factors: TK, PK, CK, PCK, TCK, TPK and TPACK relate to preservice mathematics teachers' altruistic to teach mathematics (especially core mathematics)?

The findings of the study and discussion of the findings are presented in subsequent sections.

The cognitive needs of preservice mathematics teachers

In order to answer research question 1, an effort was made to find out first, what two top content, pedagogy and ICT courses have addressed the needs of the preservice mathematics teachers before finding out how the courses have addressed their needs. Data was collected from a questionnaire and an interview protocol (see Appendices A & B). Section B of the questionnaire asked the respondents to appraise the courses they have taken up to level 300 from the Department of Mathematics Education of the UEW. The respondents were asked to indicate their level of agreement on courses that have addressed their needs as preservice mathematics teachers. Table 2 shows preservice mathematics teachers' ratings on how the content courses have addressed their needs.

Table 2

Appraisal of mathematics content courses by preservice mathematics teachers

Item	D	N	A
MATD 111: Algebra I has addressed my needs as a pre-service mathematics educator to a very large extent	4(3.2%)**	4(3.2%)	117(93.6%)*
MATD 112: Geometry I has addressed my needs as a preservice mathematics educator to a very large extent	9(7.2%)**	25 (20%)	91(72.8%)*
MATD 113: Probability and Statistics I has addressed my needs as a preservice mathematics educator to a very large extent	7(5.6%)**	16(12.8%)	102(81.6%)*
MATD 121: Algebra II has addressed my needs as a pre-service mathematics educator to a very large extent	4(3.2%)**	4(3.2%)	117(93.6%)*
MATD 122: Calculus I has addressed my needs as a preservice mathematics educator to a very large extent	9(7.2%)**	25(20%)	85(68%)*

Continuation of Table 2

Item	D	N	A
MATD 123: Probability and Statistics II has addressed my needs as a preservice mathematics educator to a very large extent	11(8.8%)**	19(15.2%)	119(95.2%)*
MATD 124: Geometry II has addressed my needs as a preservice mathematics educator to a very large extent	15(12%)**	24(19.2%)	86(68.8%)*
MATD 231: Trigonometry has addressed my needs as a preservice mathematics educator to a very large extent	2(1.6%)**	10 (8.0%)	113(90.4%)*
MATD 232: Calculus II has addressed my needs as a preservice mathematics educator to a very large extent	11(8.8%)**	16(12.8%)	117(93.6%)*
MATD 241: Linear Algebra has addressed my needs as a preservice mathematics educator to a very large extent	1(0.8)**	10(8.0%)	114(91.2%)*
MATD 242: Vectors has addressed my needs as a pre- service mathematics educator to a very large extent	2(1.6%)**	13(10.4%)	110(88.0%)*
MATD 351MA: Ordinary Differential Equations has addressed my needs as a preservice mathematics educator to a very large extent	7 (5.6%)**	19(15.2%)	99 (79.2%)*
MATD 352: Introductory Analysis has addressed my needs as a preservice mathematics educator to a very large extent	14(11.2%)**	32(25.6%)	79(63.2%)*
MATD 361: Abstract Algebra has addressed my needs as a preservice mathematics educator to a very large extent	6(4.8%)**	33(26.4%)	86(68.8%)*
MATD 362: Further Statistics has addressed my needs as a preservice mathematics educator to a very large extent	28(22.4%)**	32(25.6)	65 (52.0%)*

Continuation of Table 2

Item	D	N	A
MATD 362Ma: Mechanics has addressed my needs as a preservice mathematics educator to a very large extent	14(11.2%)**	24(19.2%)	87(69.6%)*
MATD 363: Numerical Analysis has addressed my needs as a pre- service mathematics educator to a very large extent	0(0.0%)**	15(12.0%)	110(88%)*
In general, the content courses have addressed my needs as a preservice mathematics educator	1(0.8%)**	13(10.4%)	111(88.8%)*

**Sum and percentage include Strongly Disagree and Disagree and reported as Disagree
* Sum and percentage include Strongly Agree and Agree and reported as Agree

For the 17 content courses, Table 2 shows that to a very large extent, the preservice mathematics teachers of UEW agreed that the top two (2) courses that have addressed their content needs as preservice mathematics teachers are: Algebra II (119, 95.2%) and Algebra I(117, 93.6%) out of 125 respondents. Also, Introductory Analysis (79, 63.2%) and Further Statistics (65, 52.0%) were rated respectively as the two (2) bottom courses that have addressed their needs to a very large extent. The interview summary data (see Table 3) confirmed to some extent preservice mathematics teachers' quantitative appraisal of the 17 content courses.

Table 3

Interview summary of appraisal of mathematics content courses by preservice mathematics teachers

Item	D	N	A
MATD 111: Algebra I has addressed my needs as a pre-service mathematics educator to a very large extent	0(0%)**	0(0%)	6(100%)*

Continuation of Table 3

Item	D	N	A
MATD 112: Geometry I has addressed my needs as a preservice mathematics educator to a very large extent	0(0%)**	1(16.7%)	5(83.3%)*
MATD 113: Probability and Statistics I has addressed my needs as a preservice mathematics educator to a very large extent	0(0%)**	0(0%)	6(100%)*
MATD 121: Algebra II has addressed my needs as a pre-service mathematics educator to a very large extent	0(0%)**	0(0%)	6(100%)*
MATD 122: Calculus I has addressed my needs as a preservice mathematics educator to a very large extent	0(0%)**	2(33.3%)	4(66.7%)*
MATD 123: Probability and Statistics II has addressed my needs as a preservice mathematics educator to a very large extent	2(33.3%)**	0(0%)	4(66.7%)*
MATD 124: Geometry II has addressed my needs as a preservice mathematics educator to a very large extent	0(0%)**	0(0%)	6(100%)*
MATD 231: Trigonometry has addressed my needs as a preservice mathematics educator to a very large extent	0(0%)**	0(0%)	6(100%)*
MATD 232: Calculus II has addressed my needs as a preservice mathematics educator to a very large extent	0(0%)**	0(0%)	6(100%)*
MATD 241: Linear Algebra has addressed my needs as a preservice mathematics educator to a very large extent	1(16.7%)**	0(0%)	5(83.3%)*
MATD 242: Vectors has addressed my needs as a pre- service mathematics educator to a very large extent	1(16.7%)**	1(16.7%)	4(66.7%)*

Continuation of Table 3

Item	D	N	A
MATD 351MA: Ordinary Differential Equations has addressed my needs as a preservice mathematics educator to a very large extent	1(16.7%)**	0(0%)	5(83.3%)*
MATD 352: Introductory Analysis has addressed my needs as a preservice mathematics educator to a very large extent	1(16.7%)**	0(0%)	5(83.3%)*
MATD 361: Abstract Algebra has addressed my needs as a preservice mathematics educator to a very large extent	1(16.7%)**	0(0%)	5(83.3%)*
MATD 362: Further Statistics has addressed my needs as a preservice mathematics educator to a very large extent	2(33.3%)**	0(0%)	4(66.7%)*
MATD 362Ma: Mechanics has addressed my needs as a preservice mathematics educator to a very large extent	0(0%)**	0(0%)	6(100%)*
MATD 363: Numerical Analysis has addressed my needs as a pre- service mathematics educator to a very large extent	0(0%)**	0(0%)	6(100%)*
In general, the content courses have addressed my needs as a preservice mathematics educator	0(0%)**	0(0%)	6(100%)*

** Sum and percentage include Strongly Disagree and Disagree
* Sum and percentage include Strongly Agree and Agree

From the interview data, Algebra I and Algebra II were among the top content courses that have addressed the content needs of preservice mathematics teachers and Introductory Analysis and Further Statistics were among the least agreed courses that have addressed the content needs of the preservice mathematics teachers. These findings suggested that preservice mathematics teachers perceived mainly Algebra I and Algebra II courses among other content courses as courses that have addressed their needs to teach mathematics (especially core mathematics) which invariably relates to their content needs. The choice of Algebra I and Algebra II as the two top courses by the preservice mathematics teachers might be due to the fact that the SHS mathematics (core and elective) syllabi may have contents similar to Algebra I and Algebra II course contents unlike Introductory Analysis and Further Statistics courses.

In general, 88.8%(n=111) (see Table 2) of the preservice mathematics teachers agreed that the mathematics content courses they have taken have addressed their content needs to a very large extent and the interview data (see Table 3) corroborated the questionnaire data to some extent. It presupposes that the content needs (CN) of the preservice mathematics teachers have been met to a very large extent. When the interviewees were asked in what way(s) have the content courses addressed their needs they stated various reasons (see Table 4).

Table 4

Summary reasons the mathematics content courses met preservice mathematics teachers' content needs

Interviewee	Some Reason(s)
Student A	Hmmmm, sir, what I can say is that the content courses have helped me to understand some things I didn't understood when I was at SHS. For example, I can say that I can teach logarithm which I didn't understand very well when I was at SHS.
Student B	For me, I now know the geometrical interpretation of differentiation and other things that the content courses have offered me and I say that they help me paaaa.
Student C	The content courses helped in the sense that, I can say I can explain most core mathematics stuffs when I am made to teach core mathematics or even elective mathematics.
Student D	Hmmmm, the Algebra I and Algebra II courses met my needs so that I can teach topics from the core mathematics and elective maths syllabi. E.g., some proves at the SHS level can be done easily.
Student E	When it comes to detail steps of solving mathematics problems at the SHS, I would be able to take students through so I can say that the content courses have met my needs.
Student F	I got to know that zero is an even number when I entered the university so now things that I had misconception on are now made clear to me and I hope I can deliver after leaving school.

For instance, Student A stated "*Hmmmm, sir, what I can say is that the content courses* *have helped me to understand some things I didn't underst[and] when I was at SHS. For example, I can say that I can teach logarithm which I didn't understand very well when I was at SHS*" and Student C stated that "*The content courses helped in the sense that, I can say I can explain most core mathematics stuffs when I am made to teach core mathematics or even elective mathematics*". Also, Student E was of the view that "*When it comes to detail steps of solving mathematics problems at the SHS, I would be able to take students through so I can say that the content courses have met my needs*". Similar views were espoused by Student B, Student D and Student F.

From the summary interview data (see Table 5), the following mathematics content courses were perceived by the preservice mathematics teachers as courses that could be restructured in terms of content and sequencing: Abstract Algebra, Probability and Statistics II, Ordinary Differential Equations, Introductory Analysis, Geometry I, Geometry II, Further Statistics, Calculus I, Trigonometry, and Calculus II.

Table 5

Mathematics Content courses that preservice mathematics perceived could be restructured

Interviewee	Course(s)	Remark(s) on Course(s)
Student A	1. Abstract Algebra 2. Probability and Statistics II 3. Ordinary Differential Equations 4. Introductory Analysis	Restructuring certain courses like abstract algebra because they are not actually taught at the SHS level. So, if they could restructure it so that they add some of the courses they teach here into the SHS syllabus. So that teachers learning it here will have the need teaching it there.

Continuation of Table 5

Interviewee	Course(s)	Remark(s) on Course(s)
Student B	1. Abstract Algebra 2. Introductory Analysis	You see the concept is complex and sometimes you find it difficult to understand and maybe you do your possible best to learn for the exam butafter the exam of semester then you just forget everything
Student C	1. Geometry I 2. Geometry II	Abstract instead of us to investigate
Student D	1. Further Statistics 2. Geometry I	The lecturer doesn't come to class often but rather send a lot of materials for us to read and some concepts are not clear. When we started, I think it involves a lot of ICT. The Geometry I, much of it was in the classroom. If ICT is used to demonstrate some of the drawings, it would be fine.
Student E	1. Calculus I 2. Trigonometry 3. Geometry II	I think calculus one and trigonometry should be brought to [first semester] and then the others will follow. Because, in Calculus I you will be differentiating Trigonometric Functions But you do Trigonometry in two hundred and so Calculus… ehm, Geometry II… You will take functions and then, you have not done integration and then Trigonometry yet So, it makes the learning difficult. I think if we had treated Trigonometry and Calculus one in level 100, Geometry II and other courses it will be easy.
Student F	1. Calculus II 2. ODE	The ODE should come immediately after Calculus II because after Calculus 2, we do other courses before we get to ODE and then most us [forget the basics] which we are supposed to know before the ODE.

For instance, Student A stated that "*Restructuring certain courses like abstract algebra [will be very good] because they are not actually taught at the SHS level*". Also, Student B is of the view that *[Abstract Algebra] is complex and sometimes you find it difficult to understand and maybe you do your best to learn for exam but after the exam you just forget everything.* Concerning Geometry I and II courses, Student C stated that "*[they are]* *abstract instead of us to investigate*". It can be deduced from Student C's claim that Geometry I and II courses could be restructured for learners to explore rather than have abstract contents. The exploration could be done through the use of ICTs as Student D stated that "*[for] the Geometry I, much of it was in the classroom. If ICT is used to demonstrate some of the drawings, it would be fine*". For sequencing, Student E stated that "*I think Calculus I and Trigonometry I should be brought to [the first semester of level 100] and then the others will follow. Because, [in] Calculus I you will be differentiating Trigonometric Functions but you do Trigonometry in [level] two hundred and so Calculus ehm, Geometry II… You will take functions and then, you have not done integration and then Trigonometry so, it makes the learning difficult. I think if we had treated Trigonometry and Calculus I in [semester 1 of] level 100, Geometry II and other courses will be easy [to learn]*". Per Student E's claim, it can be deduced that the following content courses (Algebra I, Trigonometry and Calculus I) could be mounted for preservice mathematics teachers of UEW in semester 1 of level 100 instead of Algebra I, Geometry I and Probability and Statistics I. Student F also stated in terms of sequencing that "*the ODE should come immediately after Calculus II because after the Calculus II we do other courses before we get to ODE and [by] then most of us [forget the basics of Calculus] which we are supposed to know before the ODE*". Student F's claim that ODE should come immediately after Calculus II maybe borne out of non-revision of Calculus II. From the qualitative data, some of the content courses offered by the department of mathematics education of the UEW need to be restructured and some also need to be rearranged.

Table 6 shows preservice mathematics teachers' ratings on the pedagogy courses that have addressed their pedagogy needs. The items in Table 6 were restated after respondents responded to negatively worded statements (see Appendix A).

Table 6

Appraisal of pedagogy courses by preservice mathematics teachers

Item	D	N	A
PMTD 111: Psychology of Learning Mathematics has addressed my needs as a preservice mathematics educator to a very large extent	31(24.8%)**	14(11.2%)	80(64.0%)*
PMTD 121: Mathematics Curriculum of Learning Mathematics has addressed my needs as a preservice mathematics educator to a very large extent	32(25.6%)**	16(12.8%)	77(61.6%)*
PMTD 231: Methods of Teaching Junior High School Mathematics has addressed my needs as a preservice mathematics educator to a very large extent	34(27.2%)**	14(11.2%)	77(61.6%)*
PMTD 241: Methods of Teaching Senior High School Mathematics I has addressed my needs as a preservice mathematics educator to a very large extent	32(25.6%)**	12(9.6%)	81(64.8%)*
PMTD 351: Methods of Teaching Senior High School Mathematics II has addressed my needs as a preservice mathematics educator to a very large extent	35(28.0%)**	11(8.8%)	79(63.2%)*
EDPD 361: Pre-Internship Seminar has addressed my needs as a pre-service mathematics educator to a very large extent	35(28.0%)**	9(7.2%)	81(64.8%)*
In general, the pedagogy courses have addressed my needs as a pre-service mathematics educator to a very large extent	30(24.0%)**	14(11.2%)	81(64.8%)*

** Sum and percentage include Strongly Disagree and Disagree and reported as Disagree
* Sum and percentage include Strongly Agree and Agree and reported as Agree

From Table 6, 64.8% (n=81) respondents agreed that Methods of Teaching Senior High School Mathematics I and Pre-Internship Seminar have addressed their pedagogy needs as preservice mathematics teachers to a very large extent. The data of the questionnaire (see

Table 6) also indicated that 80(64.0%) preservice mathematics teachers agreed that Psychology of Learning Mathematics have addressed their pedagogy needs to a very large extent. Out of 125 respondents, 63.2% (n=79) agreed that Methods of Teaching Senior High School Mathematics II have addressed their pedagogy needs to teach mathematics (especially core mathematics) after they have graduated. Out of the 6 pedagogy courses, Mathematics Curriculum and Methods of Teaching Junior High School Mathematics were found to be the least rated courses. That is 77(61.6%) of preservice mathematics teachers agreed that Mathematics Curriculum and Methods of Teaching Junior High School Mathematics courses have addressed their pedagogy needs to a very large extent. The interview data (see Table 7) on the pedagogy courses has confirmed the questionnaire data (see Table 6) to some extent.

Table 7

Interview summary of appraisal of pedagogy courses by preservice mathematics teachers

Item	D	N	A
PMTD 111: Psychology of Learning Mathematics has addressed my needs as a preservice mathematics educator to a very large extent	0(0.0%)**	0(0.0%)	6(100.0%)*
PMTD 121: Mathematics Curriculum of Learning Mathematics has addressed my needs as a preservice mathematics educator to a very large extent	0(0.0%)**	2(33.3%)	4(66.7%)*
PMTD 231: Methods of Teaching Junior High School Mathematics has addressed my needs as a preservice mathematics educator to a very large extent	1(16.7%)**	1(16.7%)	4(66.7%)*
PMTD 241: Methods of Teaching Senior High School Mathematics I has addressed my needs as a preservice mathematics educator to a very large extent	1(16.7%)*	1(16.7%)	4(66.7%)*

Continuation of Table 7

Item	D	N	A
PMTD 351: Methods of Teaching Senior High School Mathematics II has addressed my needs as a preservice mathematics educator to a very large extent	0(0.0%)**	3(50.0%)	3(50.0%)*
EDPD 361: Pre-Internship Seminar has addressed my needs as a pre-service mathematics educator to a very large extent	0(0.0%)**	1(16.7%)	5(83.3%)*
In general, the pedagogy courses have addressed my needs as a pre-service mathematics educator to a very large extent	0(0.0%)	0(0.0%)	6(100.0%)

** Sum and percentage include Strongly Disagree and Disagree
* Sum and percentage include Strongly Agree and Agree

In general, 64.8%(n=81) (see Table 6) of the preservice mathematics teachers agreed that the pedagogy courses they have taken have addressed their pedagogy needs to a very large extent and the interview data (see Table 7) corroborated the questionnaire data to some extent. It presupposes that the pedagogy needs (PN) of the preservice mathematics teachers have been met to a very large extent. During the interview sessions, the interviewees were asked how the pedagogy courses have addressed their pedagogy needs and they gave various views (see Table 8).

Table 8

Summary reasons the pedagogy courses met preservice mathematics teachers' pedagogy need

Interviewee	Some Reason(s)
Student A	With the method courses taken, I can write detail lesson plan and explain topics that are in the mathematics syllabi to learners. I can also use TLMs effectively.
Student B	The training I had so far can help me use different approaches to teach a topic which I thought it is known as multiple embodiment principle hahaha. I can also motivate students by telling them that mathematics is not a difficult subject.

Continuation of Table 8

Interviewee	Some Reason(s)
Student C	Implementing a lesson plan on a topic is something that I have learnt and I hope to implement that during my internship and after graduation. When I am on the field, I would do likewise. Understanding students also was explained to us and I will not shout on my students when I found myself in the classroom.
Student D	The pedagogy courses I have taken have met my needs that I can write SMART objectives and teach systematically.
Student E	I can assess students through various means. I can make my classroom conducive for my students.
Student F	Through the pedagogy courses I have taken; I can manage my class effectively. I can also write constructive feedback in students' exercise books. The pre-internship has helped me to be effective in the classroom.

For example, Student B stated that "*the training I had so far can help me use different approaches to teach a topic which I thought it is known as multiple embodiment principle hahaha. I can also motivate students by telling them that mathematics is not a difficult subject*" and Student D said that "*the pedagogy courses I have taken have met my needs [in the sense that] I can write SMART objectives and teach systematically*". Besides, Student F said that "*through the pedagogy courses I have taken; I can manage my class effectively. I can also write constructive feedback in students' exercise books. The pre-internship has helped me [and I hope] to be effective in the classroom*". Students A, C and E have similar statements concerning how the pedagogy courses have addressed their needs.

During the interview sessions the following pedagogy courses: Methods of Teaching J.H.S. Mathematics, Methods of Teaching S.H.S. Mathematics I, Methods of Teaching S.H.S. Mathematics II and Psychology of Learning Mathematics were mentioned as courses that could be relooked at (see Table 9). For instance, Student B said that "*my* *concern is though they teach us how to prepare lesson notes and teach[ing] learning materials and the techniques or methods to tackle individual topics, [I think] maybe if you pick the core mathematics syllabus, you pick unit one, what are the activities you use to introduce this or maybe teach*".

Table 9

Pedagogy courses that preservice mathematics perceived could be restructured

Interviewee	Course(s)	Remark(s) on Course(s)
Student B	1. Methods of Teaching J.H.S Mathematics 2. Methods of Teaching S.H.S Mathematics I 3. Methods of 4. Teaching S.H.S Mathematics II	My concern is though they teach us how to prepare lesson notes and teach learning materials and the techniques or methods to tackle individual topics. Maybe if you pick the core mathematics syllabus, you pick unit one, what are the activities you use to introduce this or maybe teach.
Student C	1. Methods of Teaching S.H.S Mathematics I 2. Methods of Teaching S.H.S Mathematics II	For both methods of teaching SHS I and II, I think they should be handled in such a way that we should be taken through how to teach difficult topics in core and elective mathematics syllabi.
Student D	Methods of Teaching Senior High School Mathematics I	Core Maths. From here the students or the learners are going to teach so I think it should be one after the other.
Student E	Psychology of learning mathematics	Ehm, personally after taking the course, even though I did well … I …. But after that, it wasn't something that actually helped much. Content should be looked at again, if the content is looked at again, it will be helpful.

Deducing from Student B's concern, it can be claimed that methods of teaching J. H. S. mathematics, methods of teaching S. H. S. mathematics I and methods of teaching S. H. S. mathematics II should be restructured in such a way that concepts/topics are taken from for example the core mathematics syllabus and learners are taken through how to introduce and teach them. Student C and Student D confirmed Student B's claim but put it in different way as "*for both methods of teaching SHS I and II, I think they should be handled in such a way that we should be taken through how to teach difficult topics in core and elective mathematics syllabi and Core Maths. From here the students or the learners are going to teach so I think [topics] should be [treated] one after the other*".

The summary of the questionnaire data on the ICT courses offered by the department of mathematics education of UEW that have addressed the technology needs of her preservice mathematics teachers is shown in Table 10.

Table 10

Appraisal of ICT courses by preservice mathematics teachers

Item	D	N	A
ICTD 111: Introduction to ICT Systems and Tools for Mathematics Teachers has addressed my needs as a preservice mathematics educator to a very large extent	7(5.6%)**	9(7.2%)	109(87.2%)*
ICTD 121: Fundamentals of Computer Programming has addressed my needs as a preservice mathematics educator to a very large extent	18(14.4%)**	29(23.2%)	78(62.4%)*
ICT 231: Courseware Design and Development Using Multimedia Tools has addressed my needs as a pre-service mathematics educator to a very large extent	7(5.6%)**	7(5.6%)	111(88.8%)*
ICTD 241: Computer Applications for Teaching and Learning Mathematics has addressed my needs as a preservice mathematics educator to a very large extent	9(7.2%)**	6(4.8%)	110(88.0%)*
ICTD 351: Introduction to Computer Programming for Mathematics Teachers has addressed my needs as a preservice mathematics educator to a very large extent	15(12.0%)**	20(16.0%)	90(72.0%)*

Continuation of Table 10

Item	D	N	A
ICTD 361: Web Technologies for Mathematics Teachers has addressed my needs as a preservice mathematics educator to a very large extent	7(5.6%)**	10(8.0%)	108(86.4%)*
In general, the pedagogy courses have addressed my needs as a pre-service mathematics educator to a very large extent	6(4.8%)**	10(8.0%)	109(87.2%)*

** Sum and percentage include Strongly Disagree and Disagree and reported as Disagree
* Sum and percentage include Strongly Agree and Agree and reported as Agree

From Table 10, majority (88.8%, n=111) of the preservice mathematics teachers agreed that Courseware Design and Development Using Multimedia Tools course has addressed their technology needs to a very large extent followed by 110 (88.0%) out of 125 respondents agreeing that Computer Applications for Teaching and Learning Mathematics has addressed their technology needs as preservice mathematics teachers. The third ranked ICT course that has addressed the technology needs of the preservice mathematics teachers was Introduction to ICT Systems and Tools for Mathematics Teachers. 87.2% (n=109) of the respondents agreed that ICT Systems and Tools for Mathematics Teachers course has addressed their technology needs to a very large extent as preservice mathematics teacher. 90(72.0%) and 78(62.4%) of the respondents agreed respectively that Introduction to Computer Programming for Mathematics Teachers and Fundamentals of Computer Programming have addressed their technology needs as preservice mathematics teachers and they were the two bottom ICT courses rated by the preservice mathematics teachers. The questionnaire data related to the ICT courses (see Table 10) were also supported by the interview data (see Table 11).

In general, 87.2%(n=109) (see Table 10) of the preservice mathematics educators of UEW agreed that the ICT courses they have taken have addressed their technology needs to a very large extent and the interview data (see Table 11) corroborated the questionnaire data. It presupposes that the technology needs (TN) of the preservice mathematics teachers have been met to a very large extent.

Table 11

Interview summary of appraisal of ICT courses by preservice mathematics teachers

Item	D	N	A
ICTD 111: Introduction to ICT Systems and Tools for Mathematics Teachers has addressed my needs as a preservice mathematics educator to a very large extent	0(0.0%)**	0(0.0%)	6(100.0%)*
ICTD 121: Fundamentals of Computer Programming has addressed my needs as a preservice mathematics educator to a very large extent	1(16.7%)**	2(33.3%)	3(50%)*
ICT 231: Courseware Design and Development Using Multimedia Tools has addressed my needs as a pre-service mathematics educator to a very large extent	0(0.0%)**	0(0.0%)	6(100.0%)*
ICTD 241: Computer Applications for Teaching and Learning Mathematics has addressed my needs as a preservice mathematics educator to a very large extent	0(0.0%)**	0(0.0%)	6(100.0%)*
ICTD 351: Introduction to Computer Programming for Mathematics Teachers has addressed my needs as a preservice mathematics educator to a very large extent	1(16.7%)**	1(16.7%)	4(66.7%)*
ICTD 361: Web Technologies for Mathematics Teachers has addressed my needs as a preservice mathematics educator to a very large extent	0(0.0%)**	0(0.0%)	6(100.0%)*
In general, the pedagogy courses have addressed my needs as a pre- service mathematics educator to a very large extent	0(0.0%)**	0(0.0%)	6(100.0%)*

** Sum and percentage include Strongly Disagree and Disagree
* Sum and percentage include Strongly Agree and Agree

The interviewees gave related views on how the ICT courses have addressed their needs (see Table 12).

Table 12

Summary reasons the ICT courses met preservice mathematics teachers' ICT need

Interviewee	Some Reason(s)
Student A	I can use MS Word to prepare detail lesson plan. Hmm, with the ICT courses I have taken, I can even teach ICT at the SHS hahahahahaha.
Student B	I can incorporate ICTs into my teaching. I can teach linear programming using Excel. I can use Geogebra to explain some coordinate geometry at the SHS and more.
Student C	The ICT courses have met my needs because I can use Word to prepare documents, type mathematics expressions, equations and other mathematics stuffs.
Student D	The multimedia course has helped me a lot and I can design a lesson using PowerPoint. I can also make videos on mathematics topics for SHS students. I can develop a website. I can do a lot of mathematics things using ICTs. I can't mention all.
Student E	Through the ICT courses, I have learned a lot of softwares which can help me explain some concepts to students. E.g. I can use Word to draw mathematical shapes.
Student F	I love most of the softwares that I was thought and I hope that's why I can say that the ICT courses have met my needs. I can use Excel to keep students' records. E.g. assessment records. I can use PowerPoint to prepare lesson and do presentation on topics effectively to students.

Student A said "*I can use MS Word to prepare detail lesson plan. Hmm, with the ICT courses I have taken, I can even teach ICT at the SHS hahahahahaha*" and Student B stated that "*I can incorporate ICTs into my teaching. [For example], I can teach linear programming using Excel. I can use Geogebra to explain some coordinate geometry at the SHS and more*". Also, Student C said that "*the ICT courses have met my needs because I can use Word to prepare documents, type mathematics expressions, equations and other mathematics stuffs*". Students D, E and F gave similar opinions as Students A, B and C on how the ICT courses have addressed their needs.

The interview data revealed that the following ICT courses: Fundamentals of Computer Programming, Computer Programming for Mathematics Teachers, Computer Applications for Teaching and Learning Mathematics and Courseware Design and Development Using Multimedia Tools (see Table 13) need to be restructured.

Table 13

ICT courses that preservice mathematics perceived could be restructured

Interviewee	Course(s)	Remark(s) on Course(s)
Student A	1. Fundamental of Computer Programming 2. Computer Programming for Mathematics Teachers	This is because ermh some of the courses (e.g. ICTD 231 and ICTD 241, comparing them I can say they didn't really help me.
Student B	1. Fundamental of Computer Programming 2. Computer Programming for Mathematics Teachers	Though the lecturers teaching that course, they make it possible, available that's is things to be done in the semester. The problem is how to derive those codes.
Student C	1. Fundamental of Computer Programming 2. Computer Programming for Mathematics Teachers	Not content restructuring but the arrangement of especially ICTD 121 and ICTD 351. We take ICTD 121 in First Year Second semester and ICTD 351 in third year first semester. I think after ICTD 121, it should be followed by ICTD 351 so that we may not forget some small small concepts.
Student D	1. Computer Applications for Teaching and Learning Mathematics 2. Courseware Design and Development Using Multimedia Tools	Hmmmmm, I am just suggesting ooo sir. After multimedia, if web tech will follow, it will be okay because some techniques in multimedia can be used in web tech. Also, ICTD 241 has some content elements such as Newton Rapson's method that are thought in numerical analysis that is taken in level 300 2nd semester so if web tech can be swapped with ICTD 241, it may help.
Student E	1. Fundamental of Computer Programming 2. Computer Programming for Mathematics Trs	ICTD 351 should follow ICTD 121

For instance, Student B stated that "*though the lecturers teaching [Fundamentals of*

Computer Programming and Computer Programming for Mathematics Teachers] course[s], make it possible [for us to learn], the problem is how to derive [the] codes". Also, student C said "*not content restructuring but the arrangement of especially ICTD 121 [Fundamental of Computer Programming] and ICTD 351 [Computer Programming for Mathematics Teachers]. We take ICTD 121 in First Year Second semester and ICTD 351 in third year first semester. I think after ICTD 121; it should be followed by ICTD 351 so that we may not forget some small small concepts*". Similarly, in terms of sequencing, Student D stated that "*hmmmmm, I am just suggesting ooo sir. After multimedia, if web tech will follow, it will be okay because some techniques in multimedia can be used in web tech. Also, ICTD 241 has some content elements such as Newton Rapson's method that are thought in numerical analysis that is taken in level 300 2nd semester so if web tech can be swapped with ICTD 241, it may help".*

Preservice mathematics teachers perceived knowledge levels on TPACK and its components

To address research question two which sought to find out preservice mathematics teachers perceived knowledge level in relation to TPACK and its components, the respondents responded to thirty-six items along the areas of technology, pedagogy, content, and the combination of these areas (see items 35-70 of Appendix A). The scale for answering consisted of 1 (Poor), 2 (Fair), 3 (Good), 4 (Very Good), and 5 (Excellent). The average mean for all items (item 35-70) was 3.43. The range of responses was 4, with a minimum response of 1, a maximum response of 5, and a standard deviation of 0.708. The number of respondents, mean, and standard deviation are reported for each item in Table 14 and for each domain/construct in Table 15.

Table 14

Summary of Descriptive Statistics of Preservice Mathematics Teachers Perceived Knowledge Level in Relation to TPACK and Its Components items

Item	Subscale	Responses	Mean	Standard Deviation
35	PK	125	3.57	.826
36	PK	125	3.48	.848
37	PK	125	3.53	.867
38	PK	125	3.47	.876
39	PK	125	3.43	.995
40	PK	125	3.42	.900
41	PK	125	3.74	.950
42	TK	125	3.54	.884
43	TK	125	3.54	.894
44	TK	125	3.43	.928
45	TK	125	3.42	.944
46	TK	125	3.23	.993
47	TK	125	3.25	.913
48	CK	125	3.75	.668
49	CK	125	3.70	721
50	CK	125	3.70	.741
51	TCK	125	3.34	.814
52	TCK	125	3.29	.869
53	TCK	125	3.26	.805
54	TCK	125	3.30	.752
55	PCK	125	3.54	.798
56	PCK	125	3.65	.918
57	PCK	125	3.50	.912
58	PCK	125	3.50	.904
59	PCK	125	3.54	.903
60	TPK	125	3.18	.817
61	TPK	125	3.26	.842
62	TPK	125	3.74	.784
63	TPK	125	3.42	.743
64	TPK	125	3.34	.823
65	TPK	125	3.31	.837

Continuation of Table 14

Item	Subscale	Responses	Mean	Standard Deviation
66	TPK	125	3.16	.865
67	TPK	125	3.47	.876
68	TPACK	125	3.22	.799
69	TPACK	125	3.18	.892
70	TPACK	125	3.00	.967

Table 15

Summary of Descriptive Statistics of the domains of TPACK

Domain/Construct	Number of items	Number of Responses	Mean	Standard Deviation
PK	7	125	3.52	.70647
TK	6	125	3.40	.77805
CK	3	125	3.72	.63225
PCK	5	125	3.55	.72707
TCK	4	125	3.30	.67777
TPK	8	125	3.36	.65850
TPACK	3	125	3.13	.77598

Three dimensions categorisation by Yurdakul, Odabasi, Kilicer, Coklar, Birinci, and Kurt (2012) as low, moderate and high were used to interpret the findings. According to Yurdakul et al. (2012), if mean scores are between 1 and 2.33, the level of perception is considered as “low”. If mean scores are between 2.34 and 3.67, the level of perception is considered as “moderate”. If mean scores are between 3.68 and 5.00, the level of perception is considered as “high”.

Preservice mathematics teachers responding to the questionnaire rated their perceived knowledge as high for the domain of CK ($M = 3.72$). This average mean score indicate that the preservice mathematics teachers reported that their knowledge is high related to for example: their ability to use a mathematical way of thinking. The highest rated individual item also fell within the category of CK, sufficient knowledge about mathematics with an average response of 3.75 (see Table 14). This result suggests that the preservice mathematics teachers claimed that they have sufficient mathematics content knowledge to teach mathematics (especially core mathematics) after they have graduated. Apart from CK, the preservice mathematics teachers rated their perceived knowledge level on the other domains as moderate (see Table 15).

The first three rated domains are CK ($M = 3.72$), PCK ($M = 3.55$), PK ($M = 3.52$). This finding is similar to the finding of Archambault and Crippen (2009) and Jang and Tsai (2012) but a little bit different. That is, in Archambault and Crippen's (2009) and Jang and Tsai's (2012) studies, the first 3 high rated domains were PK, CK, and PCK whilst in this study it was CK, PCK, and PK. The slight difference might be due to the sample sizes and the setting. For instance, in this study, the sample size was 125 whilst in Archambault and Crippen's(2009) study, the sample size was 596.

The preservice mathematics teachers responding to the questionnaire felt that their perceived knowledge associated with combining technology, pedagogy, and content, for instance, their ability to teach lessons that appropriately combine mathematics, technologies and teaching approaches was not as strong as their knowledge related to pedagogy and content. The lowest individually scored item fell within the area of TPACK, rating their ability to use technology to predict students' skill/understanding of a particular topic (Item 70) at 3.00 (see Table 14), which translates to a moderate perceived level. When technology was combined with content or pedagogy, scores were 3.30 and 3.36 respectively. These ratings are lower than those associated with pedagogy and content alone, but not as low as the domain of technology by itself. In examining all three domains/constructs together, the preservice mathematics teachers rated their perceived knowledge level at 3.13. In all, the preservice mathematics teachers rated their perceived knowledge level as high and moderate (see Table 15) on TPACK and its components.

The relationships among components of TPACK

In third research question, the relationships among the components of TPACK have been investigated. In order to answer research question three, Pearson product moment correlation analysis was conducted. The sampled preservice mathematics teachers responded to items in section C (items 35-70) of the questionnaire instrument (see Appendix A). Statistical tests mostly rely upon certain assumptions about the variables used in the analysis and when these assumptions are not met the results may not be trustworthy (Field, 2005; Field, 2015; Osborne & Elaine, 2000). Before the Pearson's product-moment correlation coefficients were calculated, the constructs were subjected to the following assumptions (Grande, 2017; Lund Research Ltd, 2013; SPSS-For-Research, 2015; SPSSisFun, 2016):

1. The variables must be either interval or ratio measurements.
2. The variables must be approximately normally distributed.
3. There is a linear relationship between the two variables. That is the relationship between the variables is approximately linear.
4. Outliers are either kept to a minimum or are removed entirely. That is there are no significant outliers among the data.
5. There is homoscedasticity of the data.

The constructs (PK, TK CK, TCK, PCK, TPK, and TPACK) were measured on the interval scale (Blaikie, 2003; Creswell, 2012), hence they met the level of measurement assumption. For the normality test, the skewness for PK, TK CK, TCK, PCK, TPK and TPACK (see Table 16) were all within the range of −1 to 1 or −0.8 to 0.8 which means that all the variables are approximately normally distributed (Field, 2013; Pallant, 2013; Stack Exchange Inc., 2018).

Table 16

Skewness of TPACK and its components

Constructs	Skewness
PK	−0.205
TK	0.053
CK	−0.107
PCK	−0.083
TCK	−0.123
TPK	0.084,
TPACK	0.010

Linearity assumption was tested and it showed that the linear relationship between the constructs is approximately linear (see Figure 6).

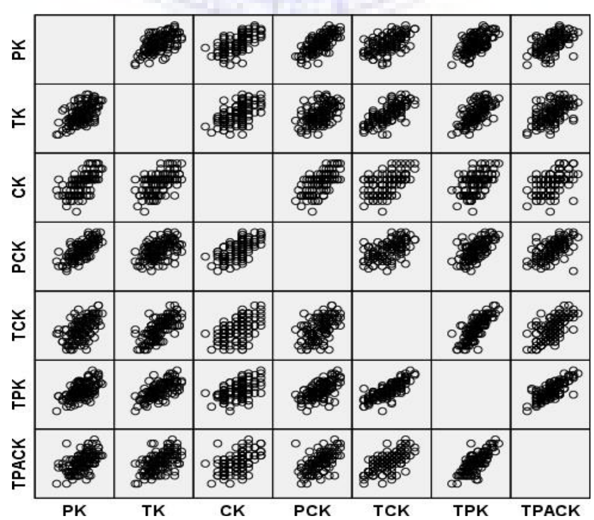

Figure 6. Linearity between TPACK and its components.

There are no outliers among the data for each construct (see Appendix D) which signifies that the outlier assumption was met. The box plot (box-and-whisker plot) was used to check for outliers (Chan, 2013; Freistadt, 2013; Grande, 2017). For homoscedasticity, from the scatter plots (see Appendix E), the points to the line of best fit for each construct have the same variance (Chee, 2015; Grande, 2017), hence the homoscedasticity assumption was met.

The Pearson Product-Moment Correlation coefficients among TPACK and its components are shown in Table 17. The examination of Pearson Correlation values indicates that there was statistically significant positive correlation among all of the components of perceived TPACK about mathematics. Moreover, the correlations were significant because they were different from zero in the entire/total population.

Table 17

Pearson product-moment correlations among TPACK and its components

	PK	TK	CK	PCK	TCK	TPK	TPACK
PK	1						
TK	.581**	1					
CK	.664**	.575**	1				
PCK	.728**	.498**	.674**	1			
TCK	.574**	.741**	.553**	.548**	1		
TPK	.607**	.682**	.543**	.634**	.807**	1	
TPACK	.548**	.549**	.547**	.570**	.680**	.775**	1

**Correlation is significant at the 0.01 level (2-tailed)

To determine the strength of the relationship, Cohen (1988) suggests a guideline: if the values of the correlation coefficient range from .10 to .29, there is a small relationship between variables. If the values of the correlation coefficient range from .30 to .49, there is a medium relationship between variables. If the values of the correlation coefficient are above .50, there is a large or strong relationship between variables (Cohen, 1988). Therefore, Table 17 indicates that there were no small relationships; all relationships among TPACK components were medium and large/strong. These strong correlations confirm similar findings by Archambault and Crippen (2009).

The highest correlation was between TCK and TPK at $\alpha = .01$ with $r = .807$, $p = .000$. The second highest correlation was between TPACK and TPK at $\alpha = .01$ with $r = .775$, $p = .000$. The third highest correlation was between TPK and TK at $\alpha = .01$ with $r = .682$, $p = .000$. On the other hand, the smallest correlation was between TK and PCK at $\alpha = .01$ with $r = .498$, $p = .000$. The r values corresponding to the remaining correlations range from .543 to .680

Altruistic to teach mathematics

In order to answer research question four, data were collected from a questionnaire and an interview protocol (see Appendices A & B). Section D of the questionnaire asked the respondents to rate their perceived altruistic to teach mathematics (especially core mathematics) on a five-point Likert scale. The respondents were asked to indicate their level of agreement on their altruistic to teach mathematics items. Table 18 shows preservice mathematics educators' ratings on their perceived altruistic to teach mathematics to a very large extent. Item 73 (see Appendix A) of the questionnaire was negatively worded so after the respondents responded to it, the item was recoded and reworded in Table 18.

Table 18

Preservice mathematics teacher ratings on altruistic to teach mathematics

To a very large extent:	SD n(%)	D n(%)	N n(%)	A n(%)	SA n(%)
I would teach with all my heart	4(3.2)	1(0.8)	4(3.2%)	33(26.4)	83(66.4)
	5(4.0%)**			116(92.8%)*	
I would help every student in my class to succeed	3(2.4)	2(1.6)	6(4.8)	42(33.6)	72(57.6)
	5(4.0%)**			114(91.2%)*	
I would research into best practices of teaching mathematics	8(6.4)	9(7.2)	9(7.2%)	25(20.0)	74(59.2)
	17(13.6%)**			99(79.2%)*	
I would be more comfortable as a mathematics educator after graduation	6(4.8)	1(0.8)	7(5.6%)	33(26.4)	78(62.4)
	7(5.6%)**			111(88.8%)*	

** Sum and percentage include Strongly Disagree and Disagree and reported as Disagree
* Sum and percentage include Strongly Agree and Agree and reported as Agree

From the summary of responses presented in Table 18, it is evident that under the altruistic to teach mathematics, 92.8% of 125 preservice respondents agreed that they are ready to teach with all their hearts (ranked first), suggesting that preservice mathematics teachers are willing to teaching mathematics (especially core mathematics) after they have graduated. Also, they might want to contribute to their society or want to make a difference in their society through teaching mathematics with all their hearts. The second most important altruistic item for preservice mathematics teachers to having the selflessness to teach mathematics obtained from the questionnaire was “I would help every student in my class to succeed” (ranked second). 91.2% of 125 preservice mathematics teachers want to have the altruistic to teach mathematics because they want to let their students, they would be teaching succeed in a mathematics class suggesting that they felt responsible for helping students succeed in mathematics (especially core mathematics) through education. Other main altruistic to teach mathematics acquired from the questionnaire data was "I would be more comfortable as a mathematics educator after graduation". 88.8% of 125 preservice mathematics teachers (ranked third) reported that no matter the odds, they would be mathematics teachers after graduation and would not change work albeit few may change work as confirmed by the interview data (see Table 19). For instance, from the interview data Student C said "*Hmmmmm, if the opportunity is better… I may leave"*. Similarly, Student F stated that "*I may [change my mind in the future not to be a mathematics educator]"* and it corroborated Student D's stand which was "*Hmmmmm, sir, if there is no opportunity, I will teach*". The data of the questionnaire also indicated that preservice mathematics teachers would research into best practices of teaching mathematics. 79.2% of 125 preservice mathematics teachers (ranked fourth) agreed that they would research into best practices of teaching mathematics. However, a closer look at the questionnaire data indicated that 13.6% of 125 preservice mathematics teachers disagree that they would research into best practices of teaching mathematics and 7.2% of 125 preservice mathematics teachers were not sure whether or not they would research into best practices of teaching mathematics.

Table 19

Some comments made by preservice mathematics teachers on altruistic to teach mathematics

Interviewee	Item	Comment(s)
Student C	I would be more comfortable as a mathematics educator after graduation	Hmmmmm, if the opportunity is better… I may leave.

Continuation of Table 19

Interviewee	Item	Comment(s)
Student C	I would be more comfortable as a mathematics educator after graduation	Hmmmmm, if the opportunity is better… I may leave.
Student D	I would be more comfortable as a mathematics educator after graduation	Hmmmmm, sir, if there is no opportunity, I will teach.
Student F	I would be more comfortable as a mathematics educator after graduation	Ooh… I can switch but then it will…. it will depend. Let's say the other side will be better than the [teaching of mathematics] I may [change my mind in the future not to be a mathematics educator]

The findings of research question four of this study indicated that it is likely preservice mathematics teachers would have the altruistic to teach mathematics (especially core mathematics) to a very large extent after they have graduated from school because over 50% of the respondents agreed to the altruistic to teach mathematics items. In all, the questionnaire data related to the altruistic to teach mathematics items were also supported by the interview data to some extent as presented in Table 20. For instance, of the 6 preservice mathematics teachers interviewed, 5 respondents agreed that they would teach with all their heart.

Table 20

Interview summary of altruistic to teach

To a very large extent:	D	N	A
I would teach with all my heart educator to a very large extent	0(0.0%)**	1(16.7%)	5(83.3%)*
I would help every student in my class to succeed	1(16.7%)**	1(16.7%)	4(66.7%)*
I would research into best practices of teaching mathematics	1(16.7%)**	1(16.7%)	4(66.7%)*
I would be more comfortable as a mathematics educator after graduation	0(0.0%)**	1(16.7)	5(83.3%)*

TPACK and its components relating to preservice mathematics teachers' altruistic to teaching mathematics

Research question five was answered using multiple regression. The criterion variable (CV) used in the multiple regression was altruistic to teach mathematics (AtTM) whilst the predictor variables (PVs) were: PV 1: TK, PV 2: PK, PV 3: CK, PV 4: PCK, PV 5: TCK, PV 6: TPK and PV 7: TPACK. For the CV and the PVs, a five-point Likert's scale items were administered. The aggregate score for the CV and the PVs were used in the multiple regression analysis.

When running a multiple linear regression, there are numerous assumptions that you need to check your data meet, in order for your analysis to be reliable and valid (Statistics Solutions, 2019; Grande, 2015; Ntoumanis, 2013; Statistics Solutions, 2018a; Statistics Solutions, 2018b) so in this study, the following assumptions were tested:

- Sample size.
- The CV is normally distributed.
- The predictors correlate with the outcome variable.
- Outliers and influential cases. That is there are no influential cases biasing the model.
- MultiCollinearity (There is no multicollinearity in the data for PVs).
- Normality of the residuals. That is the values of the residuals are normally distributed.
- Independence of residuals (Independent errors). That is the values of the residuals are independent.
- Linearity. That is the relationship between the PVs and the CV is linear.

- Homoscedasticity. That is the variance of the residuals is constant.

When an analysis meets the assumptions, the likelihoods for making Type I and Type II errors are reduced, which improves the accuracy of the research findings (Statistics Solutions, 2018b). The multiple linear regression assumptions espoused above were checked using various methods and suggestions from the literature as discussed in the subsequent paragraphs.

Sample size is essential in a multiple regression model and therefore it is important to collect enough data to obtain a reliable regression model. The rule of thumb suggests that there should be a minimum of 10 or 15 cases of data per predictor (Field, 2005). From the literature, Grande (2015) and Bradley (2017) stated that one need 20 records for each predictor variable. According to Ntoumanis (2013), there should be at least 5 participants/respondents to 1 independent variable but added that ideally, it should be 20 to 1. Further analysis of the literature shows that there is no single rule of thumb for the number of cases per a predictor. From the rule of thumb which indicated a minimum of 15 cases of data per predictor (Field, 2005; Ntoumanis, 2013), a sample size of 125 and 7 predictors (PK, TK CK, TCK, PCK, TPK and TPACK) gave approximately a ratio of 18: 1 (i.e. approximately 18 cases per a predictor) which met the sample size assumption.

For the normality of the CV, the skewness of AtTM was −0.0319 (see Appendix F). The value of the skewness for the CV falls within the range of −1 to 1 or −0.8 to 0.8 which means that the CV was approximately normally distributed (Field, 2013; Pallant, 2013; Stack Exchange Inc., 2018). Hence the CV is normally distributed assumption was met. The bivariate correlations between the PVs (PK, TK CK, TCK, PCK, TPK and TPACK) and the CV (AtTM) (see Table 21) were greater than 0.3 (Grande, 2015) which signified that the predictors correlate with the CV assumption was met.

Table 21

Bivariate correlations between PVs and CV

	AtTM	PK	TK	CK	PCK	TCK	TPK	TPACK
AtTM	1.000							
PK	.332	1.000						
TK	.584	.581	1.000					
CK	.368	.664	.575	1.000				
PCK	.350	.728	.498	.674	1.000			
TCK	.685	.574	.741	.553	.548	1.000		
TPK	.559	.607	.682	.543	.634	.807	1.000	
TPACK	.407	.548	.549	.547	.570	.680	.775	1.000

Significant outliers and influential data points can place undue influence on a model, making it less representative of data as a whole in a research (Statistics Solutions, 2019; Field, 2017; Tabachnick & Fidell, 2007). Normally, if there are no outliers, cases are within the range of -3 to 3 for the regression standardized residual (Grande, 2015; Tabachnick & Fidell, 2007). From the scatter plot (see Figure 7), there are no outliers. The box plot (see Figure 8) also showed no outlier.

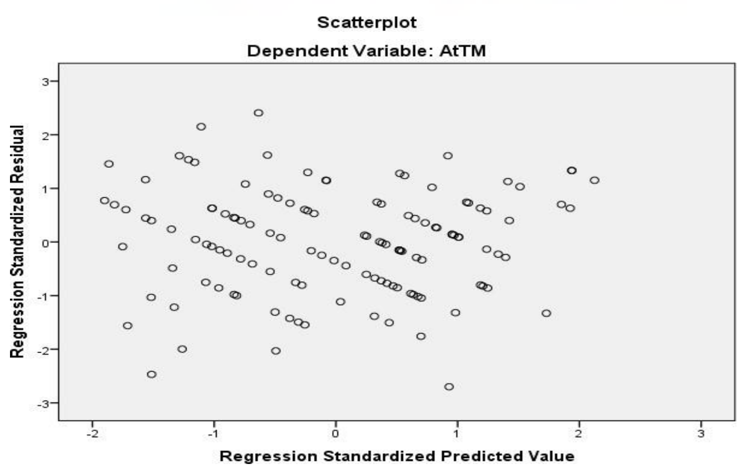

Figure 7. Scatter Plot of Regression Standardized Predicted Values against Regression Standardized Residuals.

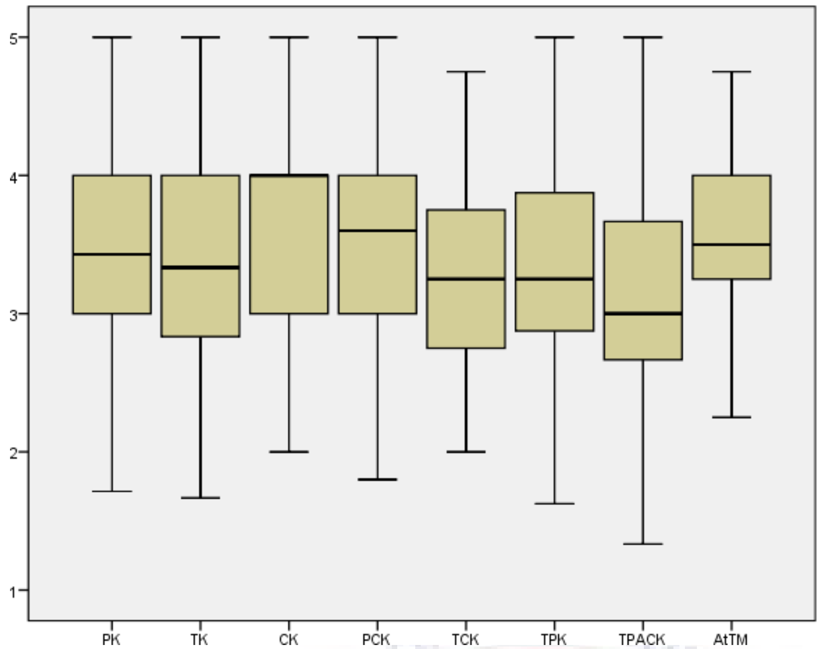

Figure 8. Box Plot.

The Cook's Distance has a minimum value of 0.000 and a maximum value of 0.104 (see Appendix F) and the values are less than 1 (Grande, 2015; Tabachnick & Fidell, 2007). Influential points were checked using Cook's Distances. According to Tabachnick and Fidell (2007), cases with values larger than 1 are a potential problem. From the table of residual statistics (see Appendix F), however, it is clear that no case had a Cook's distance greater than 1 (Max = 0.104). Cook's Distance values were all under 1, suggesting individual cases were not unduly influencing the model. Per the scatter plot, the box plot, and the Cook's Distance, the outlier and influential cases assumption was met.

Multicollinearity refers to the relationship among the PVs. Multicollinearity exists when there is a strong correlation between two or more PVs (Grande, 2015; Field, 2007). Nonetheless, in a multiple regression model, there should be no perfect linear relationship between two or more of the PVs and so, the PVs should not correlate too highly (Field, 2005; Ntoumanis, 2013). According to Tabachnick and Fidell (2007), multicollinearity exists when the PVs are highly correlated ($r \geq .9$). Also, correlation among the PVs should not be more than 0.8 (Statistics Solutions, 2019; Bradley, 2017) and Grande (2015) stated that the correlation among the PVs should not be more than 0.7. From the correlation table (see Table 21), the correlations among the PVs (PK, TK CK, TCK, PCK, TPK and TPACK) were in the range of 0.498 to 0.807 ($0.498 \leq r \leq 0.807$). From the Collinearity Statistics (see Table 22), Tolerance ranges from 0.225 to 0.428 which are all greater than 0.1 and the Variance Inflation Factor (VIF) values which range from 2.336 to 4.453 are less than 10. Hence, since the PVs correlation coefficients are less than 0.9, VIF values are less than 10 and Tolerance values are all greater than 0.1 (Statistics Solutions, 2019; Field, 2013; Ntoumanis, 2013; Tabachnick & Fidell , 2007) there is no perfect multicollinearity among the predictor variables and therefore the multicollinearity assumption was met.

Table 22

Collinearity statistics for PVs

PVs	Tolerance	VIF
PK	.379	2.639
TK	.386	2.591
CK	.428	2.336
PCK	.362	2.759
TCK	.273	3.663
TPK	.225	4.453
TPACK	.370	2.703

Residuals are differences between the obtained and predicted variable scores (i.e. AtTM). The normality of the residuals assumption is met when the residuals are normally distributed about the predicted variable, AtTM. The normality of the residuals assumption was tested by looking at the Normal P-P plot (see Figure 9). The closer the dots lie to the diagonal line, the closer to normal the residuals are distributed (Statistics Solutions, 2019; Field, 2017; Statistics Solutions, 2018b). From the normal probability plot (see Figure 9), it is clear that the scores/values lie in a reasonably straight diagonal line from bottom left to top right. It can also be seen from the histogram (Figure 10) that the distribution of the regression standardized residuals is almost normal (mean = $2.55E^{-16}$, standard deviation= 0.971). From the normal P-P and the histogram, it signified that the normality of the residuals assumption was met.

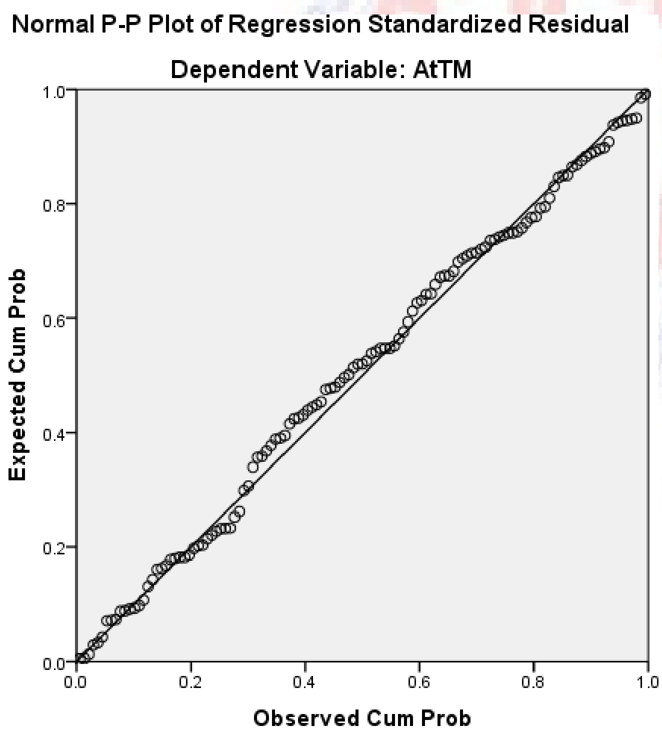

Figure 9. Normal P-P Plot.

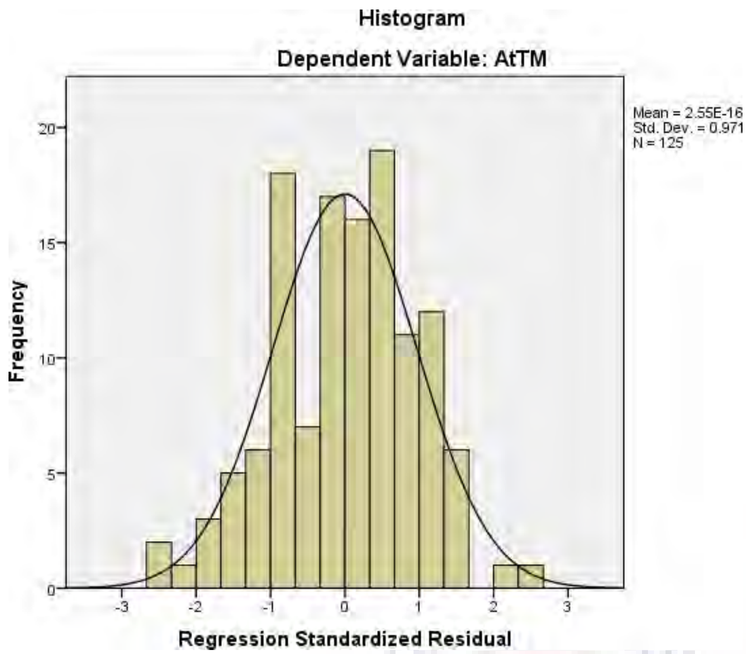

Figure 10. Histogram.

The Durbin-Watson statistic was used to test the assumption that the residuals are independent (or uncorrelated). Durbin-Watson can vary from 0 to 4 (Statistics Solutions, 2019; Field, 2017; Statistics Solutions, 2018b). For the residuals are independent assumption to be met, the Durbin-Watson statistic should be close to 2 (Statistics Solutions, 2019). Bradley (2017) is also of the view that Durbin- Watson statistic should be between 0.5 and 2.5. Durbin-Watson values below 1 and above 3 are cause for concern (Field, 2017; Statistics Solutions, 2018b). In this study, the Durbin-Watson statistic showed that the independent errors assumption had been met, as the obtained value was between 0.5 and 2.5 (Durbin- Watson = 1.703) (see Table 23). For the linearity assumption, scatterplots (see Appendix G) between the PVs and the CV show that the linearity assumption had been met. The assumption of homoscedasticity, which is the assumption that the variation in the residuals (or amount of error in the model) is similar at each point of the model was checked using the scatter plot of the standardized residuals (see Figure 11).

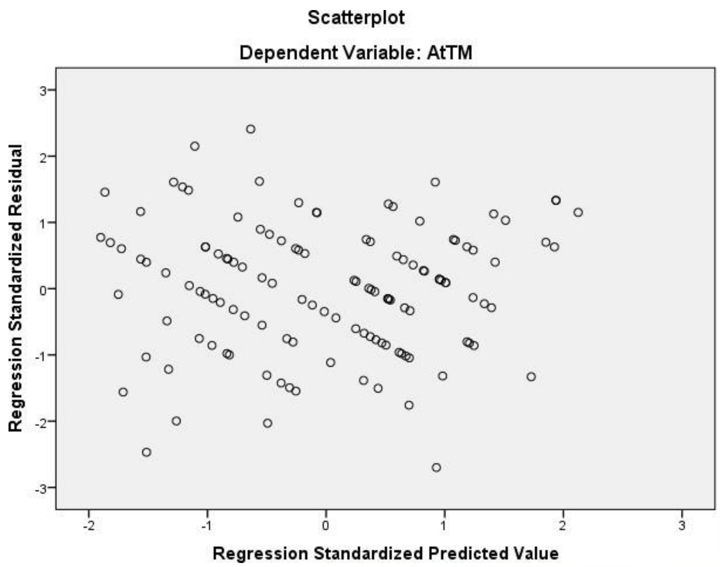

Figure 11. Plot of standardised residuals vs standardised predicted values.

The plot of standardised residuals vs standardised predicted values showed no obvious signs of funnelling, suggesting the assumption of homoscedasticity has been met. From the tests of assumptions of multiple linear regression, it was precise to conclude that no violation of the assumptions occurred in this study and therefore the use of multiple regression was justified.

All that research question 5 sought to do was to evaluate the relationship of the PVs:

PV 1: preservice mathematics educators TK,

PV 2: preservice mathematics educators PK,

PV 3: preservice mathematics educators CK,

PV 4: preservice mathematics educators PCK,

PV 5: preservice mathematics educators TCK,

PV 6: preservice mathematics educators TPK, and

PV 7: preservice mathematics educators TPACK,

individually and in linear combination, with the AtTM, using a multiple regression procedure at α = .05. In conducting a multiple regression, one can either go by the following approaches: standard approach (simultaneous method) or stepwise approach or hierarchical approach (*Analytic Strategies*, n.d.; Ge, n.d.; Kellar & Kelvin, 2013, Mitzi, 2007). Ge (n.d.) explained that for the standard approach (simultaneous method), all the predictor variables are entered at once and are treated simultaneously and on an equal footing; for the stepwise approach, the software selects the best model based on a series of steps in which variables are added and removed depending on their association with the outcome and for the hierarchical approach, the researcher compares two or more models before and after the addition of certain variables of interest and uses pre-set criteria for selecting the best model. In this study, the standard approach was employed because simultaneous model is clearly most appropriate when there are no logical or theoretical basis for considering any variable to be prior to any other, either in terms of a hypothetical causal structure of the data or in terms of its relevance to the research goals (*Analytic Strategies*, n.d.; Polit, 2010). Besides, how TPACK and its components relates to AtTM is rare in the literature so far consulted so it was expedient to employ the standard multiple regression. Also, it is only TK and PK that relate with altruism in the literature consulted so far.

In conducting the standard multiple linear regression, the following research hypotheses were tested:

(1) H_{O1}: $R = 0$, i.e. linear combination of the PVs does not significantly relate to preservice mathematics teachers altruistic to teach mathematics.

H_{A1}: $R \neq 0$, i.e. linear combination of the PVs significantly relates to preservice mathematics teachers altruistic to teach mathematics.

(2) H_{Oi}: Betai = 0, i.e. PV i does not significantly relate to preservice mathematics teachers altruistic to teach mathematics, i = 1, 2, …, 7.

H_{Ai}: Betai ≠ 0, i.e. PV i significantly relates to preservice mathematics teachers altruistic to teach mathematics, i = 1, 2, …, 7. Hypothesis (1) was used to test the significance of the combined PVs of the simultaneous regression model and hypothesis (2) was used to test for the significance of individual PVs of the simultaneous regression model.

Test of the significance of combined PVs

A simultaneous regression analysis was conducted to determine the relationship of a linear combination of the predictor variables (PV 1 – 7) with the preservice mathematics teachers AtTM. Table 23 and Table 24 show the simultaneous regression model summary and the ANOVA table respectively. The value of the multiple correlation coefficient, R, which indicates how well the PVs combined to relate with the CV (AtTM), was R = 0.718 and it signified a good level of relation. The coefficient of determination, R^2 was 0.515 and it shows that the PVs explained 51.5% of the variability of the CV (AtTM). Technically, R^2 is the proportion of variation accounted for by the regression model above and beyond the mean model (Lund Research Ltd, 2018).

Table 23

Simultaneous regression model summary

Model	R	R Squared	Adjusted R Squared	Durbin-Watson
1	.718[a]	.515	.486	1.703

a. Predictors: (Constant), TPACK, CK, TK, PCK, PK, TCK, TPK

The *F*-ratio in the ANOVA table (see Table 24) tests whether the overall simultaneous regression model is a good fit for the data. Table 24 shows that the PVs statistically significantly relate with the CV, (7, 117) = 17.779, p<0.0005 (i.e. the standard regression model was a good fit of the data). Consequently, the null hypothesis (Ho_1) was rejected which means that the linear combination of PVs significantly relates to the preservice mathematics teachers AtTM.

Table 24

ANOVA of simultaneous regression significance

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	16.013	7	2.288	17.779	.000[b]
	Residual	15.055	117	.129		
	Total	31.068	124			

a. Dependent Variable: AtTM
b. Predictors: (Constant), TPACK, CK, TK, PCK, PK, TCK, TPK

Test of the significance of the individual PVs

The significance of the individual regression coefficients, or Beta weights (see Table 25), was used to test the null hypothesis (H_{Oi}) that each of the PVs was not significantly related to preservice mathematics teachers altruistic to teach mathematics. For PV 1, the test was not statistically significant ($t = -1.506$, Beta = −.157; $p = .135$). The researcher fails to reject the null hypothesis that PV 1 does not significantly relate to preservice mathematics teachers' altruistic to teach mathematics. That is to say, preservice mathematics teachers' PK does not significantly related to their AtTM. For PV 2, the test was statistically significant ($t = 2.131$, Beta = .221; $p = .035$) and the researcher had to reject the null hypothesis that PV 2 does not significantly relate to preservice mathematics teachers' AtTM. That is to say, preservice mathematics teachers' TK does significantly relate to their AtTM. For PV 5, the test was statistically significant ($t = 5.028$, Beta = .619; p

= .000) and the researcher rejected the null hypothesis that PV 5 does not significantly relate to preservice mathematics teachers' AtTM. In other words, preservice mathematics teachers' TCK does significantly relate to preservice mathematics teachers' AtTM. PV 3, PV 4, PV 6, and PV 7 did not appear to relate to preservice mathematics teachers' AtTM. In essence, preservice mathematics teachers' PK, CK, PCK, TPK and TPACK did not appear to relate to their AtTM.

Table 25

Regression Coefficients Standard Regression Model

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	*t*	Sig.
1	(Constant)	1.948	.209		9.328	.000
	PK	-.112	.074	-.157	-1.506	.135
	TK	.142	.067	.221	2.131	.035
	CK	.007	.078	.009	.092	.927
	PCK	.033	.074	.048	.454	.651
	TCK	.457	.091	.619	5.028	.000
	TPK	.048	.103	.063	.467	.641
	TPACK	-.076	.069	-.118	-1.115	.267

Mac Tan (2019) is of the view that one should never, ever, ever drop a predictor variable just because it's not statistically significant so in this study, the full simultaneous model based on significance of combine PVs was:

$AtTM = 1.948 - 0.112(PK) + 0.142(TK) + 0.007(CK) + 0.033(PCK) + 0.457(TCK) + 0.048(TPK) - 0.076(TPACK)$. From Table 25, TCK was the single strongest predictor with a beta value of 0.619. Also, TK and TCK which were significant in the simultaneous regression model related to AtTM positively.

Discussion of major findings

Preservice mathematics teachers from UEW mostly find themselves at the SHS and it expected that their teaching skills will be apt for the transmission of the content but this study found that the pedagogy courses in general was rated the least addressing their needs among the mathematics content and the ICT courses in general and it seems to support the claim that poor teaching skills is attributed to the poor performance in core mathematics (Ansah, 2016). According to Koehler and Mishra (2009, p. 63), "Knowledge of content is of critical importance for teachers" especially preservice mathematics teachers and in this study, the preservice mathematics teachers perceived that the content courses in general (ranked 1st) have addressed their needs to a very large extent which invariably means that their content needs have been met to a very large extent. The findings for research question one in this study is consistent with findings by Brush and Saye (2009) and Cox et al. (2013) that it can be overwhelming to preservice mathematics teachers when they are taken through simultaneously the learning of mathematics content, pedagogy and technology/ICT and that is why perhaps more than 50% of the preservice mathematics teachers agreed that in general, the content, the pedagogy and the ICT courses have addressed their needs to a very large extent. The findings also concur with what earlier studies (e.g. Artzt et al., 2011; Boyd et al., 2009; da Ponte & Chapman, 2008; Hill et al., 2008; Powers & Blubaugh, 2016; Silvernam & Thomson, 2008; TEMAG, 2014) found that if preservice mathematics teachers' needs (especially content, pedagogy, and ICT needs) are addressed to a very large extent, they would have a very high confidence in teaching after they have graduated and this study reported that more than 50% of the respondents claimed that in general, the mathematics content courses, the pedagogy courses and the ICT courses have addressed their needs to a very large extent which sum up to their cognitive needs been met to a very large extent. Various views (see Tables 4, 8, and 12) were given as how the content, the pedagogy and the ICT courses have addressed the needs of the preservice mathematics teachers which confirmed studies (Cox et al., 2013; Harris & Jensz, 2006; Keith, 2004; Koehler and Mishra, 2009; Ma, 1999; Masters, 2009; Miller & Davidson, 2006; Norton, 2010; Pacific Policy Research Center, 2010; Putnam & Borko, 2000; Shulman, 1987, 1999; Silvernam & Thomson, 2008) on what fundamental needs are expected of a preservice mathematics teacher before s/he leaves schools. Moreover, this study shed light on which courses could be restructured in terms of content and sequencing by the Department of Mathematics Education of the UEW. Various suggestions by the preservice mathematics teachers on what could be done to the content courses, pedagogy courses and the ICT courses resonate the claim by Demir (2019) that preservice mathematics teachers need to be taught what they want to learn.

Within the current study, the preservice mathematics teachers reported knowledge levels were highest specific to items related to CK, PCK and PK and they were found to be the top three rated knowledge levels. This result could be for a variety of reasons, including the way the preservice mathematics teachers were taught from pre-tertiary levels up to the tertiary level. It could also suggest that the preservice mathematics teachers may have been best prepared with regard to content and pedagogy and this, together with their pre-internship course that gave them the experience of peer teaching, led to the high ratings of knowledge along these same domains. The highest mean value of preservice mathematics teachers' perceptions was content knowledge and this could mean that preservice mathematics teachers feel more competent and sophisticated related to mathematics knowledge among TPACK components. On the other hand, the least mean values of preservice mathematics teachers' perceptions correspond to TCK and TPACK. It is likely the preservice mathematics teachers do not feel themselves competent and sophisticated in knowledge that combine technologies and teaching approaches in teaching mathematical concepts.

The findings for research question two in this study is similar to or consistent with the findings from some studies (Archambault & Crippen, 2009; Bulut, 2012; Chuang & Ho, 2011; Doering et al., 2009; Doğan, 2012; Erdoğan & Şahin, 2010; Jang & Tsai, 2012; Kafyulilo et al., 2013; Koh & Chai, 2011; Özgün-Koca et al., 2010; Saltan & Arslan, 2017; Tokmak et al., 2013; Yurdakul & Coklar, 2014). For instance, Saltan and Arslan (2017) findings show that preservice mathematics teachers' ratings on technology use was not high. Also, Jang and Tsai (2012) found that preservice mathematics teachers' ratings were high on pedagogy, content, and pedagogical content. Chuang and Ho (2011) stated that in their study, preservice mathematics teachers had high level perceptions on some TPACK sub-domains and Archambault and Crippen (2009) findings indicated that knowledge ratings are high among the domains of pedagogy, content, and pedagogical content. Bulut (2012) also found highest mean value corresponding to CK and least mean value corresponding to TCK. Similarly, Erdoğan and Şahin (2010) found that mathematics teacher candidates have low TCK. These findings contribute to Koehler and Mishra (2006; 2009) theory of Technological Pedagogical Content Knowledge (TPACK).

In trying to develop preservice mathematics teachers TPACK levels, some studies (e.g. Agyei & Voogt, 2012) tried pre-test and post-test approaches. Per Yurdakul et al. (2012)

categorisation, the pre-test results in Agyei and Voogt's (2012) study showed moderate and high knowledge levels on TPACK and its components and high levels on TPACK and its components for the post-test results. Results from this study showed that preservice mathematics teachers' TPACK and its components could be developed via training in how to integrate appropriate technologies with sounding teaching approaches in teaching concepts.

The third-research question of the present study is related to the investigation of the relationships among perceptions of preservice mathematics teachers' technological pedagogical content knowledge and its components. The results indicate that there are positive relationships among the components of TPACK, and all of the relationships are statistically significant. Results of other TPACK studies support the findings of the present study. As an example, in Şahin's (2011) study, statistically significant correlations were found among the all dimensions of TPACK. Furthermore, Timur and Taşar (2011) have found high relationship between the TPACK, TPK, TCK, and TK components. Considering the findings from the present study, literature suggest that CK, PK and TK should be treated together and not separately (Koehler & Mishra, 2009; Niess, 2005; Şahin, 2011). Besides, Mishra and Koehler (2006) state that "quality teaching requires developing a nuanced understanding of the complex relationships among technology, content, and pedagogy, and using this understanding to develop appropriate, context-specific strategies and representation (p.1029)". Therefore, it can be claimed that the present study supports the intertwined relationship among CK, PK and TK as stated in the literature as well as TPACK correlational studies.

Teaching is an important profession and preservice mathematics teachers are among key players to success in education in this world (Earley, Imig, & Michelli, 2011; Lortie, 1975; Grant & Sleeter, 2007; OECD, 2005, 2010). Hence, a preservice mathematics teacher needs to be selfless in transmitting mathematics content to learners. The data from this study suggested that to a very large extent, preservice mathematics teachers have the altruistic to teach mathematics (especially core mathematics). Although academic qualification, subject matter knowledge, pedagogy and teaching skill and ICT knowledge are important, a knowledgeable teacher without altruistic to teach (especially mathematics) may not sustain quality education (Manning & Patterson, 2005). In other words, the quality of teaching is not only governed by the knowledge in content, pedagogy and ICT but also enthusiasm and commitment in teaching (Heinz, 2015; Rikard, 1999) so it was expedient to ascertain the altruistic nature of preservice mathematics teachers before they leave school. The findings for research question four indicated that two altruistic to teach mathematics measurement items were given the highest ratings by the preservice mathematics teachers: "I would be ready to teach with all my heart" was the first highest rated altruistic to teach mathematics measurement item (92.8%) and "I would help every student in my class to succeed" (91.2%) was the second highest rated altruistic to teach mathematics measurement item. These findings are consistent with what Lin et al. (2012) found that having the altruistic traits to teach learners and making learners succeed in class were the most strongly reported altruistic to teach measurement items and Kılınç et al. (2012) found that the highest rated altruistic to teach items were social utility values (make social contribution such as helping learners succeed in class, shape future of adolescent by teaching with your heart, etc.). Additionally, Kyriacou et al. (2003) found that a socially worthwhile job which in this study was “I would be more comfortable as a mathematics educator after graduation” received a high percentage of respondents and it is also similar to the findings of Lortie (1975), Yong (1995), Schutz, Crowder, and White (2001), Lai, Chan, Ko, and So (2005), Manuel and Hughes (2006), Bruinsma and Canrinus (2012) that contribution to society/country received a high percent of respondents despite it was low. This study also found that qualitative and questionnaire data revealed that the respondents were ready to research into best practices of teaching mathematics. This finding is similar to what other researchers such as Schutz et al. (2001), Hobson et al. (2004), Lai et al. (2005), Manuel and Hughes (2006), Richardson and Watt (2006), Bruinsma and Canrinus (2012), and Kılınç et al. (2012) found that researching to teach is one of the altruistic to teach measurement items which need to be ascertained before a preservice teacher leaves school. Regrettably, with the qualitative data, the 6 respondents that we interviewed did not give much information on the altruistic to teach mathematics measurement items. All the same, data show that the preservice mathematics teachers have the inner passion to teach mathematics (Nyaumwe et al., 2004; Stokes, 2007) after graduation.

For research question five, a simultaneous multiple regression was carried out to investigate whether TPACK and its components relate to preservice mathematics teachers' AtTM. The results of the simultaneous multiple regression indicated that the model explained 51.1% of the variance and that the model was a significant and a good fit of the data, $(7, 117) = 17.779$, $p<0.000$. While TK and TCK contributed significantly to the model ($\beta = 0.142$, $p<.05$ and $\beta = 0.457$, $p<.05$ respectively), PK, CK, PCK, TPK and TPACK did not ($\beta = -0.112$, $p=.135$; $\beta = 0.007$, $p=.927$; $\beta = 0.033$, $p=.651$; $\beta = 0.048$, $p=.641$ and $\beta = -0.076$, $p=.267$ respectively). These findings confirm the claim by Chan and Ma (2014), Klisanin (2011), Kuznetsov (2006), Pee (2018), Prasarnphanich and Wagner (2009), Rafaeli and Ariel (2008) and Xu and Li, (2015) that technology could relate altruism in the sense that if a preservice mathematics teacher have a positive technology knowledge, s/he could selflessly share resources to his/her will be learners. One of the conditions that might explain PK, CK, PCK, TPK and TPACK not relating significantly with preservice mathematics teachers' AtTM may be the level of their relationship with the other two (TK and TCK) PVs. It would appear, therefore, that when all PK, CK, PCK, TPK and TPACK are included in the regression model, there would be a lot of shared variance among them that is statistically removed due to their overlaps. Thus, the importance of PK, CK, PCK, TPK and TPACK may be subsumed in the contributions of the other two significant factors (TK and TCK). The findings in the simultaneous regression model revealed that TCK is the most important factor for determining the preservice mathematics teachers' AtTM followed by TK. These findings add up to other TPACK regression studies by Abbitt (2011a), Apeanti (2010), Chai et al. (2013c) and Horzum (2013).

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary

Using Maslow's theory of hierarchy of needs, TPACK's framework (Koehler & Mishra, 2006), altruism theory as theoretical frameworks and PMTCN framework in addition to extensive review of the literature, this study examined preservice mathematics teachers perceived: cognitive needs, TPACK levels as well as their altruistic to teach mathematics. The preservice mathematics teachers of UEW have never appraise all the courses they have taken at ago to find out whether the courses they have taken have addressed their needs to a very large extent or not. Also, often, stakeholders of education in Ghana normally comment on WASSCE mathematics (especially SHS core mathematics) performance of students without finding out how preservice mathematics teachers are trained. In terms TPACK studies, Chai et al. (2013) and Mishra et al. (2014) are of the view that studies in higher education setting should be carried out and more investigations into specific content areas such as mathematics are needed.

There are limited studies on whether preservice mathematics teachers have altruistic traits to teach mathematics (especially at the SHS level) after graduation and will not move to other sectors apart from the education sector. Literature shows that TK and PK relate altruism so this study made an attempt to find out how TPACK and its components relates with altruistic to teach mathematics.

The study was guided by the following research questions:

1. How do content, pedagogy and ICT courses address the cognitive needs of

preservice mathematics teachers?

2. What are the levels of preservice mathematics teachers' perceptions on their TPACK in the field of mathematics?
3. What are the relationships among perceptions of preservice mathematics teachers' TK, PK, CK, PCK, TCK, TPK and TPACK?
4. To what extent will preservice mathematics teachers have the altruistic to teach mathematics after they have graduated (before internship)?
5. How do the following factors: TK, PK, CK, PCK, TCK, TPK and TPACK relate to preservice mathematics teachers' altruistic to teach mathematics (especially core mathematics)?

This study employed the sequential explanatory mixed-methods research approaches (Creswell & Plano Clark, 2011; Creswell, 2012; Johnson & Christensen, 2008; Hughes & Sharrock, 2007; Teddlie & Tashakkori, 2009). The study involved 125 preservice mathematics teachers of UEW. The UEW site was chosen because preservice mathematics teachers of UEW are trained in how to use technologies and methods in teaching concepts. Questionnaire and interview were the instruments used to collect data. Data collected from the questionnaire were analysed using descriptive statistics, Pearson's product moment correlation and multiple linear regression. In addition, individual interviews were conducted to supplement some of the quantitative findings.

Summary of key findings

For research question one, it was found that in general, 88.8% (n=111) of the preservice mathematics teachers agreed that the mathematics content courses they have taken have addressed their needs to a very large extent, 87.2% (n=109) agreed that the ICT courses they have taken have addressed their needs to a very large extent and 64.8% (n=81) agreed that the pedagogy courses they have taken have addressed their needs to a very large extent. Since over 50% of the preservice mathematics teachers agreed that their content, pedagogy, and technology needs have met, one could conclude that their cognitive needs have been met to a very large extent. There were opinions on how the content, the pedagogy and the ICT courses have addressed the needs of the preservice mathematics teachers. From the interview data, the respondents alluded to the restructuring of some of the courses in terms of content and sequencing.

For research question two, it was found that the preservice mathematics teachers reported their perceived knowledge levels were highest specific to items related to CK, PCK, and PK. In all, the preservice mathematics teachers rated their knowledge level as moderate and high on TPACK and its components. For research question three, results indicate that there are positive relationships among the components of TPACK, and all of the relationships are statistically significant. For research question four, data from this study suggested that to a very large extent, preservice mathematics teachers have the altruistic to teach mathematics (especially core mathematics). The findings for research question four also indicated that two altruistic to teach mathematics measurement items were given the highest ratings by the preservice mathematics teachers: “I am ready to teach with all my heart” was the first highest rated altruistic to teach mathematics measurement item (92.8%) and “I would help every student in my class to succeed” (91.2%) was the second highest rated altruistic to teach mathematics measurement item.

For research question five, the results of the simultaneous multiple regression indicated that the model explained 51.1% of the variance and that the model was a significant and a good fit of the data, (7, 117) = 17.779, $p<0.000$. While TK and TCK contributed significantly to the model ($\beta = 0.142$, $p<.05$ and $\beta = 0.457$, $p<.05$ respectively), PK, CK, PCK, TPK and TPACK did not ($\beta = -0.112$, p=.135; $\beta = 0.007$, p=.927; $\beta = 0.033$, p=.651; $\beta = 0.048$, p=.641 and $\beta = -0.076$, p=.267 respectively). The findings in the simultaneous regression model revealed that TCK is the most important factor for determining the preservice mathematics teachers' AtTM followed by TK.

In a nut shell, the major findings from this study include:

- The cognitive needs of the PSMTs have been met to a very large extent
- The perceived knowledge level of the PSMTs on TPACK and its components were moderate and high
- There were positive relationships among the components of TPACK, and all of the relationships were statistically significant
- The PSMTs have the altruistic to teach mathematics (especially core mathematics) after they have graduated or during internship
- TPACK and its components combined related significantly to PSMTs' AtTM, and TCK and TK were the individual PVs that significantly related to PSMTs' AtTM

Implications for practice

This study found that the preservice mathematics teachers agreed to a very large extent that in general, the mathematics content courses have addressed their needs followed by the ICT courses and then the pedagogy courses. If preservice mathematics teachers' needs (especially content, pedagogy, and ICT needs) are addressed to a very large extent, they would have very high confidence in teaching (Boyd et al., 2009; da Ponte & Chapman, 2008; Cox et al., 2013; Silvernam & Thomson, 2008). There is the need to beef up the pedagogical skills (Ansah, 2016) of preservice mathematics teachers so that they will be able to go out there and teach mathematics (especially core mathematics) very well since they rated in general the pedagogy courses as the least courses that have addressed their needs. Since the level of preservice mathematics teachers on TPACK and its components were moderate and high, efforts should be made to maintain the level and move the moderate ones to high so that integrating technology/ICT into the teaching and learning of mathematics at the SHS level can be sustained after they have graduated. TPACK was developed to assist with the integration of technology across the curriculum, the implication is that properly prepared preservice mathematics teachers could take advantage of the exclusive features of technology to teach content in ways they otherwise could not (Garofalo et al., 2001).

Concerning the relationships among preservice mathematics teachers' perceptions of TPACK components, the findings state that there were strong relationships between TPACK, TPK, TCK, and TK. Based on the literature, in TPACK, there are also the complex interrelationship among content, pedagogy and technology, and their intersections. Nevertheless, findings of the present study show that the relationships between knowledge domains regarding technology and knowledge domains of pedagogy, content and pedagogical content are not as high as the relationships between each other. Therefore, in order to increase the relationships between knowledge domains related to technology and other knowledge domains, mathematics teacher education programmes should be able to develop preservice mathematics teachers' TPACK in an integrated manner.

It was found that preservice mathematics teachers to a very large extent have the altruistic to teach SHS mathematics (especially core mathematics) so measures need to be put in place to sustain their altruistic to teach mathematics after they have graduated. Numerous positive factors have been noted as influencing preservice mathematics teachers' desire to teach after leaving school and altruistic is one them (Yüce et al., 2013).

In this study, one of the most significant findings was TCK and TK significantly related to preservice mathematics teachers' AtTM. Also, when TPACK and its components were combined, they significantly related to preservice mathematics teachers' AtTM. As a result, there is a need for the department of mathematics education of UEW to reinforce these significant factors that relate to preservice mathematics teachers' AtTM.

Conclusions

Based on the findings made in this study, it can be concluded that:

- PSMTs cognitive needs could be met via the courses offered to them.
- PSMTs TPACK levels could be moderate or high if they are taken through how to integrate technologies interspersed with pedagogies in the T & L of mathematics.
- PSMTs having altruistic traits could help learners learn mathematics effectively.
- There are other factors that could relate to PSMTs AtTM.

Recommendations

This study examined UEW preservice mathematics teachers perceived: cognitive needs, TPACK levels and their altruistic to teach mathematics (especially core mathematics). The findings of this study, therefore, are generalizable to the preservice mathematics teachers of UEW in particular, and to similar institutions elsewhere in Africa and other developing countries. Furthermore, based on the findings in this study, it is recommended that:

- the department of mathematics education of UEW should restructure Geometry I and Geometry II course contents to include exploration through the use of ICT.
- the department of mathematics education of UEW should mount the following content courses: Algebra I, Trigonometry and Calculus I for preservice mathematics teachers in semester 1 of level 100 instead of Algebra I, Geometry I and Probability and Statistics I.
- the department of mathematics education of UEW should make sure Ordinary Differential Equations is taken the next semester after Calculus II
- methods of teaching J. H. S. mathematics, methods of teaching S. H. S. mathematics I and methods of teaching S. H. S. mathematics II should be handled in such a way by the department of mathematics education of UEW so that students are taken through unit by unit of the syllabi (J. H. S. mathematics syllabus, core mathematics syllabus, and elective mathematics syllabus) in terms of how to introduce concepts and how to teach them.
- the department of mathematics education of UEW could let preservice mathematics teachers take Computer Programming for Mathematics Teachers next semester after Fundamentals of Computer Programming and Computer Programming for Mathematics Teachers.
- the department of mathematics education of UEW should swap Computer Applications for Teaching and Learning Mathematics and Web Technologies for Mathematics Teachers for preservice mathematics teachers.

- courses in preservice mathematics teacher preparation programmmes should be designed very carefully.
- preservice mathematics teacher training could be done alongside the training in how to integrate technologies with pedagogies into the teaching of mathematics.
- the preservice mathematics teaches perceived knowledge level in terms of TPACK and its components should be maintained as high for CK and the rest improved to high so that they can integrate technologies/ICTs into the teaching and learning processes after they have graduated.
- the preservice mathematics teachers altruistic to teach especially mathematics should be maintained and having the desire to research into best practices of teaching mathematics should be work on.
- more studies need to be undertaken to find out which TPACK domains in addition to TK and TCK relate to preservice mathematics teachers AtTM.

Areas for further research

More research on cognitive needs could be conducted on preservice mathematics teachers in other jurisdiction because of varied ways of training preservice mathematics teachers. Also, TPACK studies could be conducted on preservice mathematics teachers who are trained in how to use technologies blended with pedagogies in teaching concepts every semester to see whether their TPACK is been developed from one semester to the other. Finally, similar studies could be conducted on in-service mathematics teachers.

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APPENDIX A: PRESERVICE MATHEMATICS TEACHERS' PERCEIVED: COGNITIVE NEEDS, TPACK LEVELS AND AtTM QUESTIONNAIRE

INSTRUCTIONS

Thank you for taking time to complete this questionnaire. Please answer each question to the best of your knowledge. Your thoughtfulness and candid responses will be greatly appreciated. **Your individual name or identification number is <u>not required</u>**. Your responses will be kept completely **<u>confidential</u>**.

A. DEMOGRAPHIC INFORMATION

Please tick (✓) in the appropriate space provided below where applicable

1. Gender: [ ] Female [ ] Male

2. Age range (a). 18-22[ ] (b). 23-27 [ ] (c). 28-33 [ ] (d). 34+[ ]

B. PRESERVICE MATHEMATICS TEACHERS' PERCEIVED VIEWS ABOUT THEIR COGNITIVE NEEDS PROVIDED BY THE COURSES OFFERED TO THEM

Be very candid about how the following courses you have taken have addressed your needs as a preservice mathematics teacher. *Please, tick (✓) the option that best reflects your thought in the table below. Please answer all the questions and if you are uncertain of your response you may always select "Neutral".*

Rating Scale: Strongly Agree (SA), Agree (A), Neutral (N), Disagree (D), Strongly Disagree (SD)

The following content courses have addressed my needs as a preservice mathematics teacher to a very large extent:	SA	A	N	D	SD
3. MATD 111: Algebra I					
4. MATD 112: Geometry I					
5. MATD 113: Probability and Statistics I					
6. MATD 121: Algebra II					
7. MATD 122: Calculus I					
8. MATD 123: Probability and Statistics II					
9. MATD 124: Geometry II					
10. MATD 231: Trigonometry					
11. MATD 232: Calculus II					
12. MATD 241: Linear Algebra					
13. MATD 242: Vectors					
14. MATD 351MA: Ordinary Differential Equations					

15. MATD 352: Introductory Analysis					
16. MATD 361: Abstract Algebra					
17. MATD 362: Further Statistics					
18. MATD 362Ma: Mechanics					
19. MATD 363: Numerical Analysis					
20. In general, the content courses have addressed my needs as a preservice mathematics educator.					
The following pedagogy courses have NOT addressed my needs as a preservice mathematics educator to a very large extent:	**SA**	**A**	**N**	**D**	**SD**
21. PMTD 111: Psychology of Learning Mathematics					
22. PMTD 121: Mathematics Curriculum					
23. PMTD 231: Methods of Teaching Junior High School Mathematics					
24. PMTD 241: Methods of Teaching Senior High School Mathematics I					
25. PMTD 351: Methods of Teaching Senior High School Mathematics II					
26. EDPD 361: Pre-Internship Seminar					
27. In general, the pedagogy courses have NOT addressed my needs as a preservice mathematics educator.					
The following ICT courses have addressed my needs as a pre-service mathematics educator to a very large extent:	**SA**	**A**	**N**	**D**	**SD**
28. ICTD 111: Introduction to ICT Systems and Tools for Mathematics Teachers					
29. ICTD 121: Fundamentals of Computer Programming					
30. ICT 231: Courseware Design and Development Using Multimedia Tools					
31. ICTD 241: Computer Applications for Teaching and Learning Mathematics					
32. ICTD 351: Introduction to Computer Programming for Mathematics Teachers					
33. ICTD 361: Web Technologies for Mathematics Teachers					
34. In general, the ICT courses have addressed my needs as a preservice mathematics educator.					

C. PERCEIVED KNOWLEDGE LEVEL IN RELATION TO TPACK AND ITS COMPONENTS

Technology is a broad concept that can mean a lot of different things. For the purpose of this questionnaire, technology is referring to digital technology/technologies/ICTs. That is, the digital tools we use such as computers, laptops, iPods, handhelds, interactive whiteboards, software, etc. *Please, tick (✓) the option that best reflects your perceived knowledge level in relation to the items in the table below.*

Rating Scale: Poor (P), Fair (F), Good (G), Very Good (VG), Excellent (E)

Pedagogical Knowledge (PK)	P	F	G	VG	E
35. My knowledge of how to assess student performance in a classroom is					
36. My ability to determine a particular strategy best suited to teach a specific concept is					
37. My ability to use a variety of teaching strategies to relate various concepts to students is					
38. My ability to adjust teaching methodology based on student performance/feedback is					
39. My assessment of student learning in multiple ways is					
40. My awareness with common student understandings and misconceptions is					
41. My knowledge of how to organize and maintain classroom management is					
Technological Knowledge (TK)	**P**	**F**	**G**	**VG**	**E**
42. My knowledge of how to solve my own technical problems is					
43. My ability to learn technology easily is					
44. My ability to keep up with important new technologies is					
45. My ability to frequently play around technology is					
46. My knowledge about a lot of different technologies is					
47. My ability to have the technical skills I need for technology use is					
Content Knowledge (CK)	**P**	**F**	**G**	**VG**	**E**
48. My sufficient knowledge about mathematics is					
49. My ability to use a mathematical way of thinking is					
50. My knowledge about various ways and strategies of developing my understanding of mathematics is					
Technological Content Knowledge (TCK)	**P**	**F**	**G**	**VG**	**E**
51. My knowledge about technologies that I can use for understanding and doing mathematics is					
52 My knowledge of how to choose technologies that enhance the teaching approaches for a lesson is					
53 My ability to make connections with students as to why technology is useful for certain mathematics problems is					
54. My ability to thinking critically about how to use technology in my mathematics classroom is					
Pedagogical Content Knowledge (PCK)	**P**	**F**	**G**	**VG**	**E**
55. My ability to select effective teaching approaches to guide student thinking and learning in mathematics is					
56. My ability to distinguish between correct and incorrect problem solving attempts by students is					
57. My ability to anticipate likely student misconceptions within a particular topic is					

58. My ability to comfortably produce lesson plans with an appreciation for a topic is					
59. My ability to assist students in noticing connections between various concepts in a mathematics curriculum is					
Technological Pedagogical Knowledge (TPK)	**P**	**F**	**G**	**VG**	**E**
60. My ability to choose technologies that enhance the teaching approaches for a lesson is					
61. My ability to choose technologies that enhance students' learning for a lesson is					
62. My knowledge about how the BSc. (Mathematics Education) programme has caused me to think more deeply about how technology could influence the teaching approaches in my classroom is					
63. My ability to thinking critically about how to use technology in my classroom is					
64. My ability to adapt the use of the technologies that I am learning to different teaching activities is					
65. My ability to select technologies to use in my classroom that enhance what I teach, how I teach and what students learn is					
66. My ability to experiment with new technologies for mathematics teaching and learning is					
67. My ability to use technology to manage student assessment information is					
Technological Pedagogical Content Knowledge (TPACK)	**P**	**F**	**G**	**VG**	**E**
68. My ability to teach lessons that appropriately combine mathematics, technologies and teaching approaches is					
69. My ability to use technology to create effective representations of content that depart from textbook knowledge is					
70. My ability to use technology to predict students' skill/understanding of a particular topic is					

D. PRESERVICE MATHEMATICS TEACHERS PERCEIVED ALTRUISTIC TO TEACH MATHEMATICS

In this section, you are expected to be frank on your selflessness/desire to teach mathematics (especially core mathematics) at the Senior High School level. *Please, tick* (✓) *the option that best reflects how you associate with each of the following statements in the table below.*

Rating Scale: Strongly Agree (SA), Agree (A), Neutral (N), Disagree (D), Strongly Disagree (SD)

To a very large extent:	**SA**	**A**	**N**	**D**	**SD**
71. I would teach with all my heart					
72. I would help every student in my class to succeed					
73. I would avoid researching into best practices of teaching mathematics					

74. I would be more comfortable as a mathematics teacher after graduation					

APPENDIX B: SEMI-STRUCTURED INTERVIEW PROTOCOL

Thank you for agreeing to participate in this interview which is part of my PhD work at the University of Education, Winneba. I will ask you questions about the training you have gone through so far from the Department of Mathematics Education of the University of Education, Winneba. The questions will be centred on content, technology and pedagogy courses. I will also find out from you whether you would have traits to teach mathematics (especially core mathematics) after graduation. There is no right or wrong answer to the questions, so please answer them as honestly as possible. Questions concerning some of the items you have responded to in the questionnaire may be asked again. There will be follow-up questions and you are at liberty to provide me with as many examples as you can offer. Your name will not be associated with your answers, so please feel free to answer honestly.

Question 1

Have the content courses addressed your needs as preservice mathematics teacher?

Question 2

What are some of the content courses you think can be restructured?

Question 3

Have the pedagogy courses addressed your needs as preservice mathematics teacher?

Question 4

What are some of the pedagogy courses you think can be restructured?

Question 5

Have the ICT courses addressed your needs as preservice mathematics teacher?

Question 6

What are some of the ICT courses you think can be restructured?

Question 7

Do you have the desire to teach mathematics (especially core mathematics) after graduation?

Thank you for your time for me

APPENDIX C: RELIABILITY STATISTICS OF THE QUESTIONNAIRE INSTRUMENT

Scale: ALL VARIABLES

Case Processing Summary

		N	%
Cases	Valid	55	100.0
	Excluded[a]	0	.0
	Total	55	100.0

a. Listwise deletion based on all variables in the procedure

Reliability Statistics

Cronbach's Alpha	N of Items
.961	72

Content needs provided by Content Courses Items

Reliability Statistics

Cronbach's Alpha	N of Items
.892	18

Pedagogy needs provided by Mathematics Pedagogy Courses Items

Reliability Statistics

Cronbach's Alpha	N of Items
.917	7

Technology needs provided by ICT Courses Items

Reliability Statistics

Cronbach's Alpha	N of Items
.834	7

Pedagogical Knowledge (PK) Items

Reliability Statistics

Cronbach's Alpha	N of Items
.876	7

Technological Knowledge (TK) Items
Reliability Statistics

Cronbach's Alpha	N of Items
.924	6

Content Knowledge (CK) Items
Reliability Statistics

Cronbach's Alpha	N of Items
.883	3

Technological Content Knowledge (TCK) Items
Reliability Statistics

Cronbach's Alpha	N of Items
.917	4

Pedagogical Content Knowledge (PCK) Items
Reliability Statistics

Cronbach's Alpha	N of Items
.845	5

Technological Pedagogical Knowledge (TPK) Items
Reliability Statistics

Cronbach's Alpha	N of Items
.960	8

Technological Pedagogical Content Knowledge (TPACK) Items
Reliability Statistics

Cronbach's Alpha	N of Items
.860	3

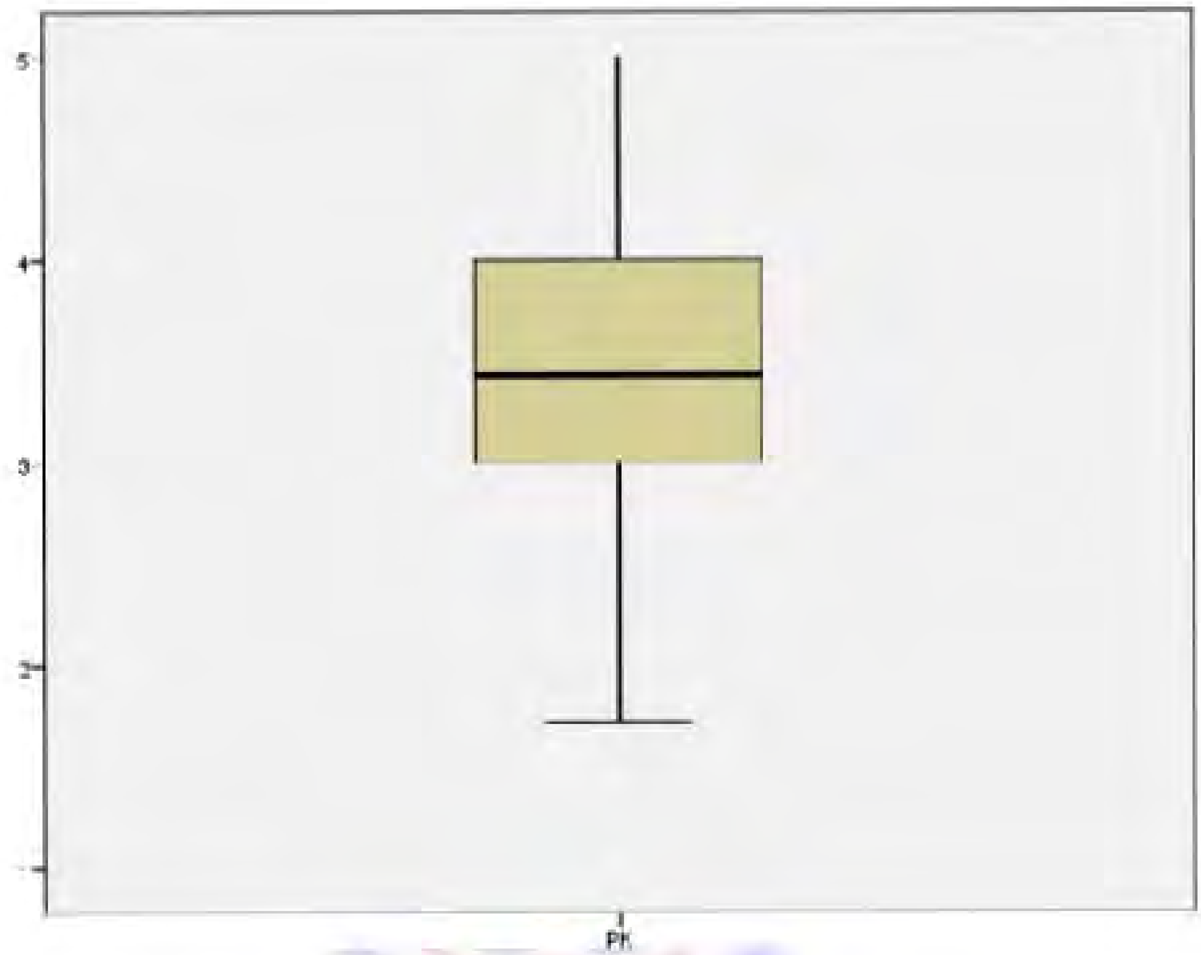
Altruistic to Teach Mathematics
Items Reliability Statistics

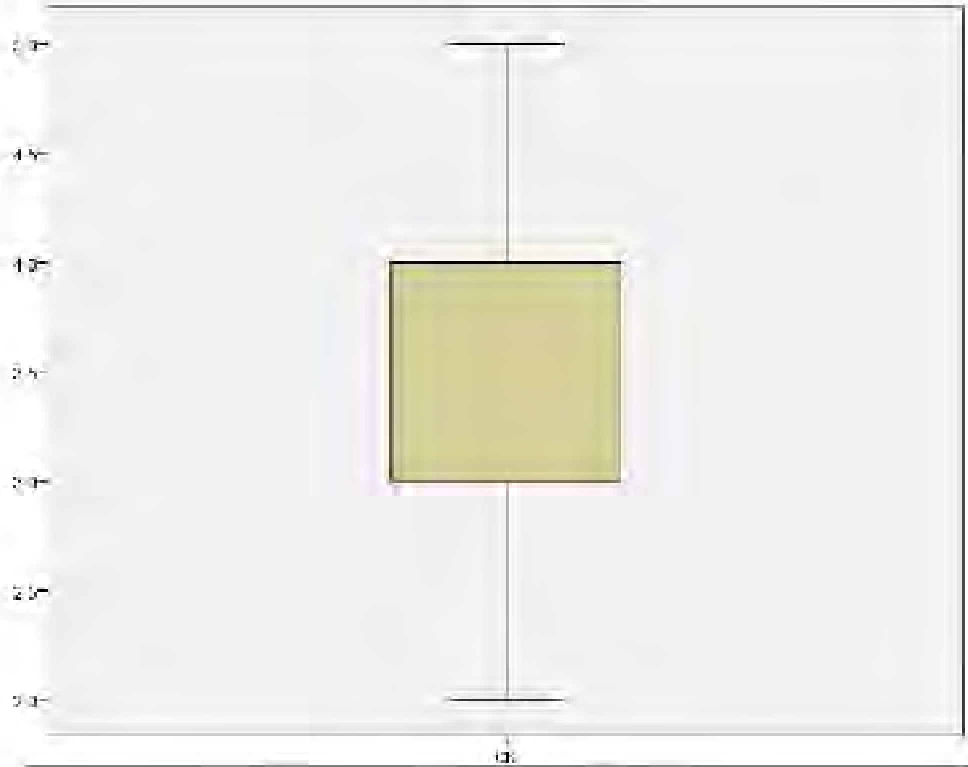
Cronbach's Alpha	N of Items
.662	4

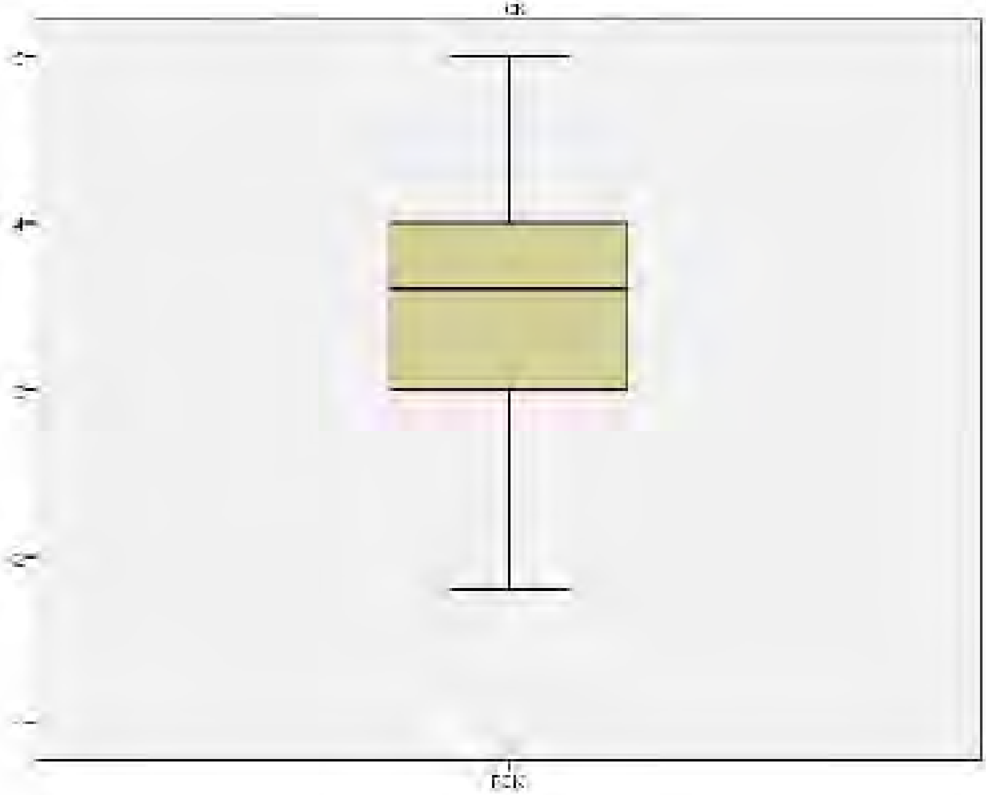
APPENDIX D: OUTLIER TESTING FOR PEASON'S PRODUCT-MOMENT CORRELATION ANALYSIS

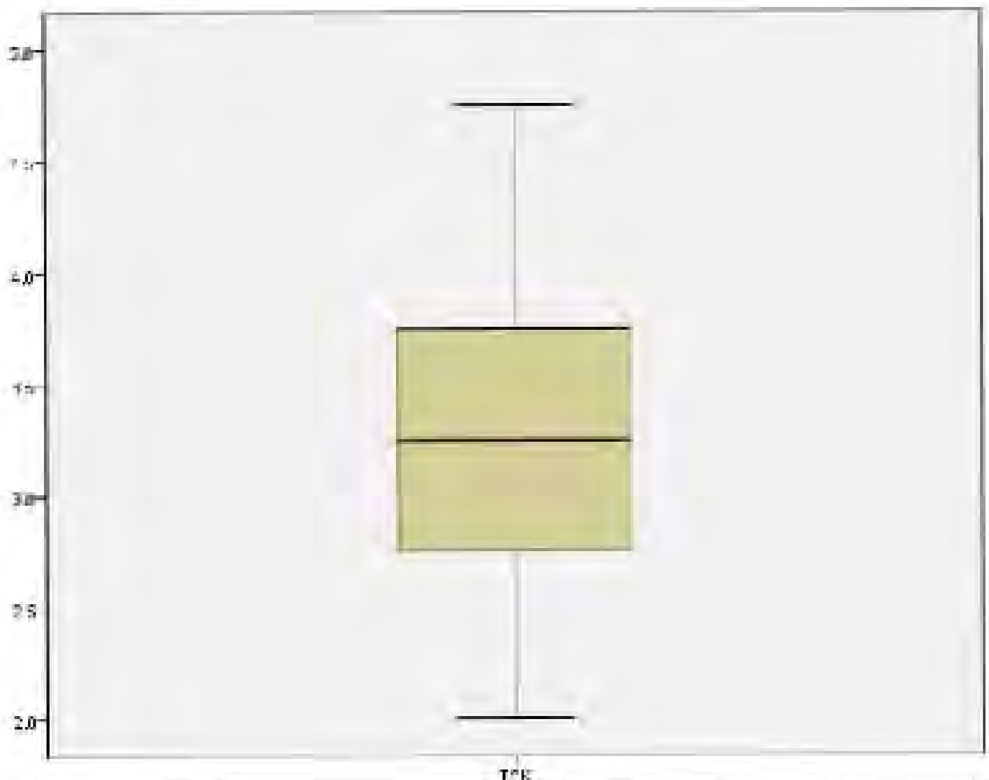
Case Processing Summary

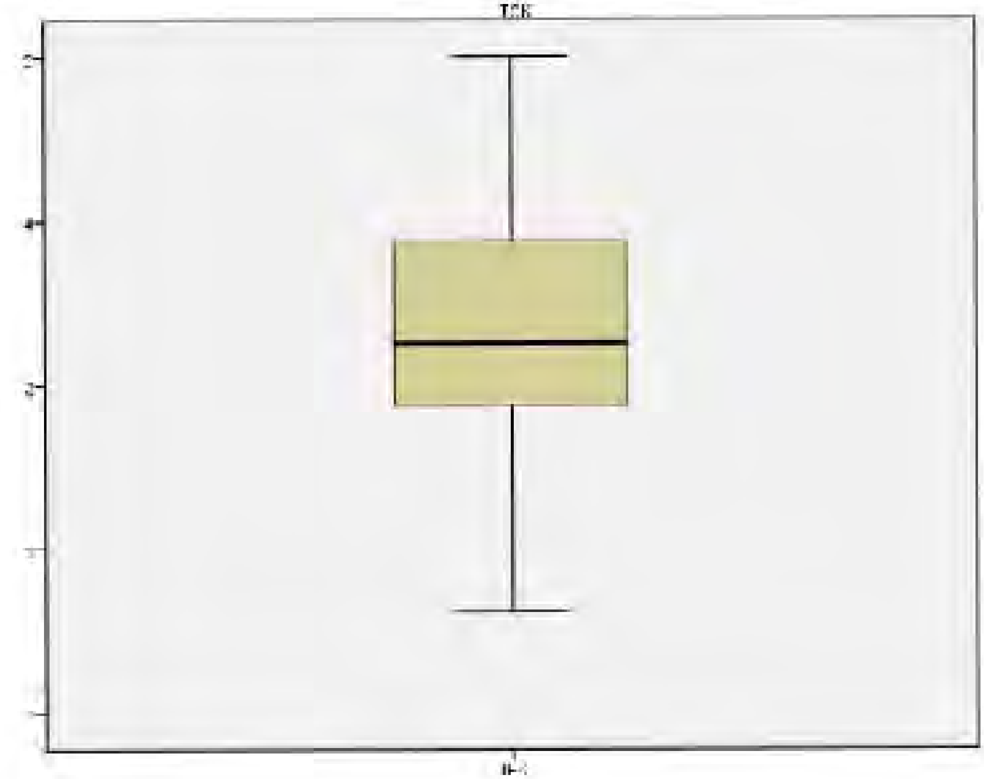
	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
PK	125	100.0%	0	0.0%	125	100.0%
TK	125	100.0%	0	0.0%	125	100.0%
CK	125	100.0%	0	0.0%	125	100.0%
PCK	125	100.0%	0	0.0%	125	100.0%
TCK	125	100.0%	0	0.0%	125	100.0%
TPK	125	100.0%	0	0.0%	125	100.0%
TPACK	125	100.0%	0	0.0%	125	100.0%

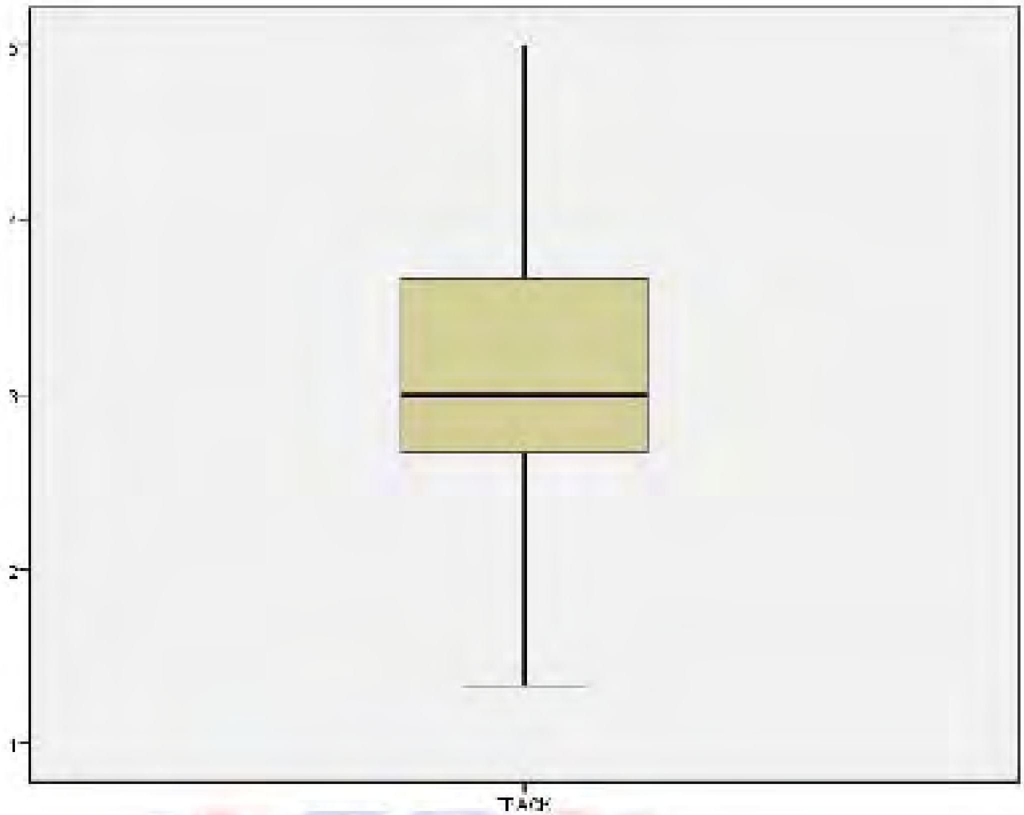

5
4
3
2
1
PK



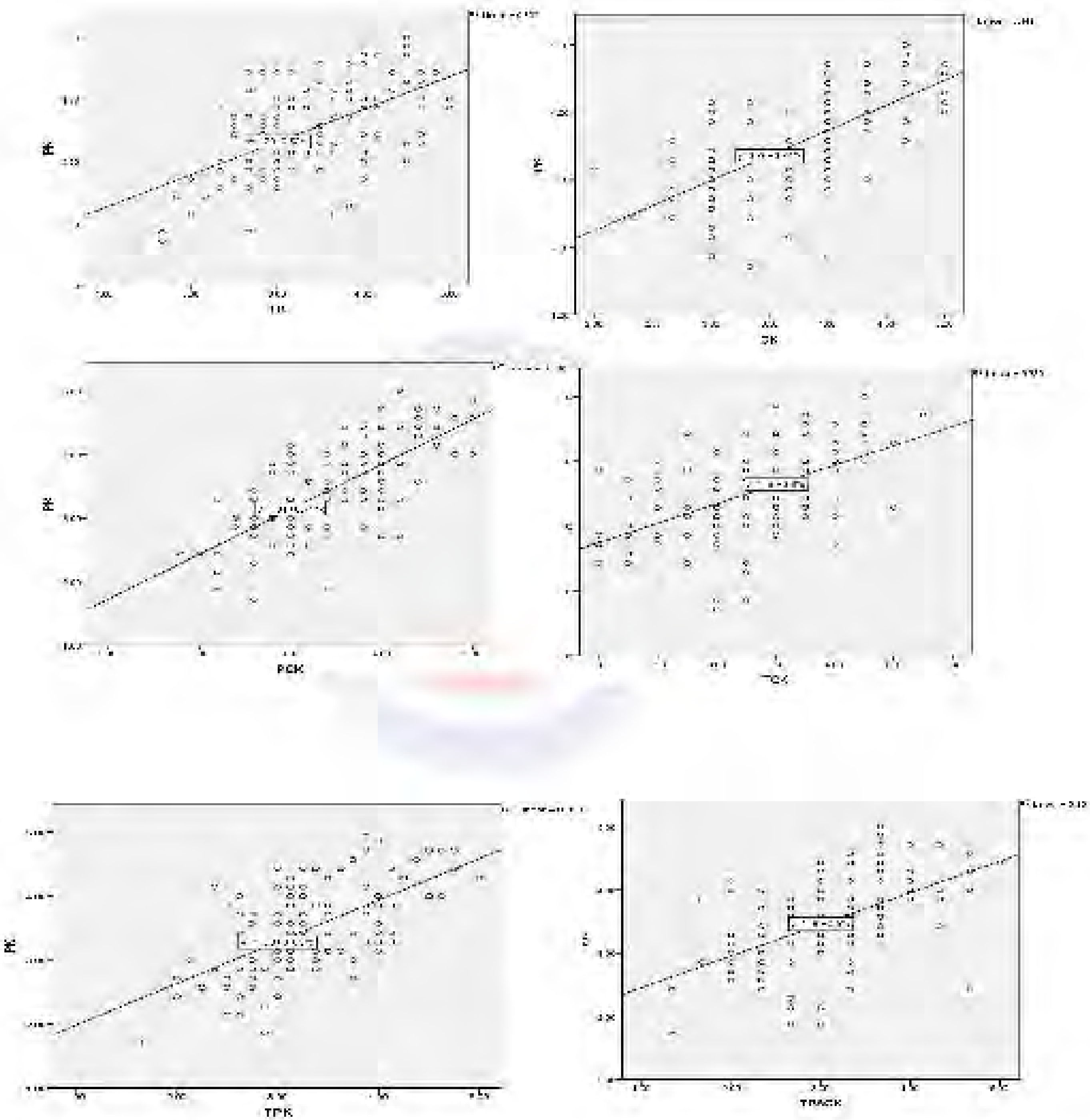


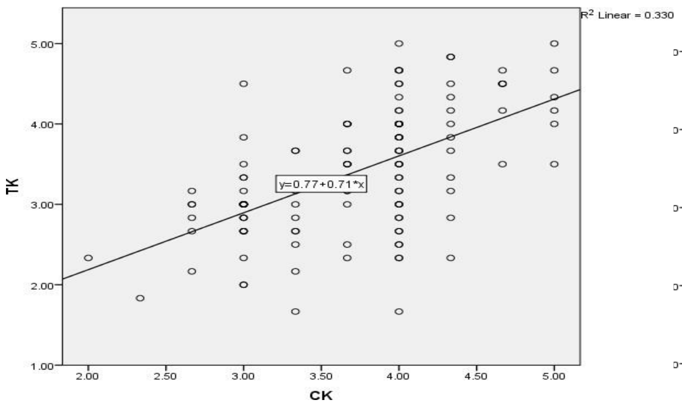


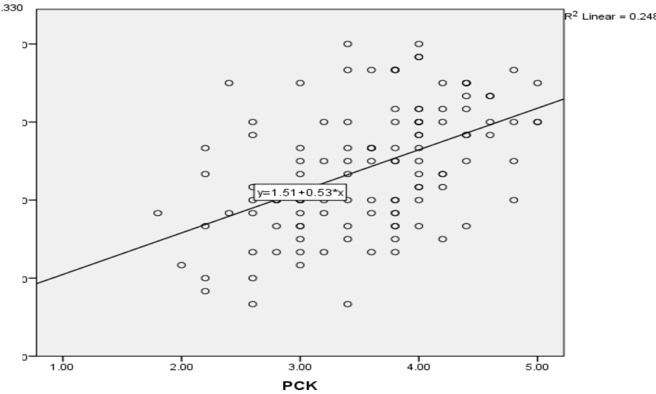


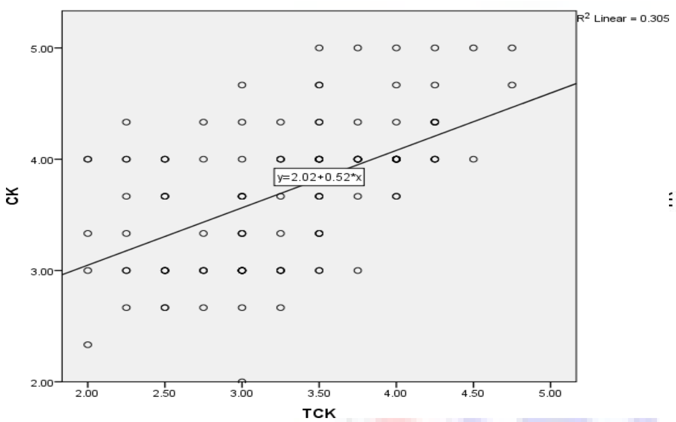

TACK

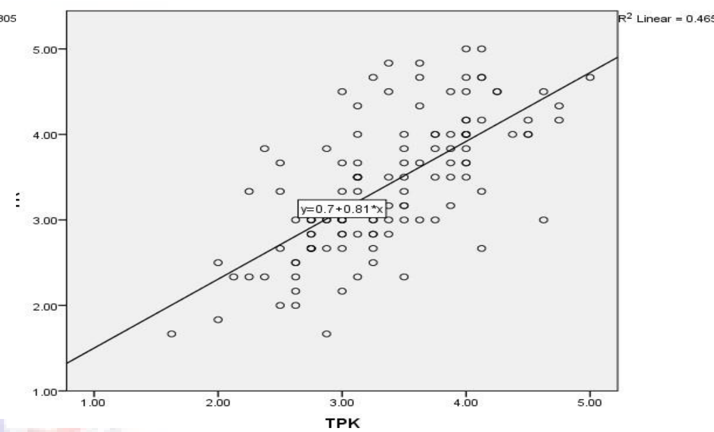
APPENDIX E: HOMOSCEDASTICITY TESTING FOR PEASON'S PRODUCT-MOMENT CORRELATION ANALYSIS

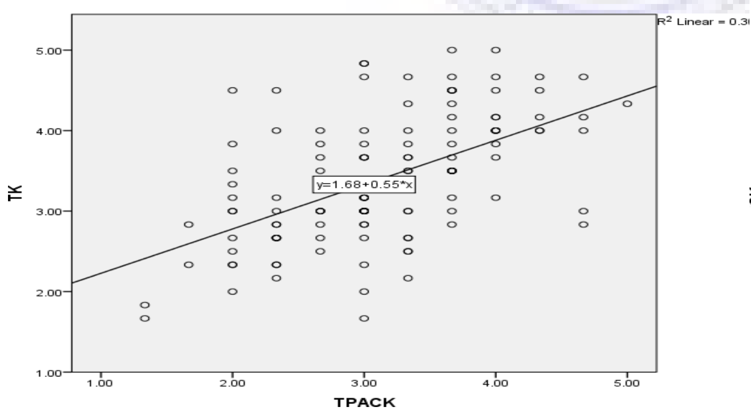


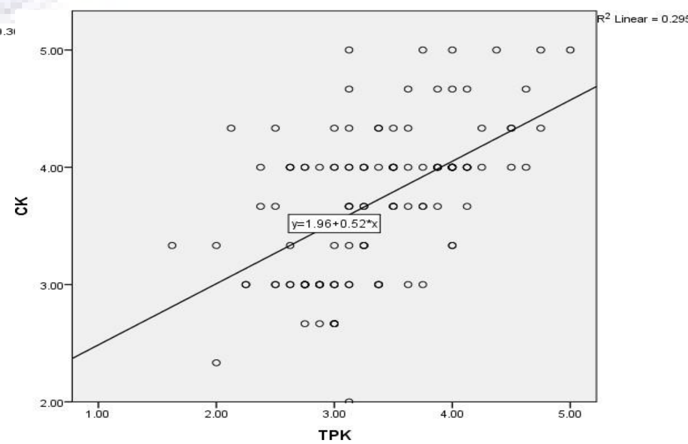

R2 Linear = 0.330
y=0.77+0.71*x
TK
CK

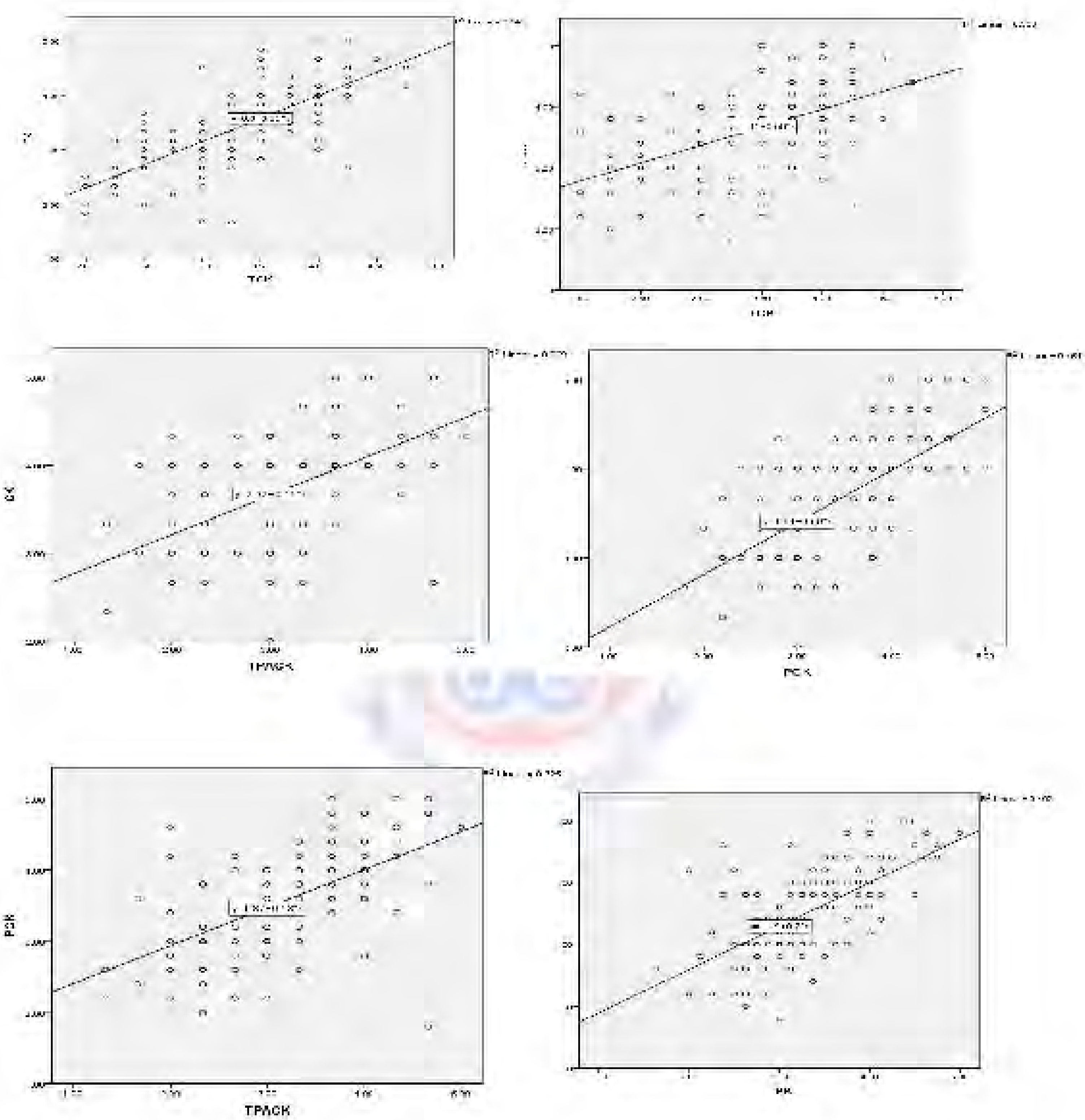

R2 Linear = 0.248
y=1.51+0.53*x
PCK

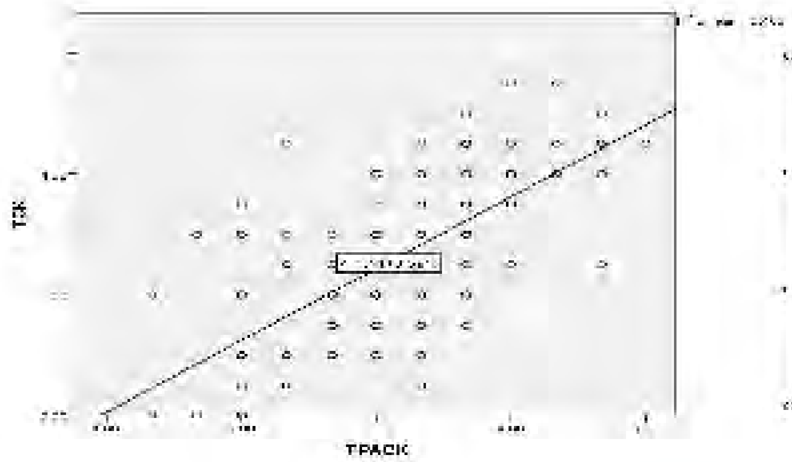

R2 Linear = 0.305
y=2.02+0.52*x
CK
TCK

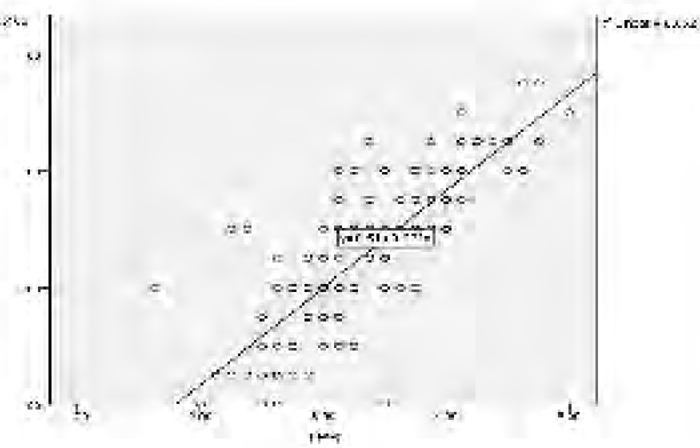

R2 Linear = 0.465
y=0.7+0.81*x
TPK

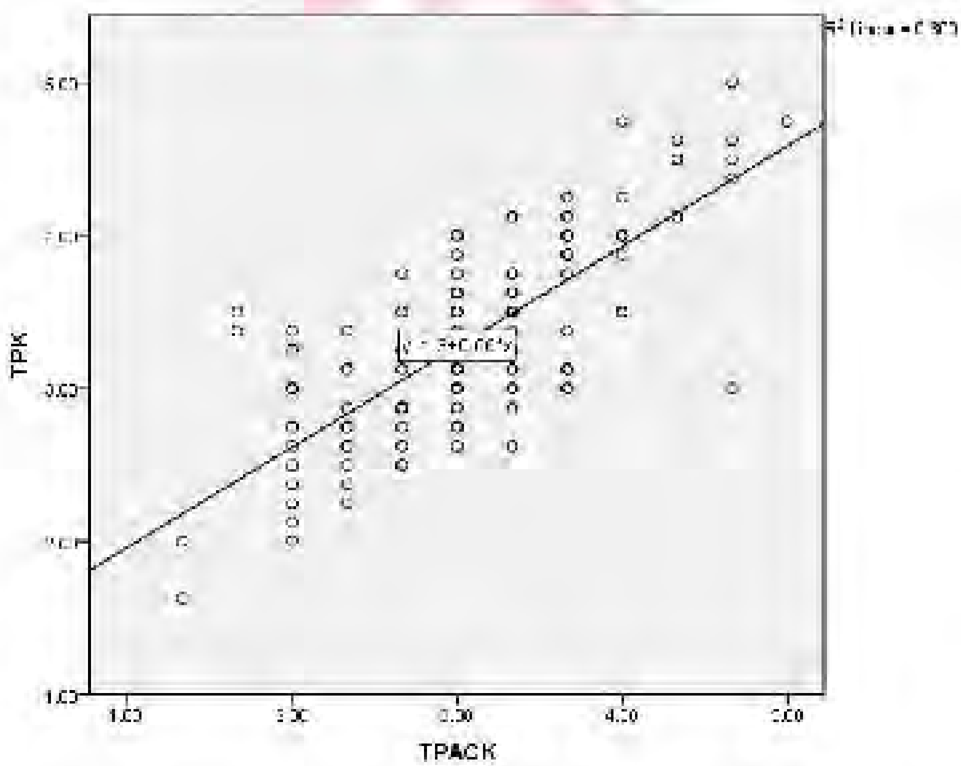

R2 Linear = 0.3
y=1.68+0.55*x
TK
TPACK


R2 Linear = 0.295
y=1.96+0.52*x
CK
TPK


TPACK


TPACK




TPK
TPACK

APPENDIX F: CV IS NORMALLY DISTRIBUTED AND OUTLIERS AND INFLUENTIAL CASES ASSUMPTIONS TESTING FOR MULTIPLE LINEAR REGRESSION ANALYSIS

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
AtTM	125	100.0%	0	0.0%	125	100.0%

Descriptives

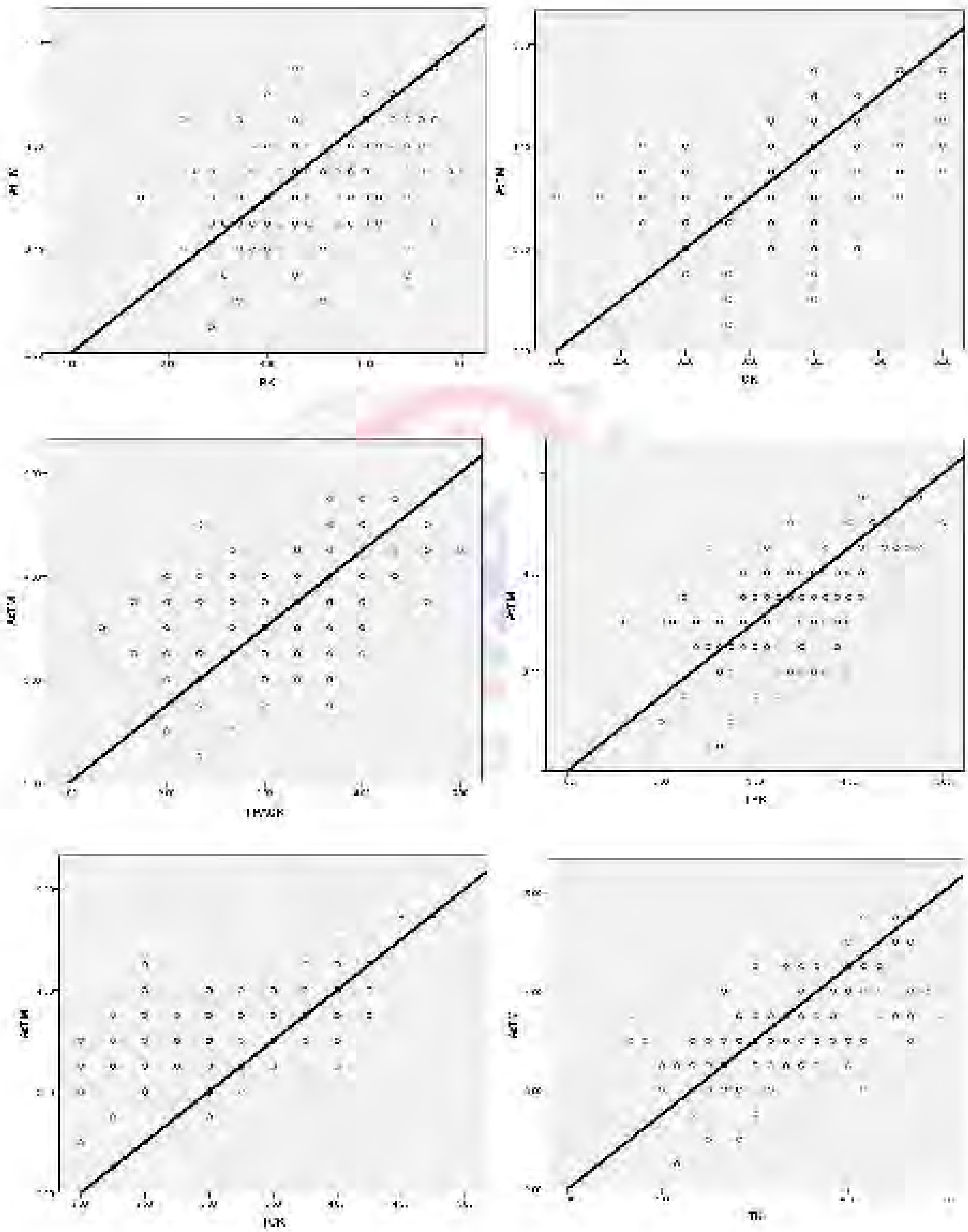
			Statistic	Std. Error
AtTM	Mean		3.6260	.04294
	95% Confidence Interval for Mean	Lower Bound	3.5410	
		Upper Bound	3.7110	
	5% Trimmed Mean		3.6278	
	Median		3.5000	
	Variance		.230	
	Std. Deviation		.48007	
	Minimum		2.25	
	Maximum		4.75	
	Range		2.50	
	Interquartile Range		.75	
	Skewness		-.031	.217
	Kurtosis		.134	.430

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	2.9800	4.3484	3.6260	.34004	125
Std. Predicted Value	-1.900	2.125	.000	1.000	125
Standard Error of Predicted Value	.040	.166	.085	.025	125
Adjusted Predicted Value	2.9566	4.3205	3.6224	.34139	125
Residual	-.94212	.84019	.00000	.33889	125
Std. Residual	-2.700	2.408	.000	.971	125
Stud. Residual	-2.744	2.556	.005	1.002	125
Deleted Residual	-.97253	.94666	.00364	.36067	125
Stud. Deleted Residual	-2.824	2.620	.004	1.010	125
Mahal. Distance	.636	27.227	6.944	4.986	125
Cook's Distance	.000	.104	.008	.014	125
Centered Leverage Value	.005	.220	.056	.040	125

a. Dependent Variable: AtTM

APPENDIX G: LINEARITY ASSUMPTION TESTING FOR MULTIPLE LINEAR REGRESSION ANALYSIS



APPENDIX H: STUDENT A'S TRANSCRIBED INTERVIEW

Interviewer: Okay? I hope you are fine? Thank you for agreeing to participate in this interview which is part of my PhD work at the University of Education, Winneba. I will ask you questions about the training you have gone through so far from the department of Mathematics education from the University of Education, Winneba. The questions will be centered on content, and content in this case we talking about teacher's knowledge about the subject matter to be learned or taught. Then also, technology and pedagogy courses. I will also find out from you whether you will have the desire to teach mathematics, especially core mathematics after graduation. There is no right or wrong answer to the questions so please answer them as honestly as possible. Questions concerning some of the items you have responded to in the questionnaire may be asked again. There would be follow up questions and you are at liberty to provide me with as many examples as you can offer. Your name will not be associated with your answers so please feel free to answer honestly. There is no way that whatever you say here, will be attributed to you as the one who has said this.

Interviewee: Okay.

Interviewer: Is that okay? So just feel free and we will just go straight briefly. Now, the main purpose of this interview is to find out how well you have seen the programme you are pursuing and how you feel about the content, the pedagogy courses and the technology/ICT courses because you have done these three courses so if you look at the questionnaire, you have answered to content courses. Now, are you sure that the content courses have addressed your needs as a preservice mathematics educator, because you are going to teach and by all means if you don't have the subject matter you can't teach. So, looking at the content courses that you have taken so far, you are in level three hundred (level 300) you are going for internship and by all means you are going to even do the teaching practice before coming for the final semester. So, looking at it, so far, would you say that the courses especially the content, we are taking the content courses first. Have they addressed your needs as a preservice mathematics educator? Because you have look at the core mathematics syllabus, so all the content courses you have taken, looking at it, are you sure they have addressed your needs to teach and teach well?

Interviewee: Yes, sir because looking at previously when I came, I had knowledge on almost all the topics in JHS and SHS but I didn't know how to approach and teach them to like coming here.

Interviewer: You've taught before?

Interviewee: Yeah

Interviewer: Okay, okay, okay.

Interviewee: Coming here they've helped me to put those knowledges that I know into students' approach.

Interviewer: Yeah. So, looking at it, in all as of now you have done seventeen (17) content courses. Are you sure all of them?

Interviewee: Not really.

Interviewer: Yes, erheh! Some of them maybe, so I can mention some if they have addressed your needs, you let me know. Like if you take Algebra I

Interviewee: Agree

Interviewer: Geometry I?

Interviewee: Agree

Interviewer: Probability and Statistics I?

Interviewee: Agree
Interviewer: Algebra II?
Interviewee: Agree
Interviewer: Calculus I?
Interviewee: Agree
Interviewer: Probability and Statistics II?
Interviewee: Disagree, not really
Interviewer: Not really, okay?
Geometry II?
Interviewee: Agree
Interviewer: Trigonometry?
Interviewee: Agree
Interviewer: Calculus II?
Interviewee: Agree
Interviewer: Linear Algebra?
Interviewee: Disagree
Interviewer: Vectors
Interviewee: Disagree
Interviewer: Ordinary Differential Equations
Interviewee: Disagree
Interviewer: Introductory Analysis?
Interviewee: Disagree
Interviewer: Abstract Algebra?
Interviewee: Disagree
Interviewer: Further statistics?
Interviewee: Agree
Interviewer: Mechanics?
Interviewee: Yeah, Agree
Interviewer: Numerical analysis?
Interviewee: Yeah, Agree
Interviewer: But in whole, would you say that the content courses have addressed your needs
Interviewee: Yeah, Agree
Interviewer: How? I mean in what way would you say that the content courses have addressed your needs?
Interviewee: Hmmmm, sir, what I can say is that the content courses have helped me to understand some things I didn't understood when I was at SHS. For example, I can say that I can teach logarithm which I didn't understand very well when I was at SHS.
Interviewer: But despite some of them may have some kind of things to do. So, in your view, what are some of the content courses you think can be restructured?
Interviewee: Restructuring certain courses like abstract algebra because they are not actually taught at the SHS level.
Interviewer: Okay
Interviewee: So, if they could restructure it so that they add some of the courses they teach here into that, SHS and JHS. SHS syllabus.

Interviewer: Okay
Interviewee: So that teachers learning it here will have the need teaching it there.
Interviewer: But, but you would agree with me that once you are going to teach that you must have a higher content.
Interviewee: Yeah
Interviewer: So that you may, but it is well noted. Which content course again?
Interviewee: Abstract Algebra
Interviewer: Yeah, you've mentioned that already. Do you have any in mind again?
Interviewee: No
Interviewer: Okay. But those that did not meet your needs, you don't think that they should be restructured? You talked of Probability and Statistics II, then you talked about Ordinary Differential Equations, Introductory Analysis
Interviewee: Analysis
Interviewer: Analysis
Interviewer: Then Abstract Algebra, okay.
Interviewee: So, all those I said could be restructured.
Interviewer: Okay, very well then. Now if we pick the pedagogy, pedagogy knowledge in this case is your deep knowledge about processes, the practices or methods of teaching and learning. They normally encompass among other things overall educational purpose, values and things. So, looking at the pedagogical or pedagogy courses that you have taken, and I will mention them; you have taken them whether they have addressed your needs as a would-be mathematics educator. Like if you pick Psychology of Learning Mathematics.
Interviewee: Agree sir.
Interviewer: Mathematics Curriculum.
Interviewee: Agree
Interviewer: Methods of teaching Junior High School mathematics.
Interviewee: Agree sir.
Interviewer: Methods of teaching Senior High School Mathematics I.
Interviewee: Agree sir.
Interviewer: Methods of teaching Senior High School Mathematics II.
Interviewee: Agree sir.
Interviewer: Then the Pre – Internship Seminar.
Interviewee: Agree sir.
Interviewer: So, with all these, do you think all of them have addressed your needs that you can teach and teach very well?
Interviewee: Agree sir.
Interviewer: How? I mean how would you say that the pedagogy courses have addressed your needs?
Interviewee: With the method courses taken, I can write detail lesson plan and explain topics that are in the mathematics syllabi to learners. I can also use TLMs effectively.
Interviewer: Okay, there is no; like for example, if you pick these six pedagogy courses, you don't think that some of them need to be restructured?
Interviewee: Not really. But I will add the Mathematics Curriculum.
Interviewer: Okay.
Interviewee: It has really taught me the curriculum in mathematics, that the mathematics curriculum in perspective. It has really broadened my knowledge about that.
Interviewer: Okay.

Interviewee: But with the others, I don't have any comment about that.
Interviewer: Okay, okay. Yeah, very well then. So, let's look at the ICT courses. So how we discussed the content and the pedagogy courses. The ICT courses too you've taken six so far and I would mention them, whether they have addressed your needs as a would-be mathematics educator or not. Then we will look at which of them can be restructured. The first one; Introduction to ICT Systems and Tools for Mathematics Teachers.
Interviewee: Agree sir.
Interviewer: Fundamentals of Computer Programming.
Interviewee: Disagree sir.
Interviewer: Courseware Design and Development Using Multimedia Tools.
Interviewee: Yes sir, Agree
Interviewer: Computer Applications for Teaching and Learning Mathematics.
Interviewee: Agree sir.
Interviewer: Introduction to Computer Programming for Mathematics Teachers.
Interviewee: Disagree, Sir
Interviewer: Web Technologies for Mathematics Teachers.
Interviewee: Agree
Interviewer: But looking at it in general, the ICT courses do they also address your needs?
Interviewee: Agree sir
Interviewer: How? I mean how would you say that the ICT courses have addressed your needs?
Interviewee: I can use MS Word to prepare detail lesson plan. Hmm, with the ICT courses I have taken, I can even teach ICT at the SHS hahahahahaha.
Interviewer: In your view, do you think some of the ICT courses need to be restructured?
Interviewee: Yes, fundamentals of computer programming and introduction to programing for mathematics teachers.
Interviewer: Yeah, but you made mention of two; fundamental of computer programming then introduction to computer programming for mathematics teachers. Any reason for the two?
Interviewee: Yeah. This is because ermh some of the, comparing the previous one that I said it has help me using ICT in teaching mathematics but the other one that I said it has not really helped me.
Interviewer: So, you think that they should be restructured?
Interviewee: Yes sir
Interviewer: Now let's look at the last segment. You know if we talk about altruistic to teach mathematics thus the desire you have, despite you are doing just be honest do you think that if you have the chance, any other opportunity you would still teach?
Interviewee: Yes sir, Agree.
Interviewer: You want to teach
Interviewee: Yes sir
Interviewer: Mathematics?
Interviewee: Yes sir
Interviewer: Ok. Do you strongly agree, agree or you not sure or disagree or strongly disagree that you are ready to teach mathematics with all your heart?
Interviewee: I strongly agree.
Interviewer: Then would you help students in your class to succeed?
Interviewee: I agree.
Interviewer: Would you be avoiding to research into best practice of teaching

mathematics?
Interviewee: Come again.
Interviewer: Like you avoid researching.
Interviewee: Disagree
Interviewer: Ok. Then would you be comfortable as a mathematics educator after graduation.
Interviewee: Yes sir. Strongly agree.
Interviewer: Ok. Thank you for this exercise and I am very grateful.
Interviewee: You are welcome sir.

APPENDIX I: STUDENT B'S TRANSCRIBED INTERVIEW

Interviewer: Thank you for agreeing to participate in this interview and it is part of getting information on you, the training you have gone through so far from the department of mathematics education, University of education Winneba. Data collected here will be used as part of my PHD work. The questions will be centered on content, the course that you have taken, the technology or ICT courses that you have taken then the pedagogy courses as well. I will also find out from you whether you have the desire to teach mathematics especially core mathematics after your graduation. There is no right or wrong answer to the questions, so please answer them as honestly as possible. Questions concerning some of the items you have responded to in the questionnaire may be asked again. There will be follow up questions and you are at liberty to provide me with as many examples you can offer. And please your name will not be associated with your answers so please feel free to answer honestly. There is no way that your name will be associated in the write out. Is that okay?

Interviewee: Okay

Interviewer: Now you realized that you went through content courses and by level 300 you have done 17 content courses and I will be mentioning them. Then you have done 6 ICT courses and also 6 pedagogy courses. Looking at some of the content courses that you have taken up to level 300 and the core-mathematics syllabus that you have gone through before. Do you think that the content courses have addressed your needs up to level 300 content courses? Do you think they have addressed your needs that you can teach and teach very well?

Interviewee: Okay, I will say yes

Interviewer: Now let's go to the specifics, I will mention the course and you will say whether you agree or disagree strongly or you just disagree or you strongly agree that the courses have addressed your needs as a preservice mathematics educator so that you can teach and teach very well after graduation. So, if you pick like Algebra1, what so you think Algebra I?

Interviewee: Agree

Interviewer: I am sure that was your first content course, just thinking back, are you sure that it has addressed your needs? You have agreed to it or not strongly agree

Interviewee: Not strongly agree

Interviewer: Okay. What about Geometry I. If for example you don't think that you agree or disagree you can just say that you do think maybe you are undecided or its neutral to you. If you pick Geometry I

Interviewee: Agree

Interviewer: Then Probability and Statistics I

Interviewee: Agree

Interviewer: Algebra II

Interviewee: Agree

Interviewer: Calculus I

Interviewee: Agree

Interviewer: Probability and Statistics II

Interviewee: Agree

Interviewer: Geometry II

Interviewee: Agree

Interviewer: Trigonometry

Interviewee: Agree
Interviewer: Calculus II
Interviewee: Agree
Interviewer: Linear Algebra
Interviewee: Agree
Interviewer: Vectors
Interviewee: Agree
Interviewer: Ordinary Differential Equations
Interviewee: Agree
Interviewer: Introductory Analysis
Interviewee: Agree
Interviewer: Abstract Algebra
Interviewee: Agree
Interviewer: Further Statistics
Interviewee: Agree
Interviewer: Mechanics
Interviewee: Agree
Interviewer: Numerical Analysis
Interviewee: Agree
Interviewer: Okay. Now we have just pick them one by one. But let me just repeat what you have said but in general will you agree or strongly agree, neutral, disagree, that all the content courses have addressed your needs. We have not taken them individually like have they addressed your needs.
Interviewee: Agree
Interviewer: Why? I mean in what way would you say that the content courses have addressed your needs?
Interviewee: For me, I now know the geometrical interpretation of differentiation and other things that the content courses have offered me and I say that they help me paaaa.
Interviewer: Do you think that some of the content courses should be re-structured like, just feel free any of them that you think can be re-structured in the near future?
Interviewee: I am taking into consideration Abstract Algebra and Introductory Analysis. You see the concept is complex and sometimes you find it difficult to understand and maybe you do your possible best to learn for the exam but after the exam of semester then you just forget everything.
Interviewer: So, to you Introductory Analysis, Abstract Algebra should be look at again. But normally where you are going to teach and you need a higher concept in this but to you it's a little bit complex. So, if they can tone it down a little.
Interviewee: Yes sir
Interviewer: This is to Introductory Analysis and Abstract Algebra, anymore?
Interviewee: No
Interviewer: Well then let's move on to the same way, the pedagogy courses. The first one psychology of learning Mathematics
Interviewee: Agree
Interviewer: Mathematics Curriculum
Interviewee: Agree
Interviewer: Method of Teaching Junior High School Mathematics
Interviewee: Neutral

Interviewer: Okay, then methods of teaching S.H.S mathematics I
Interviewee: Neutral
Interviewer: What about methods of teaching S.H.S mathematics II?
Interviewee: Also, Neutral.
Interviewer: Then pre-internship seminar
Interviewee: Neutral
Interviewer: Okay. So, looking at the pedagogy courses, not individually, do you strongly agree, agree, neutral, disagree or strongly disagree that they have addressed your needs?
Interviewee: Agree
Interviewer: How? I mean in how would you say that the pedagogy courses have addressed your needs?
Interviewee: The training I had so far can help me use different approaches to teach a topic which I thought it is known as multiple embodiment principle hahaha. I can also motivate students by telling them that mathematics is not a difficult subject.
Interviewer: Okay. So, which of the courses do you think can be restructured
Interviewee: Method of teaching junior high school mathematics
Interviewer: Okay, which one?
Interviewee: All the two
Interviewer: Okay.
Interviewee: My concern is though they teach us how to prepare lesson notes and teach learning materials and the techniques or methods to tackle individual topics.
Interviewer: Maybe if you pick the core mathematics syllabus, you pick unit one.
Interviewee: What are the activities you use to introduce this or maybe teach
Interviewer: Okay, very well then, then let's go to the ICT courses. And I am sure maybe what you are saying here, is that the grades that you have gotten in them is not influencing it. Like you think about what we are discussing.
Interviewee: Oh, it is not influencing it.
Interviewer: Okay. Very well then. I am just kidding that may be for example a typical course you did not do well so you think that what have been thought.
Interviewee: Oh, no
Interviewer: Oh yeah that's it. Feel free, this thing we are discussing I assure you your name will not mentioned and there are so many of them. So, if I am transcribing, even, I myself would not even know you have said this ok. Let's pick ICT courses, introduction to ICT systems and tools for mathematics teacher.
Interviewee: Agree
Interviewer: Then fundamentals of computer programming
Interviewee: Neutral
Interviewer: Ok. Courseware Design and Development using multimedia tools.
Interviewee: Agree
Interviewer: Computer application for teaching and learning mathematics
Interviewee: Agree
Interviewer: Introduction to computer programming for mathematics teachers.
Interviewee: Neutral
Interviewer: Web technology for mathematics teachers.
Interviewee: Neutral
Interviewer: So, the same way in general have the ICT courses address your needs to a very large extend as a preservice mathematics educator whether you agree with it strongly,

Neutral, disagree or strongly disagree
Interviewee: Agree
Interviewer: How? I mean how would you say that the ICT courses have addressed your needs?
Interviewee: I can incorporate ICTs into my teaching. I can teach linear programming using Excel. I can use Geogebra to explain some coordinate geometry at the SHS and more.
Interviewer: Now which of the courses do you think should be re-structured, the ICT courses. They are six (6).
Interviewee: It is about the programming?
Interviewer: The two. Fundamentals of computer programming. Then, introduction to computer programming for mathematic teachers. They should be looked at again; like what do you think should be going into it… to go into them
Interviewee: Though the lecturers teaching that course, they make it possible, available that's is things to be done in the semester. The problem is how to derive those codes.
Interviewer: Then we will go to the last segment…, that is after graduation, your desire to teach mathematics which sometimes we say altruistic to teach mathematics. So, do you strongly agree, then agree, neutral, disagree or strongly disagree? That for example, to a very large extent, you are ready to teach mathematics with all your heart.
Interviewee: Neutral
Interviewer: Then to a very large extent, you will help every student in your class to succeed.
Interviewee: Neutral
Interviewer: To a very large extend, you will avoid researching into best practices of teaching mathematics. Meaning, you don't want to search into it at all with the best practices of teaching mathematics.
Interviewee: Disagree
Interviewer: To a very large extent, you will be more comfortable as a mathematics educator after graduation. So that if you get any job would you like to take it?
Interviewee: I being a mathematics educator?
Interviewer: Yes. Oh, just be frank.
Interviewee: I agree. I agree
Interviewer: Yeah, so you would like to be a mathematics educator, you don't want to, if there is any opportunity, would you like to take it?
Interviewee: Yeah
Interviewer: It's has been a very fruitful interaction with you and lets me use this opportunity to thank you for your assistance and time
Interviewee: Welcome.

APPENDIX J: STUDENT C'S TRANSCRIBED INTERVIEW

Interviewer: Yeah, you are welcome and let me take this opportunity to thank you for agreeing to participate in this interview which is part of PHD work at the University of Education, Winneba. I will ask you questions about the training you have gone through so far from the department of Mathematics Education of the University of Education, Winneba. The questions will be centred on the content courses you have taken so far as in level 300, the technology courses like the ICT courses and the pedagogy courses as well. I will also find out from you whether you will have the desire to teach mathematics especially core mathematics after graduation. There is no right or wrong answer to the questions so please answer them as honestly as possible. Questions concerning some of the items you have responded to in the questionnaire may be asked again. Yeah, there will be follow up questions and you are at liberty to provide me with as many examples as you can offer. Your name will not be associated with your answers. So please feel free to answer honestly because this is just to collect data and see how best the courses you have gone through has helped you and whether you will be willing to teach core mathematics after graduation so it is about collecting data and all your responses will not be attributed to you so just feel free and just talk. When we pick the content courses by level 300 you have done 17 content courses. Now to a very large extent, do you strongly agree, agree or undecided that is neutral or disagree or strongly disagree with the following courses whether they have addressed your needs because content you are going to teach and you have seen the syllabus before whether these courses have, they address your needs as a prospective mathematics educator and now even you are going for internship. So, if you pick Algebra1, has it address your needs?

Interviewee: I agree

Interviewer: Algebra1 course do you agree strongly or just agree?

Interviewee: I agree

Interviewer: Okay

Interviewer: What about Geometry I?

Interviewee: Geometry I too, I agree

Interviewer: Then probability and Statistics II

Interviewee: I agree

Interviewer: Algebra II

Interviewee: I agree

Interviewer: Calculus1

Interviewee: Neutral

Interviewer: Then Probability and Statistics II

Interviewee: Disagree

Interviewer: Geometry II

Interviewee: Agree

Interviewer: Trigonometry

Interviewee: I agree

Interviewer: Calculus II

Interviewee: I Agree

Interviewer: Linear Algebra

Interviewee: I Strongly Agree

Interviewer: Vectors

Interviewee: Agree

Interviewer: Ordinary Differential Equation?
Interviewee: I Agree
Interviewer: Introductory Analysis?
Interviewee: Agree
Interviewer: Abstract Algebra
Interviewee: I Agree
Interviewer: Further Statistics
Interviewee: Disagree
Interviewer: Mechanics
Interviewee: Agree
Interviewer: Numerical Analysis?
Interviewee: I Strongly Agree
Interviewer: Now looking at all these content courses, in general do you on the same scale say that in general all the content courses have addressed your needs? Your needs as a preservice mathematics educator, is it do you strongly agree, agree or you strongly disagree?
Interviewee: I agree
Interviewer: How? I mean in what way would you say that the content courses have addressed your needs?
Interviewee: The content courses helped in the sense that, I can say I can explain most core mathematics stuffs when I am made to teach core mathematics or even elective mathematics.
Interviewer: Now, there is no perfect system. I would like to find whether you think some of the content courses need to be restructured.
Interviewee: Geometry II
Interviewer: Geometry II, okay. Any other?
Interviewee: Geometry I too
Interviewer: Okay. What do you think should be done to them?
Interviewee: Abstract instead of us to investigate
Interviewer: Okay. So apart from the Geometry I and Geometry II, which other course content course do you think should be restructured. If you have anything to talk about you can say but if not, you can just leave it there. Is it that all for the content courses or you have any. But if we are even going forward in this chatting and you think one of the content courses, but before we continue with the pedagogy courses, I'm sure the grades you have had in the courses is not influencing your….
Interviewee: No.
Interviewer: Okay, excellent. Now, the same way if you pick the pedagogy courses by level 300 you have done six of them. So, the same way Psychology of Learning Mathematics?
Interviewee: Agree
Interviewer: Mathematics curriculum?
Interviewee: Agree
Interviewer: Methods of teaching Junior High School Mathematics?
Interviewee: Agree
Interviewer: Methods of teaching Senior High School Mathematics I
Interviewee: Agree
Interviewer: Then methods of teaching Senior High School Mathematics II
Interviewee: Agree
Interviewer: Pre-internship Seminar

Interviewee: Agree
Interviewer: So, in general do you think that all the courses have address your needs as a preservice Mathematics educator?
Interviewee: Agree
Interviewer: How? I mean how would you say that the pedagogy courses have addressed your needs?
Interviewee: Implementing a lesson plan on a topic is something that I have learnt and I hope to implement that during my internship and after graduation. When I am on the field, I would do likewise. Understanding students also was explained to us and I will shout on my students when I found myself in the classroom.
Interviewer: But not withstanding that which of the courses do you think should be restructured?
Interviewee: Methods of teaching Senior High School Mathematics1&2
Interviewer: Any kind of things that you think that should be done, or you know will be okay.
Interviewee: For both methods of teaching SHS I and II, I think they should be handled in such a way that we should be taken through how to teach difficult topics in core and elective mathematics syllabi.
Interviewer: So, let's move on to the ICT courses the same way; Introduction to ICT systems and tools for mathematics teachers?
Interviewee: I Agree
Interviewer: Fundamentals of computer programming?
Interviewee: Agree
Interviewer: Courseware developing and design using multimedia tools?
Interviewee: Agree
Interviewer: Computer applications for teaching and learning mathematics?
Interviewee: Agree
Interviewer: Introduction to computer programming for mathematics teachers?
Interviewee: Agree
Interviewer: Web technologies for mathematics teachers?
Interviewee: Agree
Interviewer: Now in general the ICT courses too have they address your needs?
Interviewee: Agree
Interviewer: How? I mean how would you say that the ICT courses have addressed your needs?
Interviewee: The ICT courses have met my needs because I can use Word to prepare documents, type mathematics expressions, equations and other mathematics stuffs.
Interviewer: Okay, which of them do you think should be restructured?
Interviewee: Not content restructuring but the arrangement of especially ICTD 121 and ICTD 351. We take ICTD 121 in First Year Second semester and ICTD 351 in third year first semester. I think after ICTD 121, it should be followed by ICTD 351 so that we may not forget some small small concepts.
Interviewer: Any other ICT course?
Interviewee: No, Sir
Interviewer: Then now let's go to the last part that is your desire to teach mathematics. Sometimes we can refer to it in this context as altruistic to teach mathematics. So, to a very large extent do you strongly agree, agree or disagree or you undecided or neutral or strongly disagree with this statement that you are ready to teach with all you heart

Interviewee: Agree
Interviewer: And you will help your students in your class to succeed
Interviewee: I agree
Interviewer: Then you avoid researching into best practices of teaching mathematics
Interviewee: Disagree
Interviewer: Then you will be more comfortable as a mathematics educator after graduation meaning that let's assume all things being equal after graduation do think that if there is any opportunity somewhere you would leave the teaching of mathematics especially core mathematics you want to teach?
Interviewee: Yes, I agree
Interviewer: If an opportunity comes you will not?
Interviewee: Hmmmmm, if the opportunity is better… I may leave.
Interviewer: Thank you for your assistance and time. I'm grateful.

APPENDIX K: STUDENT D'S TRANSCRIBED INTERVIEW

Interviewer: Okay, you are welcome.
Interviewee: Thank you sir.
Interviewer: Thank you for agreeing to participate in this interview which is part of my PhD work. I will ask you questions about the training you have gone through so far from the department of Mathematics Education, University of Education, Winneba. The questions will be centred on the content courses you have taken, the technology courses you have taken, and the pedagogy courses you have taken.
Interviewee: Okay
Interviewer: Okay! I will also find out from you whether you have the desire to mathematics especially core mathematics after you've graduated.
Interviewee: Okay
Interviewer: Yeah, just your view. There is no right or wrong answer to the questions. So, please answer them as honestly as possible. Questions concerning some of the items that I will be asking you, you might have responded to them. The one that I gave to you before you went on recess. There will also be follow up questions and you are at liberty to provide me with as many examples as you can offer. That your name will not be associated with any of your answers so feel free to answer honestly. There is no way I will ask "What is your name?" and there is no way that if data is been reported, it will be that you, I will not even mention your name. Is that okay?
Interviewee: Yes, sir
Interviewer: So just feel free.
Interviewee: Alright.
Interviewer: Whatever you think about the three domains, the courses are there. So, we will start with the content one.
Interviewee: Okay
Interviewer: Now looking at the content courses, as a preservice mathematics educator, do you think that the following content courses have addressed your needs to a very large extent and I will give you some skills and that is if I mention the course you will say whether you strongly agree to it. You agree or maybe you don't know, that is you are neutral about it or you disagree or you strongly disagree.
Interviewee: Okay
Interviewer: So, if I pick Algebra 1, as a preservice mathematics educator, do you think it has addressed your needs to a very large extent?
Interviewee: I Agree.
Interviewer: Okay you agree. Geometry I
Interviewee: Agree
Interviewer: Probability and Statistics I
Interviewee: Agree.
Interviewer: Algebra II
Interviewee: Agree
Interviewer: Calculus I
Interviewee: Agree
Interviewer: Probability and Statistics II
Interviewee: Agree
Interviewer: Geometry II

Interviewee: Agree
Interviewer: Trigonometry
Interviewee: Agree
Interviewer: Calculus II
Interviewee: Agree
Interviewer: Linear Algebra
Interviewee: Strongly Agree
Interviewer: Vectors
Interviewee: Agree
Interviewer: Ordinary and Differential Equations
Interviewee: Strongly Agree
Interviewer: Introductory Analysis
Interviewee: Agree
Interviewer: Abstract Algebra
Interviewee: Agree
Interviewer: Further Statistics
Interviewee: Agree
Interviewer: Mechanics
Interviewee: Agree
Interviewer: Numerical Analysis
Interviewee: Strongly Agree
Interviewer: Okay, so in all, you've done seventeen content courses up to level 300. Okay, looking at all the courses, we've taken them one after the other but in totality or in general, will you strongly agree, agree, disagree, strongly disagree or you are undecided that the content courses have addressed your needs if you put them together. For example, all the content courses you have taken do you strongly agree that they have addressed your needs as a preservice mathematics educator taking into cognisance the SHS syllabus and the likes?
Interviewee: I agree but not strongly agree.
Interviewer: Why? I mean in what way would you say that the content courses have addressed your needs?
Interviewee: Hmmmm, the Algebra I and Algebra II courses met my needs so that I can teach topics from the core mathematics and elective maths syllabi. E.g., some proves at the SHS level can be done easily.
Interviewer: Okay, very well then. Do you think that some of the content courses need to be restructured?
Interviewer: Yes please.
Interviewer: You can mention some of them.
Interviewee: Further Statistics.
Interviewer: Further Statistics, if you have something to talk about you can let us know. Is it only Further Statistics?
Interviewee: Okay. The lecturer doesn't come to class often but rather send a lot of materials for us to read and some concepts are not clear.
Interviewer: But apart from not coming to class because of that you couldn't get it.
Interviewee: Yes.
Interviewer: So how do you want it to be restructured, the course content?
Interviewee: When we started, I think it involves a lot of ICT.

Interviewer: Okay, is that the only course you think that can be restructured?
Interviewee: No.
Interviewer: Which one again?
Interviewee: Geometry I
Interviewer: Okay
Interviewee: The Geometry I, much of it was in the classroom. If ICT is used to demonstrate some of the drawings, it would be fine.
Interviewer: Okay, that's the course content. How should it be structured? Maybe that's okay. Any other more?
Interviewee: No.
Interviewer: Okay. Now before we move on to the pedagogy courses the same way strongly agree, agree, neutral, disagree, strongly disagree. I would like to find out whether what you are telling me right now is not based on the grades you've gotten in the courses.
Interviewee: No.
Interviewer: So just free mind. Very well then. So, let's move on to the pedagogy courses. The same way.
Interviewee: Okay.
Interviewer: Psychology of Learning Mathematics
Interviewee: Agree
Interviewer: Mathematics curriculum
Interviewee: Agree
Interviewer: Methods of Teaching Junior High School Mathematics
Interviewee: Agree
Interviewer: Methods of Teaching Senior High School Mathematics I
Interviewee: Agree
Interviewer: Methods of Teaching Senior High School Mathematics II
Interviewee: Agree
Interviewer: Pre-Internship Seminar
Interviewee: Agree
Interviewer: So, what about in general? The pedagogy courses have they addressed your needs in general putting all together?
Interviewee: Agree
Interviewer: Why? I mean in what way would you say that the pedagogy courses have addressed your needs?
Interviewee: The pedagogy courses I have taken have met my needs that I can write SMART objectives and teach systematically.
Interviewer: Now, which of the courses do you think should be restructured?
Interviewee: Okay, the Methods of Teaching Senior High School Mathematics I
Interviewer: What about the 2.
Interviewee: No
Interviewer: What about the Methods of Teaching Junior High School Mathematics.
Interviewee: No
Interviewer: Okay, so you have… okay. But Teaching Senior High School Mathematics I. It should be restructured. Any comments on that? I'm sure the Methods of Teaching Senior High School Mathematics I is core maths
Interviewee: Core Maths. From here the students or the learners are going teach so I think it should be one after the other.

Interviewer: Let's now move to the other domain that's the ICT courses. So, the same way, as we are moving, we are going to take the ICT courses. Introduction to ICT Systems and Tools for Mathematics teachers
Interviewee: Agree
Interviewer: Fundamentals of Computer Programming
Interviewee: Agree
Interviewer: Courseware Design and Development Using Multimedia Tools
Interviewee: Strongly Agree
Interviewer: Computer Applications for Teaching and Learning Mathematics
Interviewee: Agree
Interviewer: Introduction to Computer Programming for Mathematics Teachers
Interviewee: Agree
Interviewer: Web Technologies for Mathematics Teachers
Interviewee: Agree
Interviewer: So, in general the ICT courses, have they address your needs?
Interviewee: Agree
Interviewer: How? I mean in what way would you say that the ICT courses have addressed your needs?
Interviewee: The multimedia course has helped me a lot and I can design a lesson using PowerPoint. I can also make videos on mathematics topics for SHS students. I can develop a website. I can do a lot of mathematics things using ICTs. I can't mention all.
Interviewer: Which of the courses do you think should be restructured?
Interviewee: Hmmmmm, I am just suggesting ooo sir. After multimedia, if web tech will follow, it will be okay because some techniques in multimedia can be used in web tech. Also, ICTD 241 has some content elements such as Newton Rapson's method that are thought in numerical analysis that is taken in level 300 2nd semester so if web tech can be swapped with ICTD 241, it may help.
Interviewer: Then let's go to the last segment, after graduation whether you will have the desire to teach mathematics, especially Core Mathematics, and it has been like your altruistic level? The same way, now do you strongly agree, agree or undecided, disagree or strongly disagree with the following statements to a very large extent?
Interviewee: Okay.
Interviewer: That you are ready to teach with all your heart?
Interviewee: Strongly agree
Interviewer: You will help every student in your class to succeed?
Interviewee: Strongly agree
Interviewer: And you will avoid researching into best practices of teaching mathematics?
Interviewee: Neutral
Interviewer: You will be more comfortable as a mathematics educator after graduation, meaning that you will not be thinking of leaving the job, even if there is opportunity?
Interviewee: Neutral
Interviewer: Meaning you don't know whether you want to be a mathematics teacher!
Interviewee: Hmmmmm, sir, if there is no opportunity, I will teach.
Interviewer: Thank you for your assistance and time and I am very grateful.
Interviewee: You are welcome.

APPENDIX L: STUDENT E'S TRANSCRIBED INTERVIEW

Interviewer: Good morning, or afternoon?
Interviewee: Afternoon
Interviewer: Okay, it's afternoon. How are you?
Interviewee: I'm fine Sir
Interviewer: Okay, thank you for agreeing to participate in this interview, and what I will be doing is I will ask you questions about the training you have gone through so far, from the Department of Mathematics Education of the University of Education, Winneba. This is in view of a PhD work. The questions will be centered on the content courses you have taken; the pedagogy courses as well as the ICT courses or technology courses you have taken.
Interviewee: Okay.
Interviewer: Questions will also be asked on the questionnaire that you responded to before you went on recess.
Interviewee: Okay
Interviewer: there will be follow up questions and you are at liberty to provide me with as many examples as you can offer. Please your name will not be associated with your answers. No write-up will be connected with your name so I will not even ask what is your name so that it will be recorded. So please feel free to answer nicely, what you think. Now let's pick the first segment, you have taken seventeen content courses so I will mention the content courses, if you strongly agree, agree, undecided, thus neutral, disagree or strongly disagree, with the following content courses that they have address your needs as a preservice mathematics educator to a very large extent because, I am sure you went through the core maths syllabus and now the content courses, have they address your needs? The content courses, if for example if you pick like Algebra I
Interviewee: Yes, Algebra, Yes
Interviewer: Is it you Agree or Strongly Agree?
Interviewee: Strongly Agree
Interviewer: Geometry I
Interviewee: Strongly Agree
Interviewer: Probability and Statistics one
Interviewee: Strongly Agree
Interviewer: Algebra II
Interviewee: Strongly Agree
Interviewer: Calculus I
Interviewee: Neutral
Interviewer: Probability and Statistics II
Interviewee: Agree
Interviewer: Geometry II
Interviewee: Agree
Interviewer: Trigonometry
Interviewee: Strongly Agree
Interviewer: Calculus II
Interviewee: Agree
Interviewer: Linear Algebra
Interviewee: Strongly Agree
Interviewer: Vectors

Interviewee: Neutral
Interviewer: Ordinary Differential Equations
Interviewee: Agree
Interviewer: Introductory Analysis
Interviewee: Agree
Interviewer: Abstract Algebra
Interviewee: Agree
Interviewer: Further Statistics
Interviewee: Disagree
Interviewer: Mechanics
Interviewee: Strongly Agree
Interviewer: Numerical analysis
Interviewee: Agree
Interviewer: Now looking at all the content courses I have mentioned, on the same kind of scale, strongly agree, agree, disagree, strongly disagree or neutral, in general will you say, that the content courses have address your needs as a preservice mathematics educator?
Interviewer: How? I mean in what way(s) would you say that the content courses have addressed your needs?
Interviewee: When it comes to detail steps of solving mathematics problems at the SHS, I would be able to take students through so I can say that the content courses have met my needs.
Interviewer: Okay, notwithstanding that, which content courses do you think should be or can be restructured?
Interviewee: Calculus I
Interviewer: Calculus I, okay.
Interviewee: Calculus one, Trigonometry one
Interviewer: We have only Trigonometry
Interviewee: Eii Trigonometry
Interviewer: Okay, will you say something about them or do you think that they should just be
Interviewee: I think calculus one and trigonometry one should be brought to be brought to level 100 semester I.
Interviewer: Okay, you want it to be brought to like first semester for them
Interviewee: Yes
Interviewer: Okay
Interviewee: and then the others will follow
Interviewer: You treat calculus one before
trigonometry?
Interviewee: Yes
Interviewer: Okay
Interviewee: Because, Calculus I you will be differentiating Trigonometric Functions…
Interviewer: Okay
Interviewee: But you do Trigonometry in two hundred
Interviewer: Okay
Interviewee: And so Calculus… ehm, Geometry II…
Interviewer: Okay
Interviewee: You will take functions and then, you have not done integration and then

Trigonometry yet
Interviewer: Okay
Interviewee: So, it makes the learning difficult
Interviewer: Okay, so?
Interviewee: I think if we had treated Trigonometry and Calculus one in level 100, Geometry II and other courses it will be easy
Interviewer: Yes Okay, thanks very much, anymore?
Interviewee: No
Interviewer: Then let's go to the pedagogy courses. Psychology of learning mathematics
Interviewee: Agree
Interviewer: Mathematics curriculum
Interviewee: Neutral
Interviewer: Methods of teaching junior high school mathematics
Interviewee: Agree
Interviewer: Methods of teaching senior high school mathematics one
Interviewee: Agree
Interviewer: Methods of teaching senior high school mathematics two
Interviewee: Neutral
Interviewer: Pre-internship seminar
Interviewee: Strongly Agree
Interviewer: So, in general, the same thing, will you say that the pedagogy courses have address your needs as a preservice mathematics educator?
Interviewee: Agree
Interviewer: Why? I mean in what way would you say that the pedagogy courses have addressed your needs as a preservice mathematics educator?
Interviewee: I can assess students through various means. I can make my classroom conducive for my students.
Interviewer: Which of the pedagogy courses do you think should be restructured?
Interviewee: Psychology of learning mathematics
Interviewer: Okay
Interviewee: Ehm, personally after taking the course, even though I did well … I ….
Interviewer: I have even forgotten; I am sure your responses is not based on your grades that you ………
Interviewee: No! no
Interviewer: Okay
Interviewee: Because psychology of learning mathematics I did well
Interviewer: Okay
Interviewee: But after that, it wasn't something that actually helped much.
Interviewer: Okay, so what should be done to it, if you think maybe it should be restructured?
Interviewee: Content should be looked at again, if the content is looked at it again, it will be helpful,
Interviewer: Okay
Interviewee: Because most of the things that we learnt I didn't see how I can use it in teaching every day or learning the mathematics.
Interviewer: Okay, which other pedagogy course, apart from psychology of learning mathematics, which one?

Interviewee: That's all.
Interviewer: Then let's go to the ICT courses. Introduction to ICT systems and tools for mathematics teachers.
Interviewee: Strongly Agree
Interviewer: Fundamentals of computer programming
Interviewee: Agree
Interviewer: Courseware design and development multimedia tools
Interviewee: Strongly agree
Interviewer: Computer applications for teaching and learning mathematics
Interviewee: Agree
Interviewer: Introduction to computer programming for mathematics teachers
Interviewee: Agree
Interviewer: Web technologies for mathematics teachers
Interviewee: Agree
Interviewer: What about, in general the ICT courses, have they address all your needs as a preservice mathematics educator?
Interviewee: Strongly agree
Interviewer: How? I mean how would you say that the ICT courses have addressed your needs?
Interviewee: Through the ICT courses, I have learned a lot of softwares which can help me explain some concepts to students. E.g. I can use Word to draw mathematical shapes.
Interviewer: Okay, which of the ICT courses do you think can be or should be restructured to you?
Interviewee: ICTD 351 should follow ICTD 121
Interviewer: Now let's go to the last aspect that is altruistic to teach mathematics, thus your desire to teach mathematics, especially Core Maths at the senior high school level after graduation. So, I will read out to a very large extent, do you strongly agree, agree, neutral, disagree or strongly disagree, that you are ready to teach with all your heart?
Interviewee: Agree
Interviewer: And will you help student in your class to succeed
Interviewee: Disagree
Interviewer: And you will avoid researching into best practices of teaching mathematics
Interviewee: Agree
Interviewer: And you will be more comfortable as mathematics educator after graduation. Meaning if there is any job opening, you will still be more comfortable as a mathematics educator.
Interviewee: Agree
Interviewer: Okay, thank you for your assistance and your time.

APPENDIX M: STUDENT F'S TRANSCRIBED INTERVIEW

Interviewer: Thank you, how are you?
Interviewee: Thank you.
Interviewer: Thank you for agreeing to participate in this interview which is a part of a PHD work. I will ask you questions about the training you have gone through so far from the department of Mathematics education of the University of Education, Winneba. The questions will be centred on the content questions you have taken, the I.C.T courses or Technology courses you have taken then the pedagogy courses you have taken.
Interviewee: Ok
Interviewer: Then, I will also find out from you whether you have the desire to teach mathematics especially core mathematics after you have graduated. There is no right or wrong answer to the questions that I will be asking you, so just answer them as honestly as possible. The questions may also be based on what you have responded to in the questionnaire. So, there may be some repetitions.
Interviewee: Ok
Interviewer: And once again just respond to it as you think. There will also be follow-up questions and you are at liberty to provide me with many examples as you can offer. Your name will not be associated with your answers, so please feel free to answer honestly. So, I will not even ask of your name, there are so many recordings there.
Interviewee: Ok
Interviewer: So, this will be transcribed. It will not be that you so so and so, I will not mention your name, have said so, so and so. So, feel free. Is not anything, is for academic work.
Interviewee: Ok
Interviewer: Yeah. Now, I want to find out whether the content courses that you have taken so far have addressed your needs as a preservice mathematics educator to a very large extent. So, the quick one is, I mention the course, you can just think of it whether it has addressed your needs, as a preservice mathematics educator because you have looked at the core mathematics syllabus. You have look at what you may be going to teach out there. So, if you strongly agree you just say strongly agree, you agree, or you will be neutral, you do not think whether you agree or disagree. You agree or you can strongly
Interviewee: Disagree
Interviewer: Disagree with it. That is feel free. So, if I pick for example Algebra I.
Interviewee: Agree
Interviewer: Ok Geometry I
Interviewee: Neutral
Interviewer: Probability and Statistics I
Interviewee: Strongly Agree
Interviewer: Algebra II
Interviewee: Strongly Agree
Interviewer: Calculus I
Interviewee: Strongly Agree
Interviewer: Probability and Statistics II
Interviewee: Strongly Agree
Interviewer: Geometry II

Interviewee: Agree
Interviewer: Trigonometry
Interviewee: Strongly Agree
Interviewer: Calculus II
Interviewee: Strongly Agree
Interviewer: Linear Algebra?
Interviewee: Strongly Agree
Interviewer: Vectors
Interviewee: Agree
Interviewer: Ordinary differential equations?
Interviewee: Strongly agree
Interviewer: Introductory analysis
Interviewee: Agree
Interviewer: Abstract Algebra?
Interviewee: Agree
Interviewer: Further statistics
Interviewee: Neutral
Interviewer: Mechanics
Interviewee: Agree
Interviewer: Numerical Analysis
Interviewee: Agree
Interviewer: Ok. This is individual content courses but let's assume taking into consideration in general the same scale do you strongly agree, are you undecided or neutral ,disagree or stronlgy disagree that in general the content courses have addressed your needs as a preservice mathematics educator?
Interviewee: Yes, it has so I Strongly agree
Interviewer: Why? I mean in what way(s) would you say that the content courses have addressed your needs?
Interviewee: I got to know that zero is an even number when I entered the university so now things that I had misconception on are now made clear to me and I hope I can deliver after leaving school.
Interviewer: Before even I continue am sure the grades you have gotten in these courses is not influencing your……
Interviewee: No, no, no
Interviewer: Answering
Interviewee: Not at all
Interviewer: Not at all, ok. If not all despite you have just responded to this content courses, can you tell me frankly whether some of the courses need to be restructured? Some of the courses, do you think that they can be restructured in some way, subtraction, arrangement from one level to the other or everything.
Interviewee: The ODE should come after the II
Interviewer: The ODE should come immediately after …………
Interviewee: Calculus II
Interviewer: Calculus II
Interviewee: Because
Interviewer: Ok
Interviewee: At times, after the Calculus 2 we do other courses before we get to ODE and

then most us
Interviewer: The basic
Interviewee: Yes
Interviewer: Requirement
Interviewee: Which we are supposed to know before the ODE.
Interviewer: Ok apart from the ordinary
Interviewee: And then the PDE too.
Interviewer: The PDE
Interviewee: The PDE is done after internship
Interviewer: Yeah, But now we concentrating on this
Interviewee: Ok
Interviewer: Up to this level
Interviewee: Ok
Interviewer: Have you done the PDE.
Interviewee: Not yet
Interviewer: Why do you want go into it.
Interviewee: Ok
Interviewer: This one because you are going out there for teaching practice
Interviewee: Ok
Interviewer: So is the same thing. So how well do you think this has even help you. So is the same if you want to do a follow-up, may be if you come again, we can ask you after the PDE. Any more of the content courses
Interviewee: Ok
Interviewer: So all of them apart from ordinary differential equations you think that they should stand like that
Interviewee: Ok
Interviewer: Ok. The same way. We going to the pedagogy by this time you have done six of them. May be let me refresh your mind. Do you know the number of content questions you have taken
Interviewee: No
Interviewer: No. You cannot count it. It is seventeen as of now. Seventeen. So, I will mention the same way the content courses, strongly agree that they have address you needs as a preservice mathematics educator to a very large extent. So, I will pick the first one psychology of learning mathematics
Interviewee: Agree
Interviewer: Mathematics curriculum
Interviewee: Neutral
Interviewer: Methods of teaching junior high school mathematics
Interviewee: Disagree
Interviewer: Methods of teaching senior high school mathematics I
Interviewee: Disagree
Interviewer: Methods of teaching senior high school mathematics II
Interviewee: Neutral
Interviewer: Pre-internship seminar.
Interviewee: I agree
Interviewee: in general, the pedagogy courses have they addressed your needs as preservice

mathematics educator.
Interviewee: yes, strongly agreed
Interviewer: How? I mean how would you say that the pedagogy courses have addressed your needs?
Interviewee: Through the pedagogy courses I have taken; I can manage my class effectively. I can also write constructive feedback in students' exercise books. The pre-internship has helped me to be effective in the classroom.
Interviewee: Ok. Among all these, which of them do you think should be restructured?
Interviewee: none of them
Interviewer: none of them? You comfortable with them?
Interviewee: Yes
Interviewer: That it can help you to teach well in the classroom.
Interviewee: Yes
Interviewer: Ok, let go to the ICT courses the same way
Interviewee: Mmm….
Interviewer: I will mention them and introduction to ICT system tools for mathematics teachers
Interviewee: Mmm…. Strongly agree
Interviewer: Fundamentals of computer programming
Interviewee: Neutral
Interviewer: Courseware design and development using multimedia tools
Interviewee: Strongly agree
Interviewer: Computer applications for teaching and learning mathematics
Interviewee: Agree
Interviewer: Introduction to computer programming for mathematics teachers
Interviewee: Agree
Interviewer: Web Technologies for mathematics teachers
Interviewee: Strongly Agree
Interviewer: Then in general the ICT courses have they… they have addressed your own needs as a preservice mathematics educator. Do you agree or strongly agree or?
Interviewee: Strongly agree
Interviewer: How? I mean how would you say that the ICT courses have addressed your needs?
Interviewee: I love most of the softwares that I was thought and I hope that's why I can say that the ICT courses have met my needs. I can use Excel to keep students' records. E.g. assessment records. I can use PowerPoint to prepare lesson and do presentation on topics effectively to students.
Interviewer: Ok, among these ICT courses, which of them do you think can be re-structured? Thus, your view.
Interviewee: Hmmm, none
Interviewer: Now, let go to the last part, this is where your desire mathematics especially core mathematics after you've graduated so we talking about altruistic to teach mathematics so I will ask questions. I will read some statements so if you strongly agree, you say it, if you agree, if you are undecided, you disagree or strongly disagree. For example, to a very large extent, am ready to teach with all my heart
Interviewee: Strongly Agree
Interviewer: I will help every student in my class to succeed

Interviewee: Agree
Interviewer: I will avoid researching into best practices of teaching mathematics
Interviewee: Strongly Disagree
Interviewer: I will be more comfortable as a mathematics educator after.
Interviewee: Strongly Agree
Interviewer: So, meaning if there is any job you would not want to leave the teaching field? Like let's assume after graduation you think that if there is any opportunity you want to be comfortable as a mathematics educator. Yeah, so you will not…you….you thinking you can never switch?
Interviewee: Ooh… I can switch but then it will…. it will depend
Interviewer: It will depend how?
Interviewee: on how eerh… let's say the other side will be better than the….
Interviewer: How better? That's why am asking whether you will be comfortable.
Interviewee: Ok, I agree
Interviewer: You agree but not strongly.
Interviewee: Not strongly
Interviewer: Yes, ok
Interviewee: Not strongly
Interviewer: But when it becomes worse, you can even leave, is that not it?
Interviewee: I won't leave…….
Interviewer: Aah but you just told me that ooh if the other side is better.
Interviewee: No errh…. Even if change, I will still teach I will I will still teach.
Interviewer: You will still teach?
Interviewer: Yes
Interviewer: why? What if there is no time to teach?
Interviewee: There will be time. I can………
Interviewer: Will you just be comfortable with just teaching or being a mathematics educator?
Interviewee: Mathematics educator
Interviewer: You will not change your mind maybe in the near future?
Interviewee: I may
Interviewer: You may. That's why I was saying that let's just be
Interviewee: Yes
Interviewer: You may change your mind
Interviewee: I may
Interviewer: Yeah. That's why I have told you that there is no correct or wrong answer. You may change your mind, you would not want to be a mathematics educator. Is that not what you want to say?
Interviewee: Educator?
Interviewer: No matter what.
Interviewee: Not no matter what
Interviewer: Ok. Thank you very much for errh…. am grateful.
Interviewee: Thank you too
Interviewer: Ok

APPENDIX N: STUDENTS' CONSENT FORM

UNIVERSITY OF EDUCATION, WINNEBA

Faculty of Science Education Department of Mathematics Education

RESEARCH DESCRIPTION AND RIGHTS OF RESPONDENT CONSENT FORM FOR STUDENT RESPONDENTS

For questions about the study, contact: Jones Apawu the researcher at japawu@uew.edu.gh or 0244487323 **OR** his supervisors Prof. C. A. Okpoti at okpoticao@yahoo.com or 0208148962/0246980954 and Prof. Issifu Yidana at yyidana@yahoo.com or 024-503-5900

Description: You are invited to participate in a research study that aims at examining pre-service mathematics educators' Technological Pedagogical Content Knowledge (TPACK). I am interested in how preservice mathematics educators' needs have been addressed by content, pedagogy and ICT courses. I am also interested in the perceived knowledge level of preservice mathematics educators TPACK and its components as well as preservice mathematics educators desire to teach mathematics (especially core mathematics) at the Senior High School level after graduation.

The research design is a fixed mixed methods design with emphasis on sequential explanatory design. If you decide to participate in this research, you will be required to complete a questionnaire and you are likely to take part in an interview session(s).

Risk and benefits: The study involves no potential risks. The benefits are that you will have opportunity to express your views about courses you have taken from the Department of Mathematics Education of the University of Education, Winneba. Besides, you would be able to express your opinion(s) on whether you really have the desire to teach mathematics (especially core mathematics) at the SHS level in Ghana after graduation.

Data storage to protect confidentiality: All the information related to you will be treated in strict confidence. No information that could be used to identify you, is required in the report of this study either in writing or speaking.

How will results be used? The data collected from this study will be used to write PhD thesis and journal articles.

Subject's rights: If you read this form and have decided to participate in this study, please understand that your participation is voluntary and you have the right to withdraw your consent or discontinue participation at any time without penalty. You have the right to refuse to answer some particular questions in the questionnaire. Your privacy will be maintained in all published and written data resulting from the study.

Signature statement: All of my questions have been answered to my satisfaction by the researcher. I consent to participate in the study described and have agreed that my group course representative sign on my behalf.

Signature: ………………………..................................

Date: ………………………..

The extra copy of this form is for you to keep on behalf of your colleagues

APPENDIX O: GRANTED PERMISSION CORRESPONDENCES

Permission to use TPACK Survey Instrument

Jones Apawu Dear Dr Schmidt, I would be very grateful if I could be granted permission [illegible]

Crawford, Denise A [SOE] <dschmidt@iastate.edu> [illegible]
to me

Dear Jones,
Thank you for your interest in using our TPACK survey. Your study proposal looks very interesting. You have our permission to use our survey for your study. Good luck!

Best wishes,
Denise

Denise A. Schmidt Crawford
Director and Associate Professor
Center for Technology in Learning and Teaching
School of Education
Iowa State University
0624A Lagomarcino Hall
515.294.9141
dschmidt@iastate.edu

Landry, Geri Armagost (Geri) <[illegible]@utk.edu> [illegible]2012
to me

Apawu,

You are welcome to use the M-TPACK Survey as you please. If you don't mind sharing, please let me know if you have insights or suggestions for future use. I'm always looking for improving my own practice.

Sincerely,
Geri

Geri A. Landry, Ph.D.
Department of Theory and Practice in Teacher Education
452 Claxton Education Building
Knoxville, TN 37996-3442
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