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Colleges of Education Mathematics Tutors' Problems and Challenges associated with the Teaching of Quadratics using Completing the Square Approach

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Abstract: ***The purpose of the study is to identify tutors knowledge, skills and practices that are considered secured, emerging and aspirational and their associated problems and challenges in the teaching quadratics using completing the square approach in the colleges of education in Ghana. Needs analysis was conducted among a conveniently sampled forty six (46) tutors made up of six (6) female and forty (40) male tutors from twenty three (23) Colleges of Education across the country A qualitative method was adopted to explore, so as to understand and describe appropriately the challenges and problems faced by tutors in teaching completing the square. The instrument for the study was a questionnaire made up of 43 items presented in three parts. Based on the results and discussions, Colleges of Education tutors are insufficiently grounded in certain essential knowledge, skills and practices that provide pre-service teachers real and interactive learning experiences that facilitate the acquisition of required competences in learning completing the square. It is recommended that college tutors be given the opportunity to learn innovative and practical teaching strategies that engage pre-service teachers on hands on activities in the learning of completing the square in our Colleges of Education in Ghana.***

Keywords: knowledge, skills. Practices, completing the square, quadratic equations and expressions

1. Introduction

Quadratic equations is identified as an opener to higher level study of algebra and also being found to challenge many students (Bosse & Nandakumar, 2005; Vaiyavutjamai & Clements, 2006; Vaiyavutjamai, Ellerton, & Clements, 2005; Zakaria, Ibrahim, & Maat, 2010). Ones inability to work proficiently with quadratic equations denies many students from accessing the robust mathematics that is necessary to study courses involving science, technology and mathematics education at the tertiary levels (Watt, 2005). In spite of the importance of this topic, little is known concerning the kind of knowledge, skills, and practices of colleges of education tutors have to guide the teaching of quadratics in the colleges of education.

Completing the square is a technique used by students to solve equations that are difficult to factor. It takes the form of perfect square quadratic equations/expressions and to use the structure to manipulate an expression in standard form into an equation/expression that involves a perfect square. Nielsen, 2015 stated that when the quadratic equation/expression has a positive area, the steps involved can be illustrated with a geometric representation in which students try to change area of a rectangle to an area of a square by introducing small adjustments so as not to increase the initial area of the rectangle. To do this conceptually requires sound knowledge, skill and professional practice with concrete and technological tools, which appears not to be the case in most college lecture rooms.

Techniques suggested by Bosse and Nandakumar (2005), indicated that using the quadratic formula or completing the square is more precise and a quicker method which saves students the difficulty of factoring equations/expressions that cannot be factored. Students in the Bachelor of Education Program (Primary/JHS) are mostly not able to respond to questions requiring them to use the method of completing the squares to solve a quadratic equation or factorize it. For example in 2016, most students could not solve a quadratic equation of the form $a^2+bx+c = 0$ by method of completing of squares (Institute of education Chief examiners report for Algebra and Geometry, 2018). More so, while an in depth understanding quadratic functions is a necessary indicator for student success in mathematics. It is generally accepted in mathematics education that, students understanding of quadratic functions and solving quadratic equations is one of the most difficult problems in the secondary school curriculum (Vaiyavutjamai, Ellerton, & Clements, 2005; Kotsopoulos, 2007; Didis, Bas & Erbas 2011).

This conceptually challenging concept in the curriculum could be due to improper grasp of the concept which may be largely influenced by the way they were taught by tutors in some ways that did not provide sufficient practical experiences. Hoover, Mosvold, Ball, and Lai (2016), indicates that teachers' knowledge affects the quality of their professional practice as well as learning outcomes of students. It appears mathematics teachers need to possess the content that are far in excess than what is required in classrooms (Ball, Thames & Phelps, 2008). There is the needed to determine the kind of knowledge, skills and practices of colleges of education tutors in teaching that seem insufficient to position pre-services teachers to acquire acceptable proficiencies in completing the square. Literature has shown that college tutors need to possess and demonstrate alternatives techniques needed for teaching

particular mathematical topics that are challenging to students (Hoover, Mosvold, Ball, & Lai,, 2016). This notion requires verification among colleges of education tutors to determine whether they really posses such knowledge, skills and practices in teaching completing the square.

Purpose of the Study

The purpose of the study is to identify tutors knowledge, skills and practices that are considered secured, emerging and aspirational and their associated problems and challenges in the teaching quadratics using completing the square approach in the colleges of education in Ghana.

Research Questions and Design

Needs analysis (or diagnostic assessment) was conducted to identify tutors knowledge, skills and practices that are considered secured, emerging and aspirational in order to address the question "What problems are associated with the existing practices for teaching quadratics using completing the square approach in the colleges of education in Ghana?'

2. Methods

Research methodology generally indicates a systematic approach to generate theory that supports a framework within which the research is carried out (Remenyi et al., 1998). The method employed in this article to identify tutors knowledge, skills and practices that are considered secured, emerging and aspirational and their associated problems and challenges in the teaching and learning of quadratics using completing the square approach in the colleges of education in Ghana was purely qualitative. Qualitative data were collected to achieve the result for the purpose and scope of this study. A qualitative method was adopted to explore, analyse and describe the research question in order to reveal the knowledge skills and practices which are secured, emerging and aspirational so as to appropriately identify the challenges and problems faced by tutors in teaching completing the square in the colleges of education. This research method can be used to understand the context of teaching completing the square better (Strauss & Corbin, 2008; Levitt, Motulsky, Wertz, Morrow, & Ponterotto, 2017); it can aid in our understanding of the insights to how completing the square is taught and as well as help us understand the complexity of connections and relationships between and among content, materials and pedagogy. It also provides the researcher with an opportunity to explain his/her perspectives of the challenges and the extent of the problem, which in turn can help understand the subtleties with regard to how pre-service teachers experience learning completing the square. More importantly, qualitative research can be used to ensure that proposed interventions resonate with realities and expectations in an attempt to remedy the situation.

Despite the strengths of qualitative research the understanding gained from such studies cannot easily be generalized across context. It therefore requires careful thought to avoid making sweeping statements about the findings generated from qualitative research. Qualitative research embraces different views and perspectives as it aims at getting a deeper understanding, and is likely to unearth a variety of different experiences and perceptions rendering the data gathered inappropriate to test hypotheses using rigorous statistical analysis, but lend itself to generate hypotheses that can then be tested statistically. All researches involving human behaviour and conduct are often difficult to predict and could be vulnerable to bias depending on the emotional and conditional state of the respondents. More so, qualitative research is susceptible to subjectivity (Burns & Grove, 2009), which means that personal views, experiences, perceptions and judgements are valued, irrespective of whether they are from research subjects or from the conveniences on how researchers subjectively choose the participants to the study. The interpretations derived from qualitative studies are to the extent of the experiences gathered by the researcher as well as perceived ideas about the area of study. These experiences invariably influence the generation of qualitative evidence to explain the situation under investigation. Accordingly, Madden (2010) considered the researcher to be key instrument in generating the qualitative evidence to support a claim. This means that qualitative findings are not sacrosanct, but carefully and systematically formed by the researchers. Sceptics of qualitative research often raise the question of rigour and the scientific value of conclusions drawn from such studies. As a result of these limitations, qualitative research usually suffers credibility crises, though not sufficiently proved. None the less, it behoves on users of qualitative research to maintain and further strengthen the credibility of it by ensuring data obtained are fairly and objectively described without the highly tempting personal biases.

2.1 Participants

In most scientific study, it is virtually not tenable to use all respondents of the identified population. This is the supporting principle behind using convenience sampling. Convenience sampling is a technique that does not give equal chances to respondents to participate, but members are used by virtue of being near the place of the researcher or happen to be around at a time the researcher is taken the data, or the willingness of the respondent to participate in the study (Dörnyei, 2007). The respondents were conveniently selected by their mere presence and willingness to participate in the research. Convenience sampling often place emphasis on ensuring that the knowledge gained is representative of the population. The chance to take part in the study is not equal for all respondents in the target population and outcome of the study are not usually extended to the entire population. In all, forty six (46) tutors made up of six (6) female and forty (40) male tutors from twenty three (23) Colleges of Education across the country were used for the study. These groups of tutors are seasoned tutors with a minimum qualification of a second degree in mathematics and a year and up to 28 years teaching experience.

2.2 Instrument

The instrument for the study was a questionnaire made up of 43 items presented in three parts. The first six items collected their bio data, the second part made up of a three likert scale 37 item questionnaire of which 15 measured tutors knowledge, 8 items measured their skills and the 14

remaining items measured their current practices in teaching completing the square.

Secured is understood to mean what tutors already have and being used in their professional practice. *Emerging* is what tutors want to consolidate/know more about and to use in their practices. *Aspirational* is what they lack and want to acquire and use in their practices.

The *knowledge of college tutors* in completing the square is described to mean factual information that a tutor has. It is an awareness of content, strategies that are student centred and practically oriented in fostering the development of mathematical proficiencies.

The *skills* are described to be the ability to produce solutions in completing the square that are logically convincing, conceptually understood and can justify the use of chosen strategies.

The *practices* are the tendency to translate an idea into a series of executable actions which can be observed in the daily routines of the tutor in the college classroom.

2.3 Reliability of Instruments

The Cronbach alpha (α) reliability conducted on 37 items yielded a reliability coefficient of .954. This reliability coefficient suggests a very high reliability of acceptance.

3. Results and Discussion

As stated earlier, the purpose of the study is to identify tutors knowledge, skills and practices that are considered secured, emerging and aspirational and their associated problems and challenges in the teaching and learning of quadratics using completing the square approach in the colleges of education in Ghana. To achieve this, an instrument was administered to the tutors and their responses to the items in the instrument are presented in this section.

3.1 Knowledge, Skills and Practices of Colleges of Education Tutors

To assess the knowledge of college Tutors awareness of the ***various methods of teaching completing the square*** , they were asked to indicate whether they have knowledge that are considered secured, emerging and aspirational to the statement ***'There are various methods of teaching completing the square'***. The result is presented in Table 1. The result indicates that as much as 69.6% of the 46 Tutors who responded to that item either wanted to know more about the various methods (emerging) or wanted to acquire the knowledge of the various methods of teaching completing the square (aspirational). This suggests that most tutors knew of only one method which they are currently using and would submit themselves to acquiring other innovative methods.

Table 1: Awareness of Tutors in the *various methods of teaching completing the square*

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Secure	14	30.4	30.4	30.4
	Emerging	20	43.5	43.5	73.9
	Aspirational	12	26.1	26.1	100.0
	Total	46	100.0	100.0	

The implication of this view is that, tutors are not differentiating in terms methods in teaching completing the square, but uses a fit for all methods which might not be meeting the aspirations of other pre-service teachers in their lecture rooms. Pre-service teachers who have difficulties grasping such methods may cut off from benefiting from their tutors which in turn could impact negatively on their learning outcomes. This is worrying as their failure to grasp these early polynomials could hamper their progress in learning higher order polynomials in their subsequent study of mathematics at higher levels. There is the need to equip tutors with these kind of knowledge so that these various methods could be adopted to meet the needs of pre-service teacher in learning completing the square.

To assess tutors knowledge to align teaching methods with standards, particularly those standards that embody 21st century knowledge and skills, the tutors were asked to respond to the item 'I know it is proper to align teaching methods with standards, particularly those standards that embody 21st century knowledge and skills'. The result is presented in Table 2.

The tutors in the colleges of education are expected to exhibit the alignment of teaching methods with competences, especially those standards that personify 21st century practices in the lecture rooms and to encourage pre-service teachers to do same in their lecture rooms. However, only 16 out of the 46 tutors who responded to the item have this knowledge and practicing same. The remaining 30 tutors want know more and acquire that knowledge and to use it in their practice. This situation demonstrates that pre-service teachers across the participated colleges are oblivious of this 21st century knowledge and skills and could negatively affect their current and future practice as well denied the pre-service who are under their guidance this essential knowledge and skills.

Table 2: Tutors knowledge to align teaching methods with standards, particularly those standards that embody 21st century knowledge and skills

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Secure	16	34.8	34.8	34.8
	Emerging	20	43.5	43.5	78.3
	Aspirational	10	21.7	21.7	100.0
	Total	**46**	**100.0**	**100.0**	

The '21st century skills' is generic, referring to a body of essential knowledge, skills, habits, and practices that are respected by stake holders in education for success in life (21st century skills, 2014). These include Creativity, Innovation skills, Digital literacy and fluency, Collaboration, Communication skills, Exploration skills, Problem solving skills. The rest are Critical thinking and Analysis skills,

Leadership skills and motivation to learn. All these forms the required set of essential skill to ensure effective articulation of issues in education and the world of work. In the Ghanaian context, this essential knowledge and competencies is termed '5Cs' representing communication, cooperation, curiosity, self confidence and concentration as stated in the National Pre-tertiary Education Curriculum Contextual Framework ([NPCF], 2018). The Revised Bachelor of Education (Primary Education) Programme mathematics courses are expected to equip pre-service teachers to reason, analyze, think for themselves, while it imparts confidence in their own capabilities, and toughen them with deep reasoning. Students need to master rules and critical thinking to generate convincing facts that is translated into their everyday lives, making them better problem solvers (University of Cape Coast, 2019). Although, these descriptions of mathematical competences are good, I feel they are still very general and can fit for all courses. There is the need to further develop mathematics specific proficiency standards comprising procedural fluency, conceptual understanding, strategic competence, productive disposition and adoptive reasoning as contained in the NRC, (2001). These proficiency strands are very specific, can be targeted for inculcating into pre-service teachers as well being measurable and lending itself for verification.

Table 3: Tutors awareness to aligning teaching methods with standards, particularly the national teaching standards for initial teacher education

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Secure	17	37	37	37
	Emerging	18	39.1	39.1	76.1
	Aspirational	11	23.9	23.9	100.0
	Total	**46**	**100.0**	**100.0**	

In order to access tutors awareness to align teaching methods with standards, particularly the national teaching standards for initial teacher education, the tutors were required to indicate how secured, emerging or aspirational they were 'to aligning teaching methods with standards, particularly the national teaching standards for initial teacher education'. The result is presented in Table 3. These Teachers' Standards are organised under three main domains consisting of Professional values and Attitudes, Professional knowledge and Professional Practice which encompass the domains initial teachers should value, cherish, know and practice with, to qualify to be a competent teacher so much desired at the end of the new 4-year B. Ed programme in Ghana introduced in 2018/2019 academic year for the colleges of education. If those responsible for preparing beginning teachers are themselves deficient to aligning teaching methods with standards, particularly the national teaching standards for initial teacher education, then there is justifiable course to worry. It is for this reason that this particular item was included in order to find out if indeed tutors in the colleges of education are aware of this or want to know more about it or acquire this and to practice with it. Out of the 46 respondents, only 37% representing 17 tutors indicated there secured with the remaining 63% indicating they wanted to know more about it or acquire this and to practice with it. This is an indication that majority do not feel secured in aligning teaching methods with standards, particularly the national teaching standards for initial teacher education, hence the need to design and an intervention to help tutors acquire this knowledge and to practice with it.

Table 4: Teaching awareness to complete a given square requiring the use of rigorous manipulations of algebra

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Secure	19	41.3	43.2	43.2
	Emerging	17	37	38.6	81.8
	Aspirational	8	17.4	18.2	100.0
	Total	44	95.7	100.0	
Missing	System	2	4.3		
Total		**46**	**100.0**		

Rigorous manipulations of algebra to complete the square: To access tutors awareness to Teach completing the square requires the using the of rigorous manipulations of algebra, the 46 respondents were to indicate whether they were secured, emerging or aspirational in knowledge to the item 'Teaching completing the square requires the use of rigorous manipulations of algebra'. Table 4 shows response of the tutors. 17 out of 46 tutors (37%) of the tutors who responded to the item were highly secured in knowledge in teaching completing the square. have trained teachers in ICT education. The remaining 29 tutors wanted to know more or acquire that knowledge and to use it in their practice (emerging and aspirational). Perhaps the tutors may not be aware that the method that is quite familiar with them is the rigorous manipulation of algebra.

Table 5: Tutors awareness that students' learn in various ways, hence the need to use various strategies in teaching

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Secure	25	54.3	55.6	55.6
	Emerging	13	28.3	28.9	84.4
	Aspirational	7	15.2	15.6	100.0
	Total	45	97.8	100.0	
Missing	System	1	2.2		
Total		**46**	**100.0**		

To test tutors knowledge to differentiate instruction with respect to approaches in teaching completing the square, respondents were to indicate whether they are secure, emerging or aspirational to the statement 'I am aware that students' learn in various ways, hence the need to use various strategies in teaching'. The results in Table 5 showed that 25 out of the 46 tutors representing 54.6% indicated they were secured. That means tutors are quite aware that pre-service teachers learn in various ways, hence the need to use various strategies (differentiate instruction). This awareness has some implications on tutors to be strategic competent to select the best and most suitable approach at the right time to present completing the square to pre-service teachers in a manner that best matches with the learning needs of pre-service teachers. The views expressed by tutors indicate that they are very much aware of the fact that pre-service teachers learn in various ways, hence the need to use various strategies in teaching completing the square.

To access tutors participation in learning communities, tutors' were asked to indicate how secured, emerging or aspirational to the statement '*It is good to participate actively in learning communities; tapping the expertise from departmental staff through coaching, mentoring, knowledge-sharing, and team teaching'.* Here there was parity in opinion as 50% of the 46 tutors indicated there were secured in that knowledge and are currently practicing it, the remaining 23 tutors indicated they wanted to know more about it or acquire this knowledge and to use it in their practice.

Table 6: Tutors awareness to participate actively in learning communities

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Secure	23	50.3	50.0	50.0
	Emerging	14	30.4	30.4	80.4
	Aspirational	9	19.6	19.6	100.0
	Total	**46**	**100.0**	**100**	

There is a divided opinion on the need to participate in professional learning communities were expects share resources among themselves to professionally equip themselves with best practices as well develop professionally in their practice. Tutors have divided opinion in participating in professional learning communities.

To describe tutors knowledge to create a conducive learning environment that support different ability levels of pre-service teachers, the tutors were required to respond to the item *'It is good to create teaching and learning environments that support different ability levels to do their best'.* Twenty eight (28) of the 45 tutors representing almost 62% of total valid responses indicated they were well secured in this knowledge and are practicing it. This is an indication that college tutors are very much aware to create teaching and environment that support different ability levels to do their best. This suggests that, pre-service with various learning needs are not unduly disadvantaged; the learning environment supports the different ability levels to do their best in the lecture halls.

Table 7: Tutors awareness to create teaching and learning environments that support different ability levels

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Secure	28	60.9	62..2	62.2
	Emerging	10	21.7	22.2	84.4
	Aspirational	7	15.2	15.6	100.0
	Total	45	97.8	100.0	
Missing	System	1	2.2		
Total		**46**	**100.0**		

In order to respond to the item 'Irrespective of the form of the quadratic equation/expression, there is a method to complete the square' pre-service teachers were required to indicate how secured they were or wants to know more or acquire the knowledge to use in their practices.

Table 8: Tutors awareness to find various methods to complete the square of any given quadratic equation/expression

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Secure	21	45.7	46.7	46.7
	Emerging	14	30.4	31.1	77.8
	Aspirational	10	21.7	22.2	100.0
	Total	45	97.8	100.0	
Missing	System	1	2.2		
Total		**46**	**100.0**		

Of the valid 45 respondents as in Table 8, 24 tutors representing 52.1% want to know more or acquire the knowledge to use in their practices. This is an indication that majority did not feel secured, but were ready to benefit in some form of training to acquire the knowledge and to practice with it. Any form professional development that is geared towards equipping tutors with specific skills to enable them select appropriate method to complete any given quadratic equation/expression will be welcome news. It could be said majority of the tutors were not able to select appropriate methods to complete any given square.

Table 9: Tutors awareness of the existence of the virtual algebra tiles

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Secure	18	39.1	40.9	40.9
	Emerging	16	34.8	36.4	77.3
	Aspirational	10	21.7	22.7	100.0
	Total	44	95.7	100.0	
Missing	System	2	4.3		
Total		**46**	**100.0**		

To test tutors awareness to existing technology that could be used to teach completing the square, tutors were asked to respond to the item 'I know of the existence of the virtual algebra tiles'. Out of a total of 44 valid respondents, as much as 59.1% representing 26 tutors were not familiar with virtual algebra tiles software which could be used to provide interactive opportunities for pre-service teachers to experience completing the square. This virtual algebra tiles could be a source of motivation and self-tutoring experience that could engage the pre-service teachers even beyond the physical lecture rooms. Tutors unfamiliarity of this interactive software is denying the pre-service teachers this opportunity and could likely impact on their learning experiences of completing the square.

Table 10: Tutors ability to download the virtual algebra tiles application software

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Secure	15	32.6	33.3	33.3
	Emerging	17	37	37.8	71.1
	Aspirational	13	28.3	28.9	100.0
	Total	45	97.8	100.0	
Missing	System	1	2.2		
Total		**46**	**100.0**		

To further test the ability to download the virtual algebra tiles application software, the tutors were asked to indicate whether they were secured, emerging or aspirational to the

item 'I know how to download the virtual algebra tiles application to use with my students'. For this item 45 valid responses were received, of these, 30 tutors representing 66.7% indicated it was an emerging issue for which they needed more information or an aspirational issue which they do not have any on how to go about it, but will be willing to acquire the knowledge and to use it in their practice. This an admission of serious technology challenge among Tutors in the colleges of education which needs urgent attention if we are concerned about moving ICT beyond a subject of study to a technology resource for lifelong learning. It can be concluded that, colleges of education tutors are not able to download the virtual algebra tiles application to use with their students.

Table 11: Tutors knowledge of the virtual algebra tile as a powerful tool for completing the square

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Secure	18	39.1	40.0	40.0
	Emerging	13	28.3	28.9	68.9
	Aspirational	14	30.4	31.1	100.0
	Total	45	97.8	100.0	
Missing	System	1	2.2		
Total		**46**	**100.0**		

In order to test tutors knowledge of the virtual algebra tile as a powerful tool for completing the square, out of the valid 45 responses, there is virtually a divided opinion on the issue as 22 respondents indicated they were secured in that knowledge and the remaining 23 thought it was an emerging and aspirational issue as shown in Table 11. Tutors need to consolidate this knowledge and to use it in their lessons as exemplars for those under their tutoring to follow.

Table 12: Tutors knowledge of use of virtual algebra tiles to make lessons Practical

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Secure	22	47.8	48.9	48.9
	Emerging	12	26.1	26.7	75.6
	Aspirational	11	23.9	24.4	100.0
	Total	45	97.8	100.0	
Missing	System	1	2.2		
Total		**46**	**100.0**		

'The use of the virtual algebra tiles makes lessons practical' was designed to test whether tutors are secured, emerging or aspirational in their understanding that the use of virtual algebra tiles to make lessons practical. The results as contained in Table 12 showed almost a parity between having secured knowledge on one hand and wanting to know more about it or acquire this knowledge on the other hand and to use same in their practice. The views expressed here is an indication that slightly above 50% percentage may not be using the virtual algebra tiles and could contribute to their failure to admit that virtual algebra tiles make lesson practical. Again tutors need to consolidate this knowledge and to use it in their lessons as exemplars for those under their tutoring to follow.

Table 13: Tutors awareness to use algebra tiles to teach completing the square

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Secure	21	45.7	46.7	46.7
	Emerging	18	39.1	40.0	86.7
	Aspirational	6	13.0	13.3	100.0
	Total	45	97.8	100.0	
Missing	System	1	2.2		
Total		**46**	**100.0**		

The item **'**I am aware that algebra tiles can be used to teach completing the square' was to determine whether tutors were aware that algebra tiles can be used to teach completing the square. A simple frequency ran on the item as shown in Table 13 revealed that 53.3% representing 24 tutors out 45 valid respondents wanted to know more about the item or acquire the knowledge in order to use it in their practice. Tutors quest to acquire the knowledge is to suggest that they currently do not possess this knowledge and will be willing to subject themselves to some form of training to acquire it.

Table 14: Tutors awareness to align technologies with content and pedagogy to support teaching and learning

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Secure	18	39.1	40.0	40.0
	Emerging	21	45.7	46.7	86.7
	Aspirational	6	13.0	13.3	100.0
	Total	45	97.8	100.0	
Missing	System	1	2.2		
Total		**46**	**100.0**		

In order to examine tutors awareness to align technologies with content and pedagogy to support teaching and learning, the tutors were asked to indicate whether they were secured, emerging or aspirational to the item '*I am aware it is required to align technologies with content and pedagogy to support teaching and learning'.* The result is presented in Table 14. The results showed that 60% of the respondents wanted know more about it or acquire this knowledge and to practice with it. Aligning technologies with content and pedagogy to support teaching and learning of completing the square appears to be one sure way of integrating technology into teaching. With as many as 60% indicating their intention to acquire this is simply portraying that they are currently not integrating technology into their teaching and may robbing their students from the immerse benefits that come with integrating technology into teaching and learning environment. It can be said that majority of the tutors are not aligning technologies with content and pedagogy to support teaching and learning.

Table 15: Tutors knowledge in using algebra tiles to break down difficult concepts in completing the square

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Secure	19	41.3	43.2	43.2
	Emerging	12	26.1	27.3	70.5
	Aspirational	13	28.3	29.5	100
	Total	44	95.7	100	
Missing	System	2	4.3		
Total		**46**	**100**		

The item 'I know that algebra tiles can be used to break down difficult concepts in completing the square' was designed to test whether tutors are able to use algebra tiles to explain the concept of finding half the coefficient of x, adding and subtracting the square in the completing a given square using the algebraic approach. The result of their responses is presented in Table 15. There were 44 valid responses, with this 54.4% indicated they wanted to know more about it or acquire this knowledge in order to use in their practice. The views expressed here indicate that there are certain procedures tutors are using to get good results, but might not have developed competences to explain why those procedures are used. Tutors who serve as guides and role models are expected to demonstrate appreciable command of knowledge over the course they teach, are lacking convincing explanations. This situation should be a source worry to those who matter in the training of such tutors as a matter of fact begin to fashion out teaching strategies that facilitate conceptual understanding either than rote learning which to some extend yields result, but lack deeper understanding of why certain procedures are used. It can be conclude that tutors knowledge in using algebra tiles to break down difficult concepts in completing the square is insufficient in majority of tutors.

College Tutors skills in teaching completing the square

Tutors skills to some extent influence the method they employ in explaining certain concepts to their learners. A tutor who is endowed with certain skills will be using it to his/her advantage in the lecture halls by modelling lessons that call for the use of those skills. Such tutors will as much as possible present the skills in well package manner to make it attractive to their learners. It is for this reason that this sought to identify the skills possess by tutors and to classify same into secured, emerging or aspirational so as to target skill training in a PD session if need be.

Tutors were asked to indicate how secured, emerging or aspirational there were to the item 'I can use algebra tiles/virtual algebra tiles to solve quadratic equation/factorize quadratic expressions'. This sought to find out whether they possess such skill in teaching their learners completing the square.

Table 16: Tutors skill in using algebra tiles/virtual algebra tiles to solve quadratic equation/factorize quadratic expressions

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Secure	17	37	37.8	37.8
	Emerging	14	30.4	31.1	68.9
	Aspirational	14	30.4	31.1	100
	Total	45	97.8	100	
Missing	System	1	2.2		
Total		**46**	**100**		

Out of 45 valid responses, 17 tutors representing about 38% indicated they were secured in doing so, with a whopping 62% wanting to know more about it or acquire this skill and to use it in their practice. This result as presented in Table 16 indicates that most tutors in the colleges are not able to use algebra tiles/virtual algebra tiles to solve quadratic equation/factorize quadratic expressions in teaching their students in a practical and interactive manner to facilitate conceptual understanding.

Table 17: Tutors skill in using algebra tiles to teach completing the square

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Secure	16	34.8	34.8	34.8
	Emerging	13	28.3	28.3	63
	Aspirational	17	37	37	100.0
	Total	**46**	**100.0**	**100.0**	

Tutors skill in using algebra tiles to teach completing the square is one of many ways to teach in a practical and interactive way that could likely enhanced pre-services teachers' conceptual understanding of completing the square. To this end, tutors were asked to express their views on whether they were secured, emerging or aspirational to the statement 'I can use algebra tiles to teach completing the square'. The result is presented in Table 17. About 65% representing 30 tutors of the 46 tutors who responded to the statement wanted to know more about it or acquire the skill and to use it in their practice. This shows that this interactive and practical method in not being used and could be attributable to their lack of understanding on how to use the algebra tiles to teach completing the square.

Table 18: Tutors skill in completing the square irrespective of the form of the quadratic equation/expression

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Secure	15	32.6	32.6	32.6
	Emerging	15	32.6	32.6	65.2
	Aspirational	16	34.8	34.8	100.0
	Total	**46**	**100.0**	**100.0**	

Questions involving completing the square are usually of varied formats and as such the statement 'Irrespective of the form of the quadratic equation/expression, I can complete the square using algebra tiles' was designed to find out whether tutors have the skill to do so. The result of the responses is presented in Table 18. Out of 46 respondents, 15 tutors representing 32,6% indicated they possess this skill and currently doing so. The remaining 67.4% wants to know more about it or acquire the skill in order to use it in their practice. This is an indication that majority of the tutors do not possess such skill and are not using it. Their failure to competently use the algebra tiles to teach the various formats of the quadratic expressions/equations could be a disadvantage to those who are challenged by the rigorous algebraic method which tutors are comfortably and currently using.

Table 19: I can use the virtual algebra tiles to complete the square

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Secure	14	30.4	31.8	31.8
	Emerging	14	30.4	31.8	63.6
	Aspirational	16	34.8	36.4	100
	Total	44	95.7	100	
Missing	System	2	4.3		
Total		**46**	**100**		

The tutors were asked to indicate their position on whether they could use the virtual algebra tiles to complete the square. The result is presented in Table 19. Thirty one percent (31.8%) representing 14 tutors of the valid 44 respondents indicated they were secured and 68.2% wanted to know more about it or acquire the skill to practice. This is admission that, college tutors are not very familiar with the use of the virtual algebra tiles in teaching completing the square.

Table 20: Tutors skill in using the rigorous mathematics to complete the square

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Secure	22	47.8	47.8	47.8
	Emerging	18	39.1	39.1	87
	Aspirational	6	13	13	100.0
	Total	**46**	**100.0**	**100.0**	

The statement 'I can use the rigorous mathematics to complete the square' was designed to determine whether tutors have the skill to use the rigorous mathematics (algebraic method) to complete a given square. This appears to be a common method used in teaching completing the square among teachers and are often used in textbooks. Table 20 contains results of the responses collected from 46 tutors. The results indicate that 22 tutors representing about 48% were secured in using this skill and the remaining 52% desiring to know more about it or acquire the skill and to use it in their practices. The almost parity in tutors views is a confirmation of the commonality of the method among tutors, but also an indication that being common does not necessarily mean all tutors possess this skill and are using it effectively to teach their learners. It can safely be concluded most tutors lack this skill and wish to acquire it.

Table 21: Tutors skill in modelling any given quadratic equation/expression using algebra tiles/virtual algebra tiles

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Secure	13	28.3	28.3	28.3
	Emerging	23	50	50	78.3
	Aspirational	10	21.7	21.7	100.0
	Total	**46**	**100.0**	**100.0**	

To test Tutors skill in modelling any given quadratic equation/expression using algebra tiles/virtual algebra tiles, they were asked to indicate how secured, emerging or aspirational to the statement 'I can model any given quadratic equation/expression using algebra tiles/virtual algebra tiles'. The result is in Table 21. Out of the 46 respondents, 33 tutors representing 71.7% indicated they were interested in learning more about it or acquire the skills in order to use it in their practice. This shows that most tutors do not have the skill to model modelling any given quadratic equation/expression using algebra tiles/virtual algebra tiles. Pre-service teachers who are visual learners may not be appropriate learning experiences in their lecture halls to facilitate their understanding, this situation is worrying as learning outcomes might be affected and could to a large extend curtail their progression in learning higher order polynomials.

Table 22: I use various strategies in teaching completing the square in teaching completing the square

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Secure	17	37	37.8	37.8
	Emerging	22	47.8	48.9	86.7
	Aspirational	6	13	13.3	100
	Total	45	97.8	100.0	
Missing	System	1	2.2		
Total		**46**	**100.0**		

'I use various strategies in teaching completing the square' was designed to find out whether tutors have the skill to differentiate instruction to meet the needs of their learners. The tutors were asked indicate how secured, emerging or aspirational they were in using the various strategies in teaching completing the square. The result is presented in Table 22. It can be seen that 28 tutors out of a valid 45 tutors indicated they wanted know more about the skill or acquire it and to use it in their practice. This shows that majority of tutors do not possess this skill and are not differentiating instruction in teaching completing the square, but considered a fit for all method of instruction. The danger of this kind of instruction is that a number of pre-service teachers may be denied the opportunity to learn according to their mode of learning.

Table 23: Tutors skill to align technologies with content and pedagogy

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Secure	17	37	37.8	37.8
	Emerging	18	39.1	40	77.8
	Aspirational	10	21.7	22.2	100
	Total	45	97.8	100	
Missing	System	1	2.2		
Total		**46**	**100.0**		

Tutors ability to integrate technologies that matches with content and pedagogy is a desirable skill to be acquired and practice with. To this end, the tutors were asked to indicate how skilful they were to aligning technologies with content and pedagogy. The result of the responses is presented in Table 23. From Table 23, it can be seen that only 17 out of 45 valid respondents indicated they were secured in doing so with majority of them desiring to know about the skill or acquire it in order to use it their practice. This shows that majority of tutors do not possess this skill.

College tutors practices in teaching completing the square

Tutors practices are basically the tendency to translate an idea into a series of executable actions which can be observed in the daily routines of the tutor in the college classroom. The statement 'I use the rigorous mathematical manipulations in teaching completing the square' was designed to find out the routine practices of college tutors in teaching completing the square. The result is presented in Table 24. This indicates that 57% of the participated college tutors are not secured in using this approach, hence the need to help them to develop such practice.

Table 24: College tutors use of rigorous mathematical manipulations in teaching completing the square

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Secure	19	41.3	43.2	43.2
	Emerging	19	41.3	43.2	86.4
	Aspirational	6	13	13.6	100.0
	Total	44	95.7	100.0	
Missing	System	2	4.3		
Total		**46**	**100.0**		

College lecture rooms are greeted with varied learners with different learning needs which must be met to ensure that every learner benefit from tutors' method of instruction. To verify this notion, the tutors were asked to indicate how secured, emerging or aspirational they were in using differentiated instruction as a routine to teach completing the square. The result is presented in Table 25. It can be noted from Table 25 that 58.7% representing 27 out of 46 tutors showed interest in knowing more about the practice or acquire it for use. This shows that college tutors are currently not differentiating instruction in teaching completing the square.

Table 25: College tutors use of differentiated instruction in teaching completing the square

		Frequenc y	Percent	Valid Percent	Cumulative Percent
Valid	Secure	19	41.3	41.3	41.3
	Emerging	20	43.5	43.5	84.8
	Aspirational	7	15.2	15.2	100
	Total	**46**	**100.0**	**100.0**	

Tutors participation in professional learning communities is a likely indicator of exhibiting acquired career-long learning practice. 'Pursuing continuous learning opportunities and embracing career-long learning as a professional ethic' was designed to ascertain whether college tutors participate in career-long learning as a professional ethic in the community of learners. The result of the outcome is presented in Table 26.

Table 26: Pursuing continuous learning opportunities and embracing career long learning as a professional ethics

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Secure	20	43.5	43.5	43.5
	Emerging	19	41.3	41.3	84.8
	Aslpirational	7	15.2	15.2	100
	Total	**46**	**100.0**	**100.0**	

Table 26 shows that 26 out 46 tutors are missing out in the community of learners or that such communities do not exist and perhaps the reason why they are missing out in the benefits that exist in such professional learning communities. There is the need to create and sustain such professional learning communities to provide guidance and mentorship for practicing college tutors in their respective subjects of practice.

Table 27: Tutors practice to provide students individualised opportunity to learn completing the square using algebra tiles and virtual algebra tiles

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Secure	16	34.8	35.6	35.6
	Emerging	22	47.8	48.9	84.4
	Aspirational	7	15.2	15.6	100.0
	Total	45	97.8	100.0	
Missing	System	1	2.2		
Total		**46**	**100.0**		

Ensuring that all students have the opportunity to learn using algebra tiles and virtual algebra tiles is a professional practice that ensures that every learner is given an opportunity to practice with learning resources. Failure to do so may be contributing to perpetuate an injustice against some pre-service teachers by supposed good ones in activity based lessons. Table 27 contains the result of an item designed to find out whether tutors provide pre-service teachers individualised opportunity to learn completing the square using algebra tiles and virtual algebra tiles. The result shows that about 64.5% of the valid 45 respondents felt they were not secured in providing pre-service teachers' individualised opportunity to learn completing the square using algebra tiles and virtual algebra tiles.

Table 28: Tutors practice in aligning technologies with content and pedagogy

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Secure	15	32.6	33.3	33.3
	Emerging	18	39.1	40	73.3
	Aspirational	12	26.1	26.7	100
	Total	45	97.8	100.0	
Missing	System	1	2.2		
Total		**46**	**100.0**		

Innovations in teaching appear to be a 21st century practice tutors should exhibit in their profession. One common way to be innovative is for tutors to carefully select technologies and to align such technologies to match with content and pedagogy. To this end the statement 'It is my practice to aligning technologies with content and pedagogy' was used to determine whether tutors in the colleges of are aligning technologies with content and pedagogy in their daily routines in the lecture rooms. The result of the responses is presented in Table 28. Out of a valid 45 responses, 33.3% (15) tutors indicated they are practicing it, with 66.7% (30) tutors indicating they want to know more about it or acquire the practice of aligning technologies with content and pedagogy in the profession. The 66.7% is a double of the percentage of the tutors who feel they are secured indicating that majority of tutors are not aligning technologies with content and pedagogy.

Table 29: Tutors practice of incorporating the use of algebra tiles or virtual algebra tiles to complete a given square

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Secure	12	26.1	26.7	26.7
	Emerging	22	47.8	48.9	75.6
	Aspirational	11	23.9	24.4	100
	Total	45	97.8	100	
Missing	System	1	2.2		
Total		**46**	**100.0**		

Meaningful learning appears to be facilitated by tutors' use of teaching resources that provide interactive and practical experiences to learners as such the statement 'I ensure that any quadratic equation/expression whose square I complete incorporate the use of algebra tiles or virtual algebra tiles' to find out whether tutors are proving such meaningful experiences. The outcome of the responses as in Table 29 shows that 73.3 % representing 33 tutors of the valid 45 respondents are not incorporating the use of algebra tiles or virtual algebra tiles in teaching completing the square. Their failure to incorporate the use of algebra tiles or virtual algebra tiles in teaching completing the square may be robbing of the pre-service teachers of the meaningful experiences such materials provide to them and could to likely impact negatively on learning outcomes.

Table 30: Tutors use different types of quadratic equation/expression when teaching completing the square

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Secure	17	37	37.8	37.8
	Emerging	21	45.7	46.7	84.4
	Aspirational	7	15.2	15.6	100.0
	Total	45	97.8	100.0	
Missing	System	1	2.2		
Total		**46**	**100.0**		

Tutors were asked to indicate whether different types of quadratic equations/expressions are used when teaching completing the square. Table 30 contains the responses. It is observed that 62.3% (28 tutors) out of a valid 45 tutors wanted to know more about it or acquire the practice. This is an indication that, most tutors do not vary the examples they use to include all forms of quadratic equations/expressions in teaching their students and may be using only familiar examples denying their students certain experiences which could make the learners robust in dealing with the different equations/expressions available.

Table 31: Provide opportunities for students to demonstrate how to complete the square using algebra tiles/ virtual algebra tiles

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Secure	14	30.4	31.1	31.1
	Emerging	18	39.1	40	71.1
	Aspirational	13	28.3	28.9	100.0
	Total	45	97.8	100.0	
Missing	System	1	2.2		
Total		**46**	**100.0**		

In order to determine whether it is the practice of college tutors to provide opportunities for students to demonstrate how to complete the square using algebra tiles/ virtual algebra tiles, they were asked to indicate how secured, emerging or aspirational they were in practicing it. The outcome of their responses is presented in Table 31. Out of a total of 45 valid respondents, 14 tutors representing 31.1% indicated they were practicing. The remaining 68.9% said they wish to know more about it or acquire the practice. This shows majority of college tutors are not provide opportunities for students to demonstrate how to complete the square using algebra tiles/ virtual algebra tiles.

Table 32: Tutors use of YouTube videos as a source of learning for concepts that are challenging

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Secure	15	32.6	33.3	33.3
	Emerging	17	37	37.8	71.1
	Aspirational	13	28.3	28.9	100.0
	Total	45	97.8	100.0	
Missing	System	1	2.2		
Total		**46**	**100.0**		

The statement 'Use of YouTube videos as a source of learning for concepts that are challenging to me/students' was designed to determine whether tutors use of YouTube videos as a source of learning for concepts that are challenging to them or their students. Then result of their responses is presented in Table 32. Of the 45 valid respondents, 15 indicated they were using YouTube videos as a source of learning for concepts that are challenging and the remaining 30 tutors (66.7%) showed interest in knowing more about how this can be done or acquire the skill and practice with it. This indicates that majority of the tutors are not practicing this self tutoring neither are their students exposed to this practice.

Table 33: Use of a variety of teaching resources such as text, audios and videos as means of lesson delivery in my work with pre-service teachers

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Secure	18	39.1	40	40
	Emerging	15	32.6	33.3	73.3
	Aspirational	12	26.1	26.7	100.0
	Total	45	97.8	100.0	
Missing	System	1	2.2		
Total		**46**	**100.0**		

'Use of a variety of teaching resources such as text, audios and videos as means of lesson delivery in my work with pre-service teachers' was another item to determine whether tutors are actually practicing differentiated instruction in the lecture rooms. Table 33 contains the outcome of their responses. Twenty-seven (27) out 45 responses gathered indicates that, the tutors were not practicing differentiated instruction in teaching completing the square. This has the potential of denying some pre-service teachers the opportunity to learn from current method that does not fit into their learning needs.

Table 34: Tutors Encourage the use of pair work or group work to promote dialogue and sharing of ideas

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Secure	24	52.2	54.5	54.5
	Emerging	12	26.1	27.3	81.8
	Aspirational	8	17.4	18.2	100.0
	Total	44	95.7	100.0	
Missing	System	2	4.3		
Total		**46**	**100.0**		

Group work is seen to be a likely promoter of dialogue and sharing of ideas, in view of this tutors were asked to indicate whether 'they encourage the use of pair work or group work to promote dialogue and sharing of ideas' and the results of

their responses in presented in Table 34. It can be seen that 24 out 44 tutors representing 54.5% indicated that this practice was in full use in their lecture rooms. This is an indication that tutors in our colleges value and encourage the use of pair work or group work to promote dialogue and sharing of ideas. The remaining 20 tutors showed interest in knowing more about it or acquire this practice. This 20 tutors may have been constrained in some way that is not allowing them to use pair work or group work to promote dialogue and sharing of ideas. Possible reasons that could account for this could either be that, the tutors are placing much value in completing the syllabus in order to position their students to pass examinations or that is an imbalance between work load and time available to complete the work. There is the need to encourage such tutors to begin to value pair work or group work to foster dialogue and sharing of ideas in the lecture rooms.

Table 35: Tutors practice of given assignment that require students to produce diagrams as part of their solutions

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Secure	24	52.2	53.3	53.3
	Emerging	15	32.6	33.3	86.7
	Aspirational	6	13	13.3	100.0
	Total	45	97.8	100.0	
Missing	System	1	2.2		
Total		**46**	**100.0**		

'I give assignments that require students to produce diagrams as part of their solutions' was a statement used determine whether tutors encourage their students to visually communicate their ideas. Table 35 contains the outcome of their responses. It can be observed that majority of the tutors 53.3% (24 tutors) of the 45 valid responses encourage their students to visually communicate their ideas. This idea is to promote visual learning and to encourage those who are visual learning to use what they are naturally endowed with in the learning process.

Learning is often facilitated when multiple learning experiences are presented to the learners. Tutors use of a variety of technology supported formats such as text, audio, videos and tactile experiences during teaching sessions is one way that could facilitate learning. In view of this, the tutors were asked to indicate whether they were practicing the idea of using a variety of technology supported formats during teaching sessions. The result of the responses is presented in Table 36. Nineteen (19) out of the 45 valid respondents indicated they were practicing it, with the remaining 57.8% (26 tutors) expressing their readiness to know more about it or acquire it for use in their practice. This shows that more than half of the respondents are not offering these experiences to their students.

Table 36: Encourage the use of a variety of technology supported formats during teaching sessions

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Secure	19	41.3	42.2	42.2
	Emerging	18	39.1	40	82.2
	Aspirational	8	17.4	17.8	100
	Total	45	97.8	100	
Missing	System	1	2.2		

One key principle in assessment is to provide timely feedback to learners. To achieve this the tutors were asked to indicate whether they were secured, emerging or aspirational to the statement ''Providing formative feedback on assignments and work that make clear what they have done well and what they need to do to improve on their learning'. The outcome of their responses is presented in Table 37. Out of 45 valid respondents, only 16 wanted to know more about it or acquire this practice. This shows majority of the tutors (64.4%) do not have a problem in providing formative feedback to their students. The timely feedback pointing out where learners went wrong and providing information on why it is wrong facilitates their learning as well as motivate them to take control of the learning process.

Table 37: Tutor practice of providing formative feedback on assignments and work

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Secure	29	63	64.4	64.4
	Emerging	8	17.4	17.8	82.2
	Aspirational	8	17.4	17.8	100.0
	Total	45	97.8	100.0	
Missing	System	1	2.2		
Total		**46**	**100.0**		

4. Conclusion

Based on the results and discussions, Colleges of Education tutors are insufficiently grounded in certain essential knowledge, skills and practices that provide pre-service teachers real and interactive learning experiences that facilitate the acquisition of the required competences in learning completing the square.

5. Recommendation

It recommended that college tutors be given the opportunity to learn innovative and practical teaching strategies that engage pre-service teachers on hands on activities in the learning of completing the square in our Colleges of Education in Ghana.

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