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Factors That Influence Students' Involvement in Participatory Problem Solving Approach in Derivative Of A Function in Wa Senior High School In Ghana

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The purpose of the study was to investigate factors that influence students, involvement in Participatory Problem Solving Approach (PPSA). To achieve this, one major question was answered: What factors influence students' involvement in participatory problem solving approach on derivatives/differentiation word problems of functions? The researcher used descriptive survey design for the study. A sample of 80 SHS3 students was drawn from Wa Senior High School in the Upper West Region. Data were collected using participatory problem solving approach questionnaires which was validated by experts and found to have a reliability index of 0.89. Data analyses were done using frequency counts and percentages. The results indicated that the student's intelligence quotient, home environment, reading and understanding ability, background knowledge, and teacher's quality of instructions influences students' involvement in differentiation word problems. The researcher concluded that applying participatory problem solving approach in the classroom is capable of influencing both high and low ability students. The researcher recommended that Mathematics teachers should be encouraged to integrate Participatory Problem Solving Approach in their instructional processes. Mathematics students should apply PPSA in their learning of mathematics

Key words: *Participatory Problem Solving Approach, influence, Factors, Differentiation word problems, problem solving.*

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I. Introduction

The Mathematics curriculum in Ghana over the years has received a lot of revolution which equips teachers and students ample opportunities to develop good attitudes in the directions of mathematics as a subject and to make studying of mathematics without trying but more realistic and meaningful. The students must not only learn to comprehend the mathematical concepts but apply the problem solving process to develop the ability to reason and analysis mathematical issues. Learning mathematics in the 21st century purposes to educating students to have the ability to interpret concepts, develop process skills, and thinking ability to enable him/her to transfer knowledge (Ministry of Education, 2010).Students in Ghana are expected to be encouraged to engage in exploring the various mathematical objects to enable them to develop the required skills and competencies.

One of the mathematical objects which are needed to be exploredis Calculus. Calculus isthe study of change(Heinkel (2012). Calculus has widespread applications in science, economics, and engineering and can solve many problems for which algebra alone is deficient.

There are two basic concepts underpin the study of Calculus: the differention and the integration. According to Stewart (2003), differentiation is the process of finding the derivative of a function. The derivative, also referred to as the derived function, enables us to find the way one physical quantity changes with regard to another. The derivative can be represented as slope or gradient, instantaneous velocity, marginal revenue, or marginal profit. Derivatives are applied in many fields of problem solving today. According Heinkel (2012) derivatives are applied in the following areas: Farmers applied calculus on their farms starting from clearing the piece of land, sowing, weeding, and application of farm inputs, harvesting and storage. Ghana Statistical Service applied calculus to determine population growth. Chemist and Biologist applied calculus to determine chemical reaction and the growth of bacteria culture respectively. A graphics artist uses calculus to determine the way dissimilar three-dimensional models would conduct when subjected to rapidly changing conditions; calculus can make a realistic environment for movies or video games; an electrical engineer uses derivatives to determine the exact length of power cable needed to connect two substations that are miles apart; an architect uses integration to determine the amount of materials necessary to construct a curved dome over a new sports arena, as well as calculate the weight of that dome and determine the type of support structure

required.Furthermore, one can only apply mathematics in including differentiation this way when the person has understood differentiation in a real life situation. For a one to acquire knowledge in mathematics and apply it this way there are some agents one should have and be able to apply them in the process of teaching and learning and these agents are not different from factors that influencestudents' involvement in mathematical activities.

The main thing that can sway students is the factors that influence their involvement in Mathematics, including calculus, which make them constantly in a stateof practising mathematics. The factors here mean that anything that contributes causally to a result. Some of these factors that contribute to students' achievement are direct and indirect factors that may influence students' mathematical problem-solving ability and this is consistent with Pimta, Tayruakham and Nuagchalerm (2009) who identified the factors influencing mathematics problem-solving ability in differentiation described them as direct and indirect factors. The direct factors include students'attitude towards mathematics, self-esteem and teachers' teaching behavior while the indirect factors are motivation and self-efficacy. Students could only perform effectively in mathematics (differentiation) problem solving if teachers could effectively reversethese factors positively that may cause students' higher achievement.Aidoo, Boateng, Kissi and Ofori (2016)examined the effect of factors such as: language skills, reading ability, cognitive ability, gender, ethnicity and basic mathematical(differentiation) skills on students problem solving. The results indicated that basic mathematical skills such as reading ability, cognitive ability and language skills of the differentiationwould disadvantage students not putting their best in Mathematics. Leong et al (2004) studied the factors influencing students' differentiation problem solving abilities and suggests that cognitive, external and interaction are factors that influence students' mathematical thinking and these must be the guidance to teachers. This means that teacher must provide all the necessary grounds to motivate students to do excellent performance in Mathematics. He recommended that even strong background mathematics students have misconceptions about fundamental mathematicalconcepts and teachers must therefore be diligent in their efforts to eradicate these needless misconceptions of students in mathematical sense-making and provide opportunities for them to confront possible problems that may arise in their way. Omissions and errors may signify a lack of understanding for which they are not even aware and teachers should assign problems for students to work on together outside of class with little or no interaction from them. Teachers should not only assign tasks appropriate for small-group learning but also ensure that students confront their misconceptions, modify their thinking, and make connections in the task. The task of working together influences problem solving. Some students would benefit from the opportunity to explain whereas others may be uncomfortable and reluctant to share their thinking.

Teachers' quality of classrooms instructions and their attitudes towards students increase students' involvement in mathematics problem solving (Diniz, Pocinho, and Almeida, 2011;Hanrahan, 2014). They observed that students who viewed the class positively described themselves as highly motivated to learn. This suggests that quality of instructions are consonants with more activities with positive behaviors either implicitly or explicitly to reinforce positive beliefs about the need for self-direction in learning.

NCTM (2013)reported that quality of experiences when doing mathematics are mainly related to interest, grades and course level of students are most strongly predicted by level of ability, interest is found to contribute significantly to grades and course level and quality of experiences are significantly correlated with grades but not course level. Similarly, Tella, (2007) indicated that there was a significant differencein students' achievement far as their background knowledge wasconcerned. This meant that teachers should make conscious effort to ensure mathematics teaching interesting and also consider individual differences due to students coming from heterogeneousbackground.

Zhi, Lin and Liu, (2010) found that students' attention and learning strategies in mathematics were improved with male students indicated higher motivation for learning mathematics and they used learning strategies better than female students.

An earlier study on how group discussions can enhance students' mathematics achievement found that appropriate and relevant classroom discussion activities with clear classroom demonstration, equitable activity followed with classroom evaluation and time allotment can improve students' mathematics achievements than loading students with full of activities and classroom instructional obstruction(Tasisa and Tafesse, 2013; Enu, Danso, and Awortwe, 2015) did a similar study reported on class-size indicated no significant difference in the mean scores of the three subgroups of the experimental group.

In their study Mensah, Okyere, and Kuranchie (2013) found that teachers' positive attitude fueled confidence in students hence made them develop positive attitude towards the learning of Mathematics. Diniz, Pocinho, and Almeida (2011) who explored the effect of socio-cultural background on students' achievement on word problem in mathematical word problem reported that the influence of students' socio-cultural background on academic achievement was a well-established fact. This means that the socio-cultural background was related to students' cognitive abilities and therefore has an effect on their mathematics achievement. These factors could only be developed by educating students via the strategies of participatory problem solving approach.

The Participatory Problem Solving Approach (PPSA)

Participatory problem solving approach is a learner-centered pedagogy in which students work collaboratively and cooperatively in groups to conceptual knowledge and procedural skills required to develop plausible solutions to mathematical problems (Kolmos, Fink, and Krogh, 2004). The students groups are guided by teachers who play a facilitative role and encourage groups' members to justify their thinking and guide them to discuss ideas (Hui-Chuan, 2011). Teachers provide less support to students. The main focus is students' involvement so as to assume more responsibility for their collaborative learning (Erdogan and Senemoglu, 2017), a shift from being passive to being actively participating in the problemsolving process

Learning in participatory problem solving approach begins with a problem posed in such a way that the students learn both thinking strategies and domain specific knowledge (Ha, 2003). The problem and problem solving process are used as stimulus for students to think through and determine what they knew and what they should know in order to solve the problem right from the beginning. It is through this active and reflective thinking process that they become responsible for their own learning.

Participatory problem solving approach was pioneered in the Medical school of the McMaster University, Canada in the 1960(Davidson and Major, 2014) and has since spreadworldwide to other disciplines in higher education such as engineering, economics, architecture, mathematics and law (Fatokun and Fatokun, 2013). PPSA, which aims at assisting students develop information-seeking and problem-solving skills (Savery, 2006), is grounded on constructivist principles (De Simone, 2008; Coombs and Elden, 2004)) with the philosophy state that learning is achieved by the active construction of knowledge supported by various perspectives in meaningful contexts. Knowledge and skills are not automatically given by the teacher but actively constructed by the students (Borhan, 2012). The constructivist principles according to Nabie, Raheem, Agbemaka and Sabtiwu (2016) provide space for cognitive diversity that allows solving problems in different ways. The participatory problem solving approach is consistent with the constructivist theory where students take in charge of their own learning. The individual's brain is not an empty box. Each student has background experiences in which he or she mirrors new things. This is important fact used in participatory problem solving.

The aim of participatory problem solving is to develop flexible, effective problem solving skills, self-directed learning, active, critical thinking, and effective collaborative learning skills, as well as intrinsically motivate the desire to learn for a lifetime (Hmelo-Silver, 2004; Chen, 2013; De Simone, 2008).Hmelo-Silver argued that participatory problem solving allows students to construct an extensive and flexible knowledge base, which goes beyond factual knowledge, allowing them to fluently retrieve and apply their knowledge in varied situations. Hence participatory problem solving allows students to move beyond the mental understanding of information and learn to use concepts to real-life format. Students also learn to work both independently and collaboratively. According to Simons, Klein, and Brush (2004), students proceed through a variety of activities in participatory problem solving to frame their comprehension of the problem, access resources, increase understanding, and recommend solutions.

Participatory problem solving is considered to be the most appropriate intervention approach in solving problems involving derivatives because it has the potential to increase students' learning (Mokhtar, Tarmizi, Ayub, and Nawawi, 2013) and develop their practical skills. It is a student-centered instructional strategy and students can solve problems collaboratively and reflect on their experiences (Azer, 2009). The common meaning to the varieties of participatory problem solving definitions is that students actively construct their own knowledge of mathematics. Hence, participatory problem solving typically involves significant amount of self-directed learning on the part of students.

Participatory problem solving draws on experiential learning and makes use authentic problems as a meaningful task to situate learning. Its learning process, organized around the investigation, explanation and resolution, is shaped and directed by students as they work collaboratively in small groups to solve the problem (Veneranda, 2014). The teacher acts as a coach with the objective to foster conceptual knowledge and problem solving, collaboration, self-directed and lifelong learning as well as intrinsic motivationin learners (Hmelo-Silver and Author, 2013).

Participatory problem solving stresses on student-centered learning (Hmelo-Silver, 2004) in which students work in small groups (Wen-Haw, 2013; Veneranda, 2014) collaboratively, communicatively, and cooperatively. It promotes a high level of interaction among peers and facilitator and it also teaches students how to work as a team (Uden, 2006). Working as a team, students identify what they already know, what they require to know and how and where to access new information that may lead to resolution of the problem. This procedure enhances content knowledge while at the same time fosters the development of communication, problem solving, critical thinking, and self-directed learning skills. Participatory problem solving provides students with opportunities to learn and develop the skills and attitudes valued in their chosen careers.

The role of the facilitator in PPSA is to guide the students toward discovering answers on their own rather than to simply provide the correct answer. Through the guiding process, the teacher can stimulate the students' cognitive learning processes, problem-solving skills, and self-directed learning (Aidoo, Boateng, Kissi

and Ofori, 2016).Notwithstanding, this potentialteaching and learning strategy moves with certain challenges in the process of implementation.

Challenges in Participatory Problem Solving

For many teachers always resist reforms with the simple adage that change is difficult. Challenges in using the participatory problem solving approach in the classroom is centered at three levels:

(1) Teacher (beliefs, previous experiences, pedagogical and content knowledge, and commitment to the innovation);

(2) Classroom (resources, support, class size, and class schedule); and

(3) school/community (curricular and testing policies, community support and involvement) (Kilpatric, Swafford, andFindell, 2001).

Another inhibiting factor of participatory problem solving was noted by (Albion and Gibson, 2000) in teacher education programs. Most education programs still rely heavily on traditional instructional methods that lead to instrumental learning. It is difficult to expect teachers to adopt innovative learning methodologies that they have not experienced personally or through their teacher education programs. With many administrators, curriculum developers, and teachers lacking experience in interdisciplinary education, barriers to broad scale change can be insurmountable.

Participatory problem solving implementation can also be affected by the shortage of prepared resource materials for classroom instruction. In most Ghanaian classrooms, few or non-existent training materials are available. Present curriculum guides and textbooks do not contain the variety of sample problems or assessment tools needed to support this methodology on a broad scale. The philosophies supporting participatory problem solving are well established, but prepared materials are in short supply (Burruss, 1999). Few teachers have the time or the motivation to prepare materials for classes. Likewise, not only are ill-structured problems unavailable our school curricula materials, but also assessment in use is product driven and knowledge based. Teachers' and students' performances are examined in the light of standardized testing that does not address critical thinking process skills. Meier, Hovde, and Meier (1996) report that with many time constraints and administrative pressures to improve test scores, many teachers cannot justify the time necessary for PPSA. The preparations and practice of PPSA may seem to be time consuming (Erdogan and Senemoglu, 2017).

II. Statement

In spite of the important, positive, and encouragement of factors that involve students' PPSA and derivatives/differentiations play in everyday life of the individual, many students in Ghana still find it difficult to deal with word problems involving derivatives. Research studies in Ghana (Adu, Assuah, & Asiedu-Addo, 2015) indicate that students have difficulties in solving mathematical word problems involving derivatives/differentiation. Also, the Chief Examiner's report for West Africa Senior Secondary Certificate Examination [WASSCE] (2016, 2017, 2018, 2019), consistently indicate that students have difficulty in translating word problems into mathematical, including differentiation, sentences. The reports point out that, students who answer word problems usually perform poorly because they lack basic mathematical knowledge that bounds their problem solving ability.Most students could not write useful mathematical equations from given word problems. Cruz and Lipinid (2014) foundthat, students 'difficulties in solving problems occur because they are not allowed to actively participate in the problem solving process. They do not discuss and interact to explore the problem solving process collaboratively in the classroom. Consequently, students do not see problem solving as a participatory activity that brings satisfaction in learning. Participatory Problem solving approach which embodies factors that influence students' involvement in the study of mathematics has the potential and quality to address the challenges of solving word problems and to make learning interesting to students (Hanrahan, 2014;Okyere, and Kuranchie, 2013;Borhan, 2012;Tarmizia, and Abub, 2010; Mariani, Wardono and Kusumawardani, 2014;Mokhtar, Tarmizi and Nawawi, 2013;Azer, 2009). However, participatory problem solving activities are not incorporated in the mathematics text books (see *Aki-Ola, Backhouse, James Stewart*) and are hardly used in the classroom. Besides, there is little research on the effect of factors that influence students' involvement in the Participatory Problem Solving Approach on differentiation in the Ghanaian context. It is in this vein that the study was designed to investigate the effect of the factors that influence students' involvement in Participatory Problem Solving Approach.

III. Research Questions for the Study

1. What factors influence students' involvement in participatory problem solving approach on derivatives/differentiation word problems of functions?

Research Design

A descriptive research design was employed to enable the researcher to adequately and appropriately describe the phenomenon being studied. This would also aid the researcher to explain the situation under study since descriptive research precedes explanatory research. It would be easy to deliberate properly since its results mostly rely on frequencies, average and other statistical calculation.

Participants

The study consists of 80Wa SHS form three (3) science classes such as S1 and S2. This third year students were selected because the topic of interest, derivatives word problems, was the topic to be treated in form three (3). Also, they could provide the necessary information to answer the research questions raised. Purposive (non-probability) sampling was used to select S1 and S2 classes for the study. There were science classes and each class students were 40.

3.5 Research Instruments

It is important to have deeper understanding of the effect of factors that influence students' involvement in PPSA. Wilkinson and Birmingham (2003) define research instruments simply as devices for gathering data significant to answer a research task. For the purpose of this study, one instrument namely; factors that influence students' involvement in PPSA on differentiation questionnaires were used for data collection. The questionnaires consisted of six (6) Likert scale type questions designed to provide qualitative data on factors that influence students' involvement in participatory problem solving approach. The Likert scale type items were scored on a four-point Likert-type scale: 1=strongly agree, 2=agree, 3=disagree and 4=strongly disagree. A respondent could choose any of these possible outcomes depending upon the degree of disagreement or agreement with a particular question or statement.

Validity and Reliability of Instruments

In order to validate the instrument, an expert in Likert-type scale was consultedas well as some prescribed literature in Likert-type scale for content validity. The consultation was to gain insight into what students are expected to study under the factors that influence their involvement in derivative word problems to develop the instrument accordingly. After constructing the questionnaires, an expert was again consulted to cross-check their face, construct and content validity. The reliability for the questionnaires was 0.89 after the pilot study, using Cronbach alpha coefficient value 0.7 which is an acceptable reliability coefficient, an indication of questionnaires being reliable (Field, 2009).

Data collection procedures

Before the data was collected, the students were introduced to the concept/operation of PPSA via the treatment of various topics in differentiation word problems. This was to enable the researcher to ascertain the necessary information to answer the research question. The students were necessary guided to construct their own knowledge using PPSA.The subjects were taught for five weeks and after thatfactors that influence students' involvement in PPSA on differentiation word problem questionnaires were used to collect data.

Data analysis

The closed-ended questionnaires provide quantitative data. The researcher analyzed theclosed-endedquestionnaires data by conducting frequency count and percentages of respondents to determine the most and least attitudinal factor to the attitudinal inventory. This is to enable researcher to interpret the data being analyzed.

IV. Results of Discussions

Table 1 Factors that Influence Students' Involvement in Participatory Problem Solving Approach on Derivatives/Differentiation (*n = 80*).

Factor	Agreement n(%)	Disagreement n(%)	Mean	SD	Total N
1.Your intelligence Quotient is not a factor that influences your involvement in PPSA in solving derivative word problems	18(22.5)	62(77.5)	3.30	0.992	80
2.Your environment is not a factor that influences your involvement in PPSA solving differentiation word problems	38(47.5)	42(52.5)	0.63	0.125	80
3.Your ability to read and understand the problem is a factor that influences your involvement with PPSA in solving derivatives word problems	70(87.5)	10(12.5)	1.60	0.900	80
4.Your background knowledge of the PPSA is a factor that influences your involvement in solving differentiation word	54(67.5)	26(32.5)	2.15	1.189	80

problems					
5.Teacher quality of instruction is a factor influence your involvement in PPSA in solving word problems on derivatives	72(90)	8(10)	1.43	0.813	80
6.Your participation in PPSA is not a factor in your proficiency in mathematical word problem solving in differentiation	14(17.5)	66(82.5)	3.28	0.987	80

Table1shows that most of the students did show a favorable agreement to the factors which influence their involvement in PPSA in solving differentiation word problem. This is because majority of the students agreed to the factors that influence their involvement in the approach indifferentiation word problems while few of them disagreed. The frequency and percentages from Table1 indicated that students agreed that the Intelligence Quotient, the ability to read and understand the problem, teachers' quality of instructions and students participation are 62(77.5%), 70(87.5%), 72(90%) and 66(82.5%) respectively influence their involvement in using PPSA in solving differentiation word problems while 18(22.5%), 10(12.5%), 8(10%) and 14(17.5%) also respectively disagreed to the same constructs. This suggests that the students generally agreed to the six factors in the questionnaire as factors influencing their involvement in PPSA.

The students' mean ratings of the statements describing their involvement in PPSA in differentiation word problems were also determined. The table1 shows that the mean agreement was higher on the negative items than the positive ones. For example, the means of students' intelligence quotient and the mean of students' participations in classroom learning are 3.30 and 3.28 respectively. These indicate that, all the respondents reasoned in line with disagreement with scale point 3 and 4. But these items were negatives and respondents disagreed meaning there were good factors which influence students' involvement in PPSA on differentiation word problems solving. The rest of the itemsmeans were less than 3 indicating that the respondents' agreed with the statements in the items which have a scale points 1 and 2.

The standard deviation provides an indication of how far the individual responses to a question vary or deviate from the mean responses. It provides some idea about the distribution of scores around the mean (average). The smaller the standard deviation, the more narrow the range between the lowest and highest scores or, more generally, that the scores cluster closely to the average score. The standard deviation of background knowledge is 1.189 means that the standard deviation is 1.189 away from the mean. The rest of the standard deviations are less than 1. These indicate that their standard deviations are less than 1 away from their means.

The researcher found that factors such as the student's intelligence quotient, home environment, reading and understanding ability, background knowledge, teacher's quality of instructions, and the student's participation were found to influence students' involvement in using the PPSA in solving differentiation word problems. These results are consistent with (Leong et al, 2004;Sam and Lourdusamy, 1994;with Diniz, Pocinho, and Almeida, 2011;Tella, 2007;Arı and Katrancıb, 2014; Pimta, Tayruakham and Nuagchalerm, 2009;Hanrahan, 2014;Okyere, and Kuranchie, 2013;Borhan, 2012;Tarmizia, and Abub, 2010; Mariani, Wardono and Kusumawardani, 2014;Mokhtar, Tarmizi and Nawawi, 2013;Azer, 2009).

V. Conclusion

PPSA applied for teaching and learning of mathematics provides a mean for solving mathematical problems, which makes the students to be accountable for their own knowledge.

The factors studied are potential factors that influence students' involvement in participatory problem solving approach on derivative word problems.

Recommendations

1. Teachers are encouraged to apply PPSA in their classroom to teach mathematics.
2. Teachers should guide and explain the factors well to students to develop the skills so that the students could apply during mathematics lessons.
3. The study recruited only one school students so future research should go beyond one school.

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