QUESTION- GENERATION: A TOOL FOR ENHANCING ENGAGEMENT OF STUDENT IN MATHEMATICS LEARNING

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Abstract

The study explored the effect students-generated questions after instruction have on their engagement time in mathematics learning. This was done by comparing the engagement time of students who are exposed to question generation as an instructional strategy and those who were not exposed to the strategy. Gender was incorporated as a moderating variable. Two research questions and two null hypotheses guided the conduct of the research. A blend of experimental and survey research designs were adopted. A sample of 132 SS2 students was selected from two secondary schools in Umuahia Education Zone of Abia State by purposive sampling technique. Students were randomly assigned to experimental and control groups. Data were collected using student engagement questionnaire validated by two lecturers from measurement and evaluation and t – test statistic was used to compare the engagement time of students who were exposed to question generation and those who were not exposed to the strategy. Results indicated significant difference in the engagement time of experimental and control groups with the experimental group having higher engagement time. However, no significant difference was found in the engagement time of boys and girls who were exposed to question generation strategy even though question generation as an instructional strategy equally enhanced the time both male and female students are engaged in mathematics learning. The researchers recommended among other things that students should be asked to construct questions after instruction to keep them actively engaged in learning activities.

Introduction

Engaging students and staff effectively as partners in teaching, learning and assessment is arguably one of the most important issues facing education in the 21st century. Students as partners is a concept which interweaves through many other debates, including assessment and feedback, employability, flexible pedagogies, internationalization, linking teaching and research and retention and success (Flint & Harington, 2014). Based on current educational theories, educational activities should be designed to maximize learners' opportunities to construct meaningful personal knowledge and develop higher – order thinking abilities, such as meta-cognition which has been shown as the most important factor contributing to learning (American psychological Association, 1997 as cited in Mok, 2005). This concept or idea is supported by Wanner (2015) who noted that students want interactivity and active learning and that learning is shifting from teachers to more students – centered approaches. This means a shift in pedagogies to constructivist teaching practices that entails engaging students fully during teaching and learning activities.

According to Shaun and Quaye (2009), student engagement has emerged as one of the principal cornerstones and objectives of teaching and learning in the higher education systems around the world. This idea is supported by Radloff and Coates (2009) who noted that the concern with student engagement in higher education is nothing new as university educators have always had a core interest in understanding and managing students' engagement in effective learning. With globalization, increasing internationalization of curricula and more student – centered and constructivist educational pedagogies, the focus is more than ever on understanding and improving student engagement at all levels.

In secondary schools, students are mostly engaged in solving assignments, class works, tests and quizzes; as such, the idea of engaging students in teaching and assessment through question construction is not popular since students are only required to provide answers to the questions posed by the teachers or ask questions in areas that are not clear to them during or at the end of the class instructions. But many researchers in student learning have opined for greater student engagement in the learning process (Astin, 1984; Coates, 2008; Kuh, 2009; Radloff& Coates, 2009).

Many scholars have defined student engagement in diverse ways. Coates (2008:1) defines student engagement as "students' involvement with activities and condition likely to generate high – quality learning". In another definition, Astin (1984:297) defined student engagement as "the amount of physical and psychological energy that the student devotes to the academic experience". It can be observed that these definitions put the onus of engagement on the student and not the educational institutions which should structure programmes to keep students engaged. A more encompassing definition of student engagement which tries to combine student and instructional factors of student is given by Kuh (2009: 683) who stated that "student engagement represents the time and effort students devote to activities that are empirically linked to desired outcomes of college and what institutions do to induce students to participate in these activities". It is clear that there is "compelling" evidence that enriching the experiences and academic challenges for students in the most successful strategy for engaging them. (Zepke& Leach 2010: 171). Hence, it is ultimately the responsibility of teachers at all levels to provide stimulating and engaging learning environments for students.

Furthermore, Coates (2005, 2b: 37) states: "the concept of student engagement is based on the constructivist assumption that learning is influenced by how an individual participates in educationally purposeful activities. Hence, individual learners are ultimately the focus in discussions of engagement. He concludes that student engagement is concerned with the interaction between the time, effort and other relevant resources invested by both students and their institution intended to optimize the learning outcomes and development of students and the performance, and reputation of the institution.

In addition, Coates (2007:122) described engagement as "a broad construct intended to encompass salient academic as well as certain non-academic aspects of the student experience" that comprises active and collaborative learning, participation in challenging academic activities, formative communication with academic staff, involvement in enriching educational experiences, and feeling legitimated and supported by university learning communities. While student engagement can be measured along six engagement scales such as academic challenge (extent to which expectations and assessments challenged students to learn), active learning (students efforts to actively construct their knowledge), student and staff interaction (level and nature of student contact with teaching staff), enriching educational experiences (participation in broadening educational activities), supportive learning environment (feelings of legitimation within the university community), and work integrated learning (integration of employment focused work experience into study).

There are different strategies to adopt in order to motivate and help students engage with their peers, their teachers and the course materials; but one of such strategies is question generation. Question generation as instructional strategy entails asking students to construct questions for themselves on the topics covered at the end of an instruction. The students may construct both multiple choice and essay type questions as the case may be and also provide the keys(correct answers) for the questions so developed. It is believed that in the process of constructing the test items and providing solution (including possible distracters in the response options as could be found in an objective test); the students will be able to scrutinize their course materials which is expected to keep them engaged in the just concluded instructional activity.

A number of theoretical perspectives have been developed to explain how student question generation can be of value to learning and cognitive development in particular. Constructivists posits that learning is most likely to occur in contexts where individuals are allowed to reflect and build their knowledge based on learning experiences to which they have been exposed (Bodner, Klobuchar & Geelan, 2001; Von –Glasersfeld, 1987 cited in Yu, Tsai & Wu, 2013). Hence constructivism emphasizes that learners construct their own interpretations of the world of information around them in terms of their own conceptual structures (Steffe, 1991). The goal of instruction, from the perspective of constructivists is thus to create situations that enhance individual interpretations and reflections rather than mirroring the representations or fixed structures of the external objective world. As such, a constructivist approach supports having students construct their own questions in contrast to the situation that commonly occurs in traditional class rooms where they answer questions that teachers regard as important based on the content of the study material (Yu, 2011).

Another concept that is widely cited by researchers examining student question – generation is meta-cognition. Meta-cognitive emphasizes the role of executive processes in overseeing and regulating persons' cognitive processes, such as planning, monitoring, predicting, evaluating and revising (Brown, 1987; Flavel, 1979; Livingston, 2003 cited in Yu, Tsai & Wu, 2013). When learners need to generate questions based on material they have studied, this triggers many meta-cognitive processes, thus aiding learning. Put another way, when asked to create questions, students need to reflect on any parts of the material that seem important but which they do not comprehend, as well as how the core concepts can be understood, and then rephrased and used in test items. Based on meta-cognitive theory, students who generate questions are more likely to be aware of state of their own knowledge and competence and become more intellectually active in and engaged in the learning process (Yu, 2005). Hence question generation helps students to conduct self-assessment which is concerned with learners' valuing their own learning and achievement on the basis of evidence from themselves and from others. With self – assessment, student check their works, revisit assignments, drafts, tests and research works and reflect upon their past practice. The judgment they make may be about what they have done, what they should be doing and why they should be doing it.

Vygostsky (1978) noted that questions are one of the psychological tools for thinking and when embedded in the discourse of collaborative peer groups help learners to co – construct knowledge inter-psychologically. This knowledge is then appropriated or constructed intra – psychologically by the individual members, he stated. From a socio – cognitive perspective, questioning in a group contest can also encourage students to reconsider their ideas in new ways because they are exposed to different peer perspectives. It is a common knowledge among educators that to know how to question well is essential to knowing how to teach well. Given the curriculum emphasis on critical thinking, inquiry and student centered learning, there is also need to impress upon our students that to know how to question well is also to know how to learn well. According to Chin (2002) questioning is a hallmark of self – directed reflective learning.

A lot of benefits are inherent in students' generated questions. According to Chin (2001) and (2002), the formation of a good question is a creative act, and at the heart of what science and mathematics is all about. Questions help learners to make sense what has been taught and to construct meaning from data and information giving during the class session. More so, they are psychological tools that aid thinking and help to explore and scaffold ideas, steer thinking in certain specific directions so as to advance students' understanding of scientific concepts and phenomena.

Furthermore, questions constructed by students help them to recognized knowledge gaps and solve problems. They also provide the teachers with insights into students thinking and conceptual understanding, as well as their reasoning and what they want to know. Reflective learners ask themselves questions that help them monitor the status of their understanding and provide feedback which helps them to re-direct their use of learning strategies. Self-questioning allows an internal dialogue with oneself, driving the mind to look for patterns and connections, establishing relationships with prior knowledge and building bridges to new perceptions as well as converting raw data into new meaning. Thus, the effectiveness of self-questioning is attributed to both its cognitive and meta-cognitive (thinking about the thinking process that created one's thought) functions. This is supported by Thompson (2005) who asserted that students can become even more involved in problem solving by formulating and solving their own problems or by re writing problems in their own words in order to facilitate understanding.

Scholars have studied the efficacy or otherwise of students' generated questions as an instructional strategy and based on their findings have reported that engaging students with the development and discussion of student – generated content in the form of MCQs support student learning in a way that is not critically dependent on course instruction, instructor or the student (Hardy et al, 2014). Rather, it fosters a culture of inquisitiveness in the classrooms as well as improves students' ability to analyze and respond to multiple choice questions used in examinations ((Chin, 2002; Arthur, 2006).

Gender equality has been a conflicting issue in Mathematics achievement. Several studies have discussed the efficacy of different instructional strategies by gender. Whereas some researchers reported the effectiveness of some innovative instructional strategies in favour of boys, others reported some in favour of girls and still many researchers have found no significant difference in the efficacy of instructional strategies by gender. For instance, Gambariand and Adegbnro (2008), Osemnwinyen (2009),Abakpa and Iji (2011), Ifeanacho (2012) and Ihendinihu and Mkpa (2015) found no significant effect of instructional strategies on male and female students in science and Mathematics. However, Uwadie (2008), Amalek (2009) and Agomuoh (2010) reported that male students are better affected by instructional strategy than female students in science Technology and Mathematics, whereas Kurumeh (2004) reported better effect of instructional strategies/techniques on girls than boys.

The relevance of mathematics to science technology and everyday life cannot be over – emphasized. Mathematics by nature is a practical and activity oriented subject and this creates the need to improve students' engagement during the teaching and learning of the subject. To achieve this, there is need to review routine practices in the educational process. A regular practice in the educational process is for teachers or instructors to generate questions for students after instruction so as to evaluate the attainment of the pre-stated objectives of the instruction while the students are more or less expected to provide answers the questions rather than to ask them. However, it is speculated that allowing students to generate questions (both objective and essay) after instruction will keep them both mentally and physically engaged in the learning process. Therefore this study sought to determine the effect of asking students to generate questions after instruction on the time they are engaged in academic activities in mathematics learning.

The following research question and hypotheses guided the study

- What is the average engagement time of students who were exposed to question generation and those who were not exposed to the strategy?
- To what extent does the engagement time of boys and girls who were exposed to question generation differ?
- There is no significant difference in the engagement time of students who were exposed to question generation and those who were not exposed to question generation.

- There is no significant difference in the engagement time of boys and girls who were exposed to question generation.

Method

The researcher adopted a blend of experimental and survey research designs. A sample of 132 SS II students was selected from two secondary schools in Umuahia Education Zone of Abia State using purposive sampling techniques. Two randomly composed groups were formed in each of the two schools; as such, each school had experimental and control groups. The instrument for data collection was a questionnaire titled "Engagement Time Questionnaire" (ETQ) which was used to determine the time students spent in academic activities due to question generation. The questionnaire was designed to elicit response on the time spent on private studies at home, interaction with students and teachers at school, and attendance to mathematics lessons. The instrument was validated by two lecturers from measurement and evaluation and administered to 20 students in SS3from another school that was not used for the study in order to determine the reliability. This was done to test their reaction to the items in the instrument. Also the instrument was re-administered after two weeks, and the scores obtained in the first and second administration were correlated using Pearson Product Correlation formula and a coefficient of 0.78 was obtained. Consequently, the study compared the time spent in learning activities by students who were engaged in question generation and those who depended only on the teachers' assessment questions. Furthermore, the study compared the engagement time of students who used question generation by gender.

Experimental Procedure /Method of Data Collection

The experiment lasted for 6 weeks. The Mathematics teachers for SS2 in the two schools selected for the study were trained as research assistants to help in conducting the experiment. During the training, the purpose of the study, the nature of the experiment, lesson plans and assessment questions, the modalities of question construction, levels of educational objectives in cognitive domain were discussed.

The same teacher taught all the students in the school using the current scheme of work and lesson plans with the liberty to use any teaching method of choice. Each student in the experimental group was asked to generate 15 objective questions and 5 essay questions on each topic covered at the end of the week. They were also required to do whatever assignment or class work given by the teacher. A total of 4 topics were covered during the experiment. The students were discouraged from lifting statements or questions directly from the note rather they were asked to use their own words or sentences. Also they were required to provide plausible options for the objective questions. The questions were expected to cover all the levels of educational objectives in the cognitive domain.

For the control group, the students were not asked to generate any questions. They only solved whatever assignment or class work given by their teacher. During the experiment, the students in the experimental and control groups were given the Student Engagement Questionnaire to complete at the end of each week. Their responses in the questionnaire were collated by the researchers for analysis and t-test statistic used to test for significance difference in the mean of the two groups.

Results

Table 1: Mean engagement time of experimental and control groups

Group	Number	Mean	Standard deviation
Question generation	66	17.79	3.399
Control	66	10.48	2.724
Difference		7.31	

From Table 1, the mean engagement time of group 1 is 17.79 with standard deviation of 3.399, whereas the mean engagement time of group 2 is 10.48 with standard deviation of 2.724. The difference in the mean of the groups is 7.31. From the result the mean of group 1 (question generation) is greater than the mean of group 2 (conventional).This suggests that Question Generation as instructional strategy enhanced the engagement of students in mathematics learning.

Table 2: Independent t-test analysis of mean engagement of experimental and control groups

Variables	n	$\bar{x}$	SD	t-cal
Experimental group	66	17.79	3.40	13.62
Control group	66	10.48	2.72	

P< .05; df = 130; Crit. t = 1.96

The result of data analysis in Table 2 shows that the t value of 13.619 is significant at 0.05 level since the significance level 0.00 is less than 0.05. Hence the null hypothesis is rejected. The implication is that the difference in the mean engagement time of students who were asked to generate questions after instruction and those who were not exposed to the strategy is significant. Since the question generation group has a greater mean score (as shown above) then this strategy enhanced the engagement time of students.

Table 3: Mean engagement time of boys and girls in experimental group

Gender	Number	Mean	Standard Deviation
Boys	27	17.26	3.789
Girls	39	18.15	3.100
Difference		1.11	

Table 3 shows that the mean engagement time of boys is 17.26 with standard deviation 3.789 while the mean engagement time of girls is 18.15 With standard deviation 3.100 .The difference in their mean engagement is 1.11. The fact that the mean engagement of girls is greater than the mean engagement of boys, suggests that the strategy of asking students to generate questions after instruction enhanced the engagement of girls more than boys. However t-test analysis was used to test the significance of this difference.

Table 4: Independent t-test analysis of mean engagement time of boys and girls in experimental group

Variables	**n**	**$\bar{x}$**	**SD**	**t-cal**
Experimental group (boys)	27	17.26	3.79	-1.052
Experimental group (girls)	39	18.15	3.10	

P< .05; df = 66; Crit. t = 1.96

The result of data analysis in Table 4indicates that the t-value of -1.052 is not significant at 0.05 level of significance since the significance level 0.297 is greater than 0.05.Therefore the null hypothesis is not rejected. This implies that the difference in the mean engagement of boys and girls exposed to question generation is not significant. Hence the strategy equally enhanced the engagement time of boys and girls.

Discussions

Result of data analysis in table 1 shows that the mean engagement of the group that were exposed to question generation is greater than the mean engagement of the conventional group. Also result of data analysis in table 2shows that the difference in the mean engagement of experimental and control groups is significant in favour of the question Generated group. Hence the strategy of asking students to generate questions after instruction enhanced the time they were engaged in Mathematics learning and consequently improved their achievement in mathematics. This result agrees with the report of Hardy et al (2014) who noted that engaging students with the production and discussion of student-generated content in the form of MCQs can support student learning in a way that is not critically dependent on course instruction, instructor or student. It also corroborates the report of Chin (2002) who noted that student generated questions foster a culture of inquisitiveness in the students and improves students' ability to analyze and respond to multiple choice questions used in examinations.

The finding is also in line with a priori expectation. The act of constructing questions and providing solutions and possible distracters as options (in objective questions) is expected to keep students engaged. The process involves students scrutinizing their course material to reflect on whether there are any parts of the material that seem important but which they do not comprehend as well as how the core concepts can be understood and then rephrased and used in test items. The activity will likely promote discussions between peers as well as with their teachers who may be consulted to ascertain the appropriateness or otherwise of the questions (and their proposed solutions) generated by the students.

In Mathematics, the act of changing figures and/or symbols/signs in order to create new questions may help students discover new relationships in Mathematics. All these will no doubt increase the time the students are engaged in the learning process.

Result of data analysis in table 3 shows that the difference in mean engagement of boys and girls is 1.11 with girls having greater mean. However the t-test analysis in table 4 shows that this difference is not significant. This implies that both boys and girls equally benefitted from question generation as instructional strategy.

The finding agrees with those of Gambari and Adegbnro (2008),Osemnwinyen (2009),Abakpa and Iji (2011),Ifeanacho (2012) and Ihendinihu and Mkpa (2015) who reported equal response of male and female students to innovative instructional strategies. Ithowever contrasts the result of Uwadie (2008),Amalek (2009), Agomuoh (2010) and Kurumeh (2004) who reported significant difference in the response of male and female students to innovative instructional strategies.

Conclusion

The current shift in pedagogy from teacher-centered to student-centered approach and the need to adequately engage students in the teaching and learning process creates the need to explore strategies that could enhance engagement of students in the learning. The result of the present study indicates that question generation as instructional strategy is effective in enhancing the engagement of students in the learning process.

The findings of this study have implications for teachers, students and educational planners. The teachers and students have been exposed to a strategy that can be used to engage students in the learning process. The teacher may be exposed to other ways of constructing questions from different topics due to the exercise. They can even draw questions from the pool of questions generated by students during class tests or examinations. The students on the other hand may get acquainted with possible examination questions during the exercise.

The researcher therefore recommends the adoption of question generation strategy in teaching and learning process by Mathematics teachers in particular and other subject teachers in general. Also curriculum planners should incorporate question generation as part of evaluation techniques in the curriculum.

References:

Arthur, N. (2006). *Using student-generated assessment items to enhance team work, feedback learning process,* Institute for Teaching and Learning, Synergy Issue 24.

Astin, A. W. (1984). Student involvement: A developmental theory for higher education. *Journal of College Student Personnel,* 25(4), 297-308.

Bodner, G. M.; Klobucher, M. & Geelan, D. R. (2001).The many forms of constructivism, *Journal of Chemical Education,* 78(8) 1107.

Brint, S. & Cantwell, A. M. (2010). Undergraduate time use and academic outcomes: Results from the University of California undergraduate experience survey 2006, *Teachers College Record,* 112(9) 2441-2470.

Chin, C. (2001). Learning in Science: What do students questions tell us about their thinking? *Educational Journal,* 29(2) 87-103.

Chin, C. (2002). Student generated questions: Encouraging inquisitive minds in learning. Science Teaching and Learning, 23(1), 59-67.

Coates, H. B. (2008). Attracting, engaging and retaining: New conversations about learning. Australian student engagement report, *Australian Council for Educational Research* (ACER), Camberwell, Victoria.

Draper, S. W. (2009).Catalytic assessment: Understanding how MCQs and EVs can foster deep learning. *British Journal of Educational Technology*, 40(2), 285-293.

Hardy, J.; Bates, S. P.; Casey, M. M; Galloway, K. W.; Galloway, R. K, ; Kay, A E.; Kirsop, P. & McQueen. H. A. (2014). Student generated content: Enhancing learning through sharing multiple-choice questions, *International Journal of Science Education*, 33(13), 2180-2194.

Healey, M.; Flint, A. & Harington, K. (2014). Engagement through partnership: Students as partners in learning and teaching in higher Education, *The Higher Education Academy UK.*

Ihendinihu, U. E. & Mkpa, N. D. (2015).Comparative effect mastery learning models on achievement of secondary school students in mathematics, *Journal of Agricultural and Science Education*, 1, (1), 449-458.

Kuh, G. D. (2009).What student affairs professionals need to know about student engagement, *Journal of College Student Development,* 50, (6), 683-706. Available on at doi:10.1353/csd.0.0099.

Light, &Piersor, E. (2014). Increasing student engagement in Mathematics: The use of Khan academy in Chilean classrooms, *International Journal of Education and Development*, 10, (2), 103-119.

Mok, M. M. C. (2005).*A conceptual framework for the design of web-based self-directed learning curriculum,* Keynote presented at the International Conference on Education and Information Technology, National Ocean University, Keelung, Taiwan.

Radloff, A,&Coaetes, H. (2009). Doing more for learning: Enhancing engagement and outcomes- Australasian Student Engagement Survey, Australian Council for Educational Research (ACER)' Camberwell, Victoria, Australia.

Shaun, R. H. &Quaye, S. J. (2009). *Student engagement in higher education: Theoretical perspectives and practical approaches for diverse populations,* New York: Routledge.

Steffe, L. P. (1991). The constructivist teaching experiment: Illustrations and implications. In E. von Glasersfeld (Ed.), Radical constructivism in mathematics education. Dorddrecht: Kluwer Academic Publishers.

Vygostsky, L. (1978). *Mind in society: The development of higher psychological process*, Cambridge M A: Harvard University Press.

Yu, F. Y. (2005).Promoting meta-cognitive strategy development through online question-generation instructional approach, In C. K. Loof, D. Jonassen, & M. Ikeda, (Eds), Towards sustainable and scalable educational innovations informed by the learning sciences 564-571, Amsterdam, the Netherlands: IOS Press.

Yu, F. Y. (2011). Multiple peer assessment modes to augment online student question-generation processes, Computers and Education, in a science class, *Australasian Journal of Educational Technology*, 29(3) 416-433.

Yu, F.; Tsai, H. & Wu, H. (2013). Effect of online procedural scaffolds and the timing of scaffolding provision on elementary Taiwanese students' question-generation, 56(2).484-494.

Wanner, T. (2015). Enhancing student engagement and active learning through just-in-time teaching and the use of power point, *International Journal of Teaching and Learning in Higher Education,* 27,(1), 154-163.

Zepke, N., X & Leach, L. (2010). Improving student engagement: Ten proposals for action. *Active Learning in Higher Education,* 11(3), 167-177.