Students' Problem-Solving and Critical Thinking Skills: Bases for the Development of Contextualized Learning Module in Geometry

Efren S. Tellermo, Guimaras State College, Philippines
Chive G. Gabasa, West Visayas State University, Philippines

Abstract
This design research aimed at designing and developing a contextualized learning module on the basis of the level of problem-solving and critical thinking skills of the Grade 7 students particularly in Geometry under the K to 12 Curriculum. This study utilized the researcher-made problem-solving and critical thinking skills test. The results revealed that the students' problem-solving and critical thinking skills were at the beginning stage. The least-learned competencies in problem-solving and critical thinking skills were the bases of developing a contextualized learning module utilizing the ADDIE model. The design and development of the module was done through a seminar-workshop participated in by secondary school mathematics teachers. The implementation of the final draft of the module was done through pilot testing to determine the quality of the module. The results revealed that majority of the students found that the module was easy, exciting, enjoyable, and could enhance their problem-solving ability and critical thinking skills. The teachers also found that the contextualized activities could arouse the interest of the students. Hence, the contextualized learning module developed by the researcher can be used by teachers as support instructional material. Competencies in Mathematics will be learned by more students if the contents are taught in the students' real-world context.

Keywords: Problem-solving skills, critical thinking skills, contextualized learning module

Introduction

Mathematics is one of the subjects that pervade life at any age and at any circumstances (K to 12 Mathematics Curriculum Guide, 2016). Students are expected to be equipped with the 21st century skills especially the problem solving skills and the critical thinking skills. However, many students have poor performance in Mathematics. In an international setting, the study of Ogena, Laña, and Sasota (2010) showed that out of 10 countries participated in the Trends in International Mathematics and Science Study (TIMSS), the Philippines is on the 10^{th} place with science high schools participating. They also found out that only 1% of the students have reached the advanced level. The problem of low performance in Mathematics is not only apparent in elementary and high school students. In the local setting, the study of Junsay (2016) showed that pre-service Mathematics teachers possess inadequate skills in critical thinking and problem solving. They lacked the ability to analyze, evaluate, interpret, infer, explain, and self-regulated(Junsay, 2016). Thus, they need to enhance their critical thinking and problem solving skills. The study of Saylo (2016) also showed that students had fairly developed critical thinking skills. This is an alarming reality and served as a great challenge for teachers and other educators to exhaust all means in achieving the goal of higher level achievement of students and bring great change to happen in the educational system.

The National Council of Teachers in Mathematics (NCTM, 2000) suggests that critical thinking and problem solving should be the focus of teaching Mathematics. The development of students' critical thinking and problem solving abilities are the primary objectives of Mathematics instruction (K to 12 Mathematics Curriculum Guide, 2016). Critical thinking skills should be developed through teaching and learning process an integral part of student's learning in schools(Firdaus, Ismail Kailani, Md. Nor Bin Bakar, Bakry, 2015). Students will have the characteristics of an independent learner if they internalize the skills and competencies of critical thinking and problem solving. (Elder and Paul, 2010).

In addition, the Philippines is the only country in Southeast Asia which has 10 year basic education (SEAMEO INNOTECH, 2012). There's really a need to enhance our curriculum because when compared with other countries, the Philippines is almost far at the bottom in terms of educational development program. By virtue of RA 10533, the Philippine education system shifted from 10-year to 12-year basic education by implementing the K to 12 curriculum. It started its implementation last school year 2012-2013. One of the problems encountered on its first implementation was the shortage of textbooks or learner's modules. Section 10 paragraph 3 of rule II of the RA 10533 states that production and development of locally produced instructional materials should be encouraged. However, these materials should meet the national policy standard. The learning material or learning module should be contextualized(RA 10533). It should also enhance problem solving and critical thinking skills of the students.

Theory of constructivism emphasizes that the learner construct knowledge when they were able to draw ideas from their own experiences and connect them to new ideas (Bruner, 1977). It contends that learners construct from what they learn through active involvement. That's why in the teaching and learning process, students must be involved actively in their learning and will be provided with experiences that

challenge their thinking. For Bruner, the purpose of education is to facilitate the learner's critical thinking and problem-solving skills which can then be applied to a range of situations.

On the other hand, Situated Learning Theory emphasizes that people's knowledge is constructed within and linked to the activity, context, and culture in which it was learned (Brown, Collins, & Duguid, 1989). For Lave and Wenger(1992), Situated Learning is learning that takes place in the same context in which concepts and theories are applied. Heckman and Weissglass (1994) believe that mathematics will be learned if taught within the context of the learners. In situated learning environments, students are actively involved in learning activities by using problem-solving and critical thinking skills.

An instructional-design theory offers explicit guidance on how to help people learn, develop and require at least two components: methods for facilitating human learning and development, and indications as to when and when not to use those methods (Reigeluth, 2011). Design theories are somehow prescriptive since they provide methodical guidelines to achieve a goal.

Methodology

This design research utilized the ADDIE(Analysis, Design, Develop, Implement, and Evaluate) model in developing a module. Participants in each stage were identified. The results of the problem-solving and critical thinking skills test of the 143 students were analyzed and the basis for developing a contextualized learning module in Geometry. The design and development stages were done through a seminar workshop participated by 25 Mathematics teachers who have at least two years of experience teaching Geometry subject. The implementation stage was done through pilot testing of the final draft of the module to 31 students. The final module was evaluated by 17 teachers who actually teach the subject.

This research also utilized the researcher made problem-solving and critical thinking skills test. The tests were content validated by Mathematics teachers who were considered experts in their field of specialization. The four dimensions of problem solving by Wu and Adams (2006) which includes reading or extracting all information from the question, sense making and common sense approach to solving problems, mathematization and reasoning, and standard and computational skills were utilized for the problem-solving test while the six core skills on Critical Thinking of Facione (2013) which include interpretation, analysis, inference, evaluation, explanation, and self-regulation for critical thinking test. The final instrument has a reliability coefficient of .803 for problem-solving test and a reliability coefficient of .834 for critical thinking test through Kuder-Richardson(KR_{20}). A focused-group discussion was conducted to determine the teachers' teaching experiences and the students' learning experiences with the use of the module during implementation. During the evaluation of the module, the teachers rated the module in terms of learning objectives, content, activities, assessment, and design and presentation.

This study used the research design to develop a learning module in Geometry. Design research is the the systematic analysis, design and evaluation of educational interventions with the aims of generating research-based solutions for complex

problems in educational practice, and the advancement of the knowledge about the characteristics of these interventions and the processes of designing and developing them(McKenney and Reeves, 2012)). Furthermore, the students' level of problem-solving and critical thinking skills and the least-learned competencies served as the bases for the development of learning modules in grade 7 Geometry. Specifically, this study utilized the ADDIE model which follows the five stages: analysis, design, develop, implement and evaluate.

Results

The data in table 1 shows that students level of problem solving skills is at beginning stage (*M*=9.64*, SD*=6.46). This means that students neither identify the problem nor develop a coherent plan to solve the problem. They were not able to collect viable information as well as interpret the findings or reach a conclusion. This result was consistent with the study of Junsay (2016) that even pre-service teachers were short of the ability to apply concepts and mathematical principles to solve problems.

The beginning level of problem-solving can be attributed to the lack of problem-strategies or heuristics of the students. Problem-solving strategies help the students understand and solve the problem (Schoenfeld, 1985; Dolan, 1983). Dolan (1983) added that students' performance at solving problems could be improved if they are aware of the problem-solving strategies.

The data in table 1 further shows that students level of critical thinking skills was also beginning (*M*=11.55, *SD*=6.71). This means that students offered biased interpretations of evidence, statements, graphics, questions, information, or the points of view of others. They failed to identify relevant counter-arguments, and ignored or superficially evaluated obvious alternative points of view. Moreover, they argued using fallacious or irrelevant reasons and unwarranted claims. They neither justified results nor explained reasons, and regardless of the evidence or reasons, maintains or defends views based on self-interest or preconceptions and also exhibited close-mindedness or hostility to reason. A larger variance on students' scores on problem-solving compared to critical thinking was also noted. It indicated that the students' scores in problem-solving had wider spread from the mean.

This result is backed up by the study of Junsay (2016) that prospective teachers did not possess adequate critical thinking skills and were short of the ability to apply concepts, and mathematical principles. They lacked the ability to analyze, evaluate, interpret, infer, explain, and self-regulate. Furthermore, the study of Junsay (2016) and Saylo (2016) shows that even prospective teachers' critical thinking skills were between the beginning and developing levels.

The beginning level of students' critical thinking skills can be meager of students' exposure to classroom situations that could tickle their critical thinking skills. Asking higher order thinking skills (HOTS) questions to stimulate students' critical thinking skills is important. Brown & Kelley (1986) emphasized the importance on integrating questioning techniques into class discussions to support an educational environment where students can demonstrate and practice critical thinking skills. Another fact is that most students find mathematics difficult specifically in problem solving. This was confirmed by TIMMS (Ogena, Laña, & Sasota, 2010) and Junsay (2016). Hence,

there's a need for teachers to revisit their teaching strategies. They must utilize strategies that suit the need of their students.

Table 1. Level of Students' Problem-Solving and Critical Thinking Skills

Test(*n*=143)	*SD*	*M*	Description
Problem Solving Skills	6.71	11.55	Beginning
Critical Thinking Skills	6.46	9.64	Beginning

Scale of Means: Problem Solving - accomplished (41.26 –55.00), competent (27.76-41.25), developing (13.76 – 27.50), beginning (0 – 13.75). Critical Thinking - accomplished (37.51 - 50.00), competent (25.01-37.50), developing (12.51 – 25.00), beginning (0 – 12.50)

The top five(5) least-learned competencies for problem-solving skills were: Problems involving points, lines and planes; Conditions for convexity and concavity of polygons; Relationships of sides and angles of a polygon; Perimeter of a Polygon; Relationship of segments formed by bisectors of line segments, Angles formed by parallel lines cut by a transversal using measurement; supplementary pair. For critical thinking skills, the top five(5) least-learned competencies were: Conditions for convexity and concavity of polygons; Relationships of geometric figures using measurements and by inductive reasoning; coplanar, skew and parallel lines, Relationships of geometric figures using measurements and by inductive reasoning; intersecting and perpendicular lines, Relationships of sides and angles of a polygon ;Perimeter of a Polygon, Angles formed by parallel lines cut by a transversal using inductive reasoning; supplementary pair .

In summary, the least-learned competencies for both problem-solving and critical thinking skills were: Problems involving points, lines and planes, Conditions convexity or concavity of a polygon, Perimeters of a polygon, Relationships of geometric figures using measurements and by inductive reasoning; intersecting and perpendicular, coplanar, skew and parallel lines, Relationships of segments formed by bisectors of line segments, Angles formed by parallel lines cut by a transversal using measurement and by inductive reasoning. These were the bases of the module developed by the researcher.

Table 2. Least-learned Competencies Problem-solving and Critical thinking skills

Learning Competency/Topics(n = 143)	% of incorrect answers	Rank
Problem Solving Skills		
Problems involving points, lines and planes.	93.71	1
Conditions for convexity and concavity of polygons	88.11	2
Relationships of sides and angles of a polygon ;Perimeter of a Polygon	86.01	3
Relationship of segments formed by bisectors of line segments.	81.12	4
Angles formed by parallel lines cut by a transversal using measurement; supplementary pair	80.42	5
Critical Thinking Skills		
Conditions for convexity and concavity of polygons	86.71	1
Relationships of geometric figures using measurements and by inductive reasoning; coplanar, skew and parallel lines.	83.92	2
Relationships of geometric figures using measurements and by inductive reasoning; intersecting and perpendicular lines,	82.52	3.5
Relationships of sides and angles of a polygon ;Perimeter of a Polygon	82.52	3.5
Angles formed by parallel lines cut by a transversal using inductive reasoning.- supplementary pair	81.12	5

The data in table 3 showed the responses of the students on their experience with the module during the pilot implementation of the module. The results revealed that majority of the students found that the module was easy and enjoyable. The module's simplified activities encouraged everyone maximum participation. The result also revealed that majority of the students found that the module enhanced their problem-solving ability because they thought of a process in finding answers to the problem and by leading them how to solve the problem. In addition, the activities were understandable that it made them easy to find answers to the problem. They added that the activities allowed them to compute and solve. This was confirmed by the study of Wu and Adams (2006) that the domains of problem solving are reading and extracting information from the question and standard computational skills in carrying out computations.

The result further revealed that still majority of the students found that the module allowed the students to think critically. The activities allowed them to think and analyzed the situations that they could understand and answer the problems were given. One student said that they could explain the situation if they understand. This also confirms the cores of critical thinking skills by Facione (2013) and the Delphi Research Team. Through cooperation and collaboration with others, they have a better understanding of the lesson.

Table 3. Students' Responses on their Experience with the Module during the Pilot Implementation.

Items (n = 31)	Yes		No	
	f	*%*	*f*	*%*
The module is easy to understand and enjoyable.	30	96.77	1	3.23
The module enhances the students' problem-solving ability.	27	87.10	4	12.90
The module allows the students to think critically.	21	67.74	10	32.26
The module is of good quality	30	96.77	1	3.23

Table 4 shows the summary of teachers' evaluation of the module in terms of objectives, content, activities, assessment, and design and presentation. The results revealed that the teachers rated the quality of the module as excellent for objectives (M=3.88, SD = 0.27), activities (M=3.79, SD = 0.28), assessment (M=3.74, SD=0.35), design and presentation (M=3.46, SD = 0.28) except for content (M=3.11, SD = 0.16) that is very good. From this result, it can be derived that the module is accompanied by a list of specific objectives, suit a particular topic, clear and simple, fitted to the level and needs of the learners, and it is attainable. The content of the module is easily understood, cleared and well organized. The activities are congruent to the objectives of the lesson, interesting and contextualized, and can enhance the problem solving and critical thinking skill of the students. The module also provides assessments that can enhanced problem-solving skills, congruent to the objective of the lesson, challenge students to think critically, and are adequate to measure student learning. Furthermore, the design and presentation is clear observing with correct grammar and the layout of the module is appealing. Finally, the overall rating of the teachers of the module is excellent as shown by the mean score (M = 3.60, SD = 0.20). This means that the teachers found the overall components of the module to be of excellent quality.

Table 4. Teachers' Evaluation of the Module

Areas (n=17)	Mean	Std. Deviation	Interpretation
Objectives	3.88	0.27	Excellent
Content	3.11	0.16	Very Good
Activities	3.79	0.28	Excellent
Assessment	3.74	0.35	Excellent
Design and Presentation	3.46	0.28	Excellent
Overall	3.60	0.20	Excellent

Scale of Means: 3.26-4.00 Excellent, 2.51-3.25 Very Good, 1.76-2.50 Fair, 1.00-1.75 Poor

Conclusions

The students do not have adequate problem-solving and critical thinking skills in grade 7 Geometry since they are in the beginning stage. They lacked the ability to apply mathematical concepts and principles in order to solve mathematical problems. They also don't have adequate knowledge and skills in reading or extracting all information from the questions and careless in carrying out computations since they cannot identify the problem, develop a coherent plan to solve the problem, and did not collect viable information. In addition, the students lack the ability to analyze, evaluate, interpret, infer, explain, and self-regulate. The students offer biased

interpretations of evidence, statements, graphics, questions, information, or the points of view of others. They also fail to identify relevant counter-arguments. They do not justify results or explain reasons, and argue using fallacious or irrelevant reasons and unwarranted claims. Hence, they needed to enhance their problem-solving and critical thinking skills. There's also a need for teachers to revisit their teaching strategies. They must utilize strategies that suit the need of their students. With the introduction of the contextualized learning module, they are required to provide solutions to a given problem. By doing this, students are given opportunity to apply what they understand about the problem and construct mental actions to arrive to a correct solution. They can also apply their previous knowledge and experiences by connecting it with the present situation. Thus, students can formulate solutions to problems if they have a better understanding about the problem situation.

The insufficiency of instructional material provided by DepEd to the teachers may have contributed to the low performance of the students in problem-solving and critical thinking skills in grade 7 Geometry. This may due to the fact that when teachers use reference materials, the concepts and activities may not be suited or appropriate to the specific grade level of the students. That's why in the teaching and learning process, there must be enough learning support of instructional materials that suit the needs of the students.

The contextualized feature of the module contributes mainly to the excellent rating of the learning module developed by the researcher in terms of its quality to enhance the problem-solving and critical thinking skills of the students. The contextualized activities enable students to apply their real life sense-making approach to problem-solving. Competencies in Mathematics will be learned by more students if the contents are taught in the students' real-world context. Likewise, this feature promotes information drive of the local culture of Guimaras.

Aside from this, teaching strategies must be complemented with appropriate learning instructional materials such as learning modules. Surya et.al. (2017) found that students' problem solving ability was improved with the use of the module. With the use of the module, students will be encouraged to work cooperatively in groups. Through active involvement in group activities, students enjoyed and appreciated the input and perspectives from peers(Herrmann, 2013). Herrmann added that cooperative learning groups can offer potentially valuable learning opportunities, but teachers should be aware that this does not guarantee a successful teaching and learning. This should be augmented with strategies that suit the needs of the students.

The result of this current study further showed that until now the modules for grade 7 have not been completed and delivered to schools specifically for Grade 7 Mathematics. The teachers are preoccupied by many responsibilities in the classroom. So, what could be expected from these teachers? Furthermore, looking for additional instructional materials may add to the burden of teachers.

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Contact email: etellermo@yahoo.com
c_gabasa@wvsu.edu.ph