Contextualized teaching on the problem solving performance of students

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ABSTRACT

This study investigated the effect of contextualized teaching on students' problem solving skills in physics through a quasi-experimental approach. Problem solving performance of students was described quantitatively through their mean problem solving scores and problem solving skills level. A unit plan patterned from the cognitive apprenticeship approach and contextualized using maritime context of ship stability was implemented on the experimental group while the control group had the conventional lecture method. Pre and post assessment, which is a researcher-developed word problem assessment, was administered to both groups. Results indicated increased problem solving mean scores ($p < 0.001$), problem solving skill level ($p < 0.001$) of the experimental group while the control group increased only their problem solving skill level ($p = 0.008$). Thus, contextualized teaching can improve the problem solving performance of students. This study recommends using contextualization using other physics topics where other contexts can be applied.

***Keywords**: Contextualized Teaching, Problem Solving Skills, Cebu, Philippines.*

INTRODUCTION

Problem solving is a skill in science that has received considerable attention from researchers all over the world. Some of the major areas effecting problem solving that have received considerable attention include the difference between expert and novice problem solvers (Chi, Feltovich & Glaser, 1981; Hardiman, Dufresne & Maestre, 1989; Larkin & Reif, 1979), use of representations and diagrams in problem solving activities (Chi, Feltovich & Glaser, 1981; Kohl & Finkelstein, 2006; Maries & Singh, 2011; Kohl, 2001), transfer of learning in problem solving performance (Engle, Nguyen and Mendelson, 2011), use of multimedia representations to enhance problem solving (Stelzer, Gladding, Mestre & Brooks, 2009; Titus, Martin & Beichner, 1998) and teaching strategies for problem solving (Caliscan, Selcuk & Erol, 2009, 2011; Gangoso, Moyano, Buteler, Coleoni & Gattoni, 2006; Heller, Keith & Anderson, 1992; Leonard, Dufresne & Mestre, 1996). There are also cognitive studies on problem solving (Dickie, 2003; Litzinger et al., 2010; Slava, Renkl, & Paas, 2010; Teodorescu, Bennhold & Feldman, 2008) and problem solving difficulties encountered by students (Chi, et al. 2010; Clement, 1982; Ogunleye, 2009).

Problem solving is an essential skill assessed by teachers and instructors in all levels from basic to higher education because of the belief that this is an essential life skill that will prepare students to adapt to the rapidly changing world. However, students find problem solving assessments in the form of word problems difficult (Clement, 1982; Ogunleye, 2009; Chi, Bassok, Lewis, Reimann & Glaser, 2010). Despite the efforts of the teacher thoroughly discussing a multitude of examples, there remains some barriers that make problem solving relatively challenging to learn. One important factor that is argued to have a significant impact on the problem assessment is 'context' (Bond, 2004; Fegghi & Valizalde, 2011; Huang, 2011; McCullough, 2004; Miller, 2006; Perin, 2011).

Context in this sense is operationally defined as situations or circumstances that can help clarify a certain event or situation. Context of word problems can vary from formulation (realistic, abstract) to delivery (print, animated, manipulative). Researches (Khan et al., 2012; Geelan, 2003; Vignouli et al., 2002; Steinberg & Donelly, 2002) suggest that word problems in physics must be based on actual experiences in order to bridge the gap between the abstract concepts and the real world applications. This explicit emphasis of the classroom and real-world connection is highlighted by contextualization of word problems (Perin, 2011; Miller, 2006) to ensure that students are familiar with the context and so that they can activate their knowledge base (Bond, 2004). Moreover, an examination of the wide array of context and the nature of learning of the students must be taken into consideration in order to effectively contextualize word problems.

Situated Learning Theory and Cognitive Apprenticeship Approach

One theory that supports the use of context both in teaching and assessment is the Situated Learning Theory that provides the link between the classroom learning experiences and the reality of the world of work (Lave, 1991). In addition, this theory argues that learning occurs in a specific context as an individual immerses into practice, which is influenced by the physical, social and cultural context (Brown, Collins and Duguid, 1989; Clancey, 1995: Hansman, 2002; Unan and Inan, 2010). Thus, it is crucial to align the context of the lesson to the real world applications and reality of the students. This aspect of enculturating students into authentic reality is put into classroom practice in the process of cognitive apprenticeship approach (Brown, Collins, & Duguid, 1989). This approach suggests the following steps in the instructional process: modelling, coaching, scaffolding, articulation, reflection and exploration. With due emphasis on both content and dynamics, these processes effectively allow students to learn from specific context to generalized transfer of learning to other context (Unal & Inal, 2010; Brown, Collins, & Duguid, 1989; Collins, Brown, & Newman, 1989; Bond, 2004). Contextualized Teaching is also supported by situated learning theory (Berns &Erickson, 2001; Perin, 2011).

Contextualized teaching and learning is defined as an approach that provides the link between classroom learning and real-life applications through the use of relevant activities that enhance the motivation of students to learn (Perin, 2011; Berns & Erickson, 2001). This characteristic is the same with the situated learning theory which explicitly bridges the knowledge with its corresponding real life applications.

In order to really see the impact of how cognitive apprenticeship approach can help students learn problem solving, a dedicated unit plan anchored on these approach was developed wherein the lessons are designed according to the instructional process as suggested by the cognitive apprenticeship approach. Consequently, the assessment problems are intentionally contextualized to the real life applications of the students' intended field of work in order for these students to see the actual applications in their future job. Through the cognitive apprenticeship approach, the students are not only exposed to the expert performance of masters in the field but they are also invited to assume a role as they interact with the community of learners which in this case is the other students in the class. Students undergo changing multiple roles during the lessons as they eventually develop their knowledge and skills and eventually become the master of their field. In this study, the skill to be mastered is in the context of solving real-life problems that may occur in the performance of their professional job. The assessments are formulated in order to link the word problems to the actual job-related problems that the professionals encounter.

METHODOLOGY

Design

This study adopted a quasi-experimental design utilizing a control group (N = 45) to compare the effect of the intervention with the experimental group (N = 45). The two classes were taught by only one instructor using two distinct and different approaches. The control group was taught using the traditional lecture method. In this method, the teacher delivers the lesson through chalk and talk and the usual classroom drills and end of session assignments. The lesson is context free and most of the problems discussed are context free and mostly plug and chug method. On the other hand, the experimental group was taught using the contextualized teaching based on a dedicated unit plan developed using the cognitive apprenticeship approach previously validated by content and instructional experts in science education.

Instruments

The researcher developed and literature-based standardized instrument instruments were used. The levels of problem solving skills guide was an instrument adopted from a model used by Adamovic and Hedden (1997) which categorizes the students' problem solving skills to six levels. In the said model, skills in problem solving are described using an ordered categorical data: level 1 (Non-Analytical stage), level 2 (Number Writing stage), level 3 (Symbol Association stage), level 4 (Early Analytical stage), level 5 (Simple Analytical stage) and level 6 (Complex Analytical stage). A problem solving grading rubric was used to score the students solutions to the problem solving activity. The rubric was adopted from the problem solving rubric developed and validated by Docktor and Heller (2009). It was composed of five categories (useful description, physics approach, specific physics application, mathematical procedures and logical progression) with each category corresponding to a certain step in the problem solving process. Each category has six performance descriptors (0 to 5) with appropriate descriptions for each point to be rewarded and two non-numerical sub categories designated for non-applicable cases in the solutions of the students. The data gathered using the contextualized word problems were scores from the problem solving activities taken from the administered pre and post assessments.

Data Gathering and Treatment

The problem solving scores of the students during the pre-test and post-test was obtained from the 3-item word problem activity. The pre-test was based on the topic of Force and the post-test was based on the topic of Equilibrium. The mean scores for the pre-test and post-test results for both experimental and control groups were calculated. The levels of problem solving skills for each student were determined by taking the mode among the three items in the problem solving activities. Independent samples t-test was used to compare the problem solving mean scores for both the pre-test and the post-test scores. Wilcoxon sign rank test was used to compare the problem solving skills for dependent paired sample and Mann-Whitney U test for independent samples.

RESULTS AND DISCUSSION

Problem solving mean scores

The problem solving scores of the students for all the 3 items are summed up. Students could get as low as 0 and as high as 25 points for each item. The maximum total score for the entire test is 75 points. The mean scores of the students for both experimental and control groups are presented in Table 1.

Table 1. Mean Scores and Standard Deviations of the Problem Solving Activities

	Experimental group		Control group	
	Pre-test	Post-test	Pre-test	Post-test
Mean	15.38	28.73	13.39	13.34
SD	10.24	9.16	9.31	8.52
N	45	45	44	38

Students from the experimental group have slightly higher scores during the pre-test compared to the control group. Upon examination of the pre-test assessment papers of the students using the rubrics, the experimental group scored better in the useful description category of the rubric. Some of the students in the experimental group were able to associate the numbers with the proper symbol and thus scored a point higher than those who merely wrote the numbers from the problem. The rest of the categories were nearly the same for both groups. In addition, most of the students from both groups had very poor performance on the specific application of physics and logical progression category of the rubric. During the post-test assessment, the experimental group scored better in physics approach, specific application of physics and logical progression. Majority of the students from the experimental group picked the right formula, performed appropriate mathematical calculations although some had major errors, and applied the approach to solving the problem. The control group, on the other hand, improved in their useful description but had trouble identifying the right formula to perform the calculations, resulting to erroneous mathematical procedures and lack of coherence in the solution. The mean scores of the students from both groups during the pre-test had a slight difference (see Table 1). An independent–samples *t*-test showed that the pre-test scores of the control group and the experimental group did not have any significant difference, $t(80) = 0.369$, $p = 0.71$. This result showed that in the beginning, both groups are equivalent and that there is no superior group in terms of problem solving mean scores. An independent-samples *t*-test for the post-test scores of the control and experimental group revealed that the difference between the mean scores was statistically significant, $t\ (80) = 7.85$, $p < 0.001$.

The increase in problem solving performance could be attributed to the contextualization of the test to maritime related problems that were novel to the control group since there was no explicit mention of maritime related context during the parallel lessons. Introduction of context to problem solving can sometimes trigger wrong responses (Fout, 2009), distract students due to superficial features (Huang, 2004), and prevent students from making explicit connection between unfamiliar context and the learned context (Vesali & Noori, 2009). The superior performance of the students in the experimental group over the control group emphasized the benefits of contextual teaching. The mean scores of the students in the experimental group increased significantly compared to the control group because majority of them were able to pick the correct approach and formula in solving the problems, although, majority had mathematical errors which resulted to erroneous final answers. They scored better in terms of the physics approach, specific physics application, and logical progression as compared to the control group who only did well in the aspects of useful description and specific physics application. The familiarity of the terms, concepts, and situation that were embedded in the post-test problem solving questions facilitated in the activation of the knowledge (Bond, 2004) explicitly studied during contextual teaching. Sustained instruction using contextualized teaching must be practiced and the focus must be on the context useful to the students in their future career.

The results of the statistical treatment of data revealed the potential of contextualized teaching in increasing the performance of students (Bottge, 1990; Fout, 2009; Huang, 2011; Miller, 2006; Mulcahy & Krezmien, 2009). In terms of the mean scores on the problem solving activities, students who were taught using contextualized teaching through maritime related context had positive gains and had superior scores over those not given the intervention.

Problem solving skill level

The problem solving skill level is obtained per item of the test based on the fitting description from the model of Adamovic and Hedden (1997). The test consists of three-item word problems, and the mode of the three items is used to represent the problem solving skill level of the student. The sample size for both groups is reduced significantly due to the absence of eight students from the control group during the post-test while for the experimental group, eight students had problem solving skill levels that did not have any modal value during the post-test. Most of the eight students from the experimental group passes problem solving skill levels 2, 3, and 1 corresponding to each item in the post-test. Further probing into the case revealed that most of the students posses skill level 1 as they did not finish the third problem due to time constraint. Table 2 shows the percentage of students belonging to each level for both the pre-test and post-test problem solving assessments. The percentage was used in order to see if there was an increase or decrease in the number of students belonging to a certain level.

Table 2. Distribution of Students Based on their Pre and Post Problem Solving Skill Level

	Experimental (*N*=37)		Control (*N*=36)	
Problem Solving Skill Level	Pre-test %	Post-test %	Pre-test %	Post-test %
Level 1 (Non-Analytical Stage)	24.32	2.7	13.89	2.78
Level 2 (Number Writing Stage)	35.14	2.7	63.89	44.44
Level 3 (Symbol Association Stage)	29.73	16.22	19.44	50.0
Level 4 (Early Analytical Stage)	10.81	75.68	2.78	2.78
Level 5 (Simple Analytical Stage)	0	2.7	0	0
Level 6 (Complex Analytical Stage)	**0**	**0**	**0**	**0**

Majority of the students for both groups belong to level 2 (Number Writing Stage) during the pre-test. This indicates that most of the students cannot associate the number with their corresponding meaning and often randomly write numbers and mathematical operations. In addition, during the pre-test, there are more students in the experimental group who had higher problem solving skill levels (level 3 and 4) compared to the control group which are mostly in level 2; but there are also more students in the experimental group who are in the lower levels (level 1) compared to the control group. There is an observable shift in the problem solving skill level of the students for both groups after comparing the pre-test and post-test problem solving skill level for each group. The mode of the experimental group moved two levels higher from level 2 to level 4 indicating that students are now in early analytical stage. The mode of the control group also moved from level 2 to level 3 indicating that they are now in the symbol association stage. A greater number of students in the control group still belong to level 2 while a great number of students from the experimental group had moved to level 3 and 4 leaving only a few students in the lower levels.The problem solving skill level of the students from both groups during the pre-test are the same which is at level 2 (Number Writing Stage) where 35.14% from the experimental group and 63.89% from the control group were listed. Table 3 summarizes the test statistics results for the problem solving skill level for the pre-test and post-test.

Table 3. Pre and Post Problem Solving Skill Statistical Tests

Type of Test	Experimental(N=38)	Control (N=38)
Wilcoxon Sign Rank Test	-3.99	-2.67
p-value	< 0.001	0.008
	Pre-test	Post-test
Mann-Whitney U test	-0.71	-6.23
p-value	**0.48**	**< 0.001**

The Wilcoxon Signed Rank Test showed that the difference between the pre-test and the post-test problem solving levels of the experimental group was statistically significant, $Z = -3.99$, $p < 0.001$. The difference for the control group was also statistically significant, $Z = -2.67$, $p = 0.008$. The post-test problem solving skill level increased for both groups from level 2 (Number Writing Stage) to level 3 (Symbol Association Stage) for the control group and from level 2 (Number Writing Stage) to level 4 (Early Analytical Stage) for the experimental group. Most of the students from the experimental group (75.68%) were already at level 4 while a substantial number of students from the control group were still in level 2 (44.44%) and level 3 (50.0%). An equivalent non-parametric test for significant difference across independent groups called the Mann-Whitney U test was conducted to check for significant difference in the problem solving skill levels across the control group and experimental group. The pre-test problem solving levels of the control group and the experimental group were not significant by difference ($Z = -0.71$, $p = 0.48$). This indicated the equivalence of the groups during the pre-test and that prior to the intervention, both groups were of the same skill level in terms of problem solving. The difference between the post-test problem solving levels of the control group and the experimental group was statistically significant, $Z = -6.23$, $p < 0.001$. There may be an increase in the problem solving skill levels of the students in the experimental group, but the level they are currently placed is not at par with the expectations of the course.

CONCLUSIONS AND IMPLICATIONS

The study revealed the potential of contextualized teaching using the context of equilibrium in improving the problem solving performance of maritime students in learning Physics. This study also strengthened the claims of other research over the superiority of contextualized teaching over traditional teaching methods. The exclusive use of maritime context in the lessons facilitated the classroom interaction which is instrumental in increasing the motivation of the students to perform better. These students who were taught using the specific context of equilibrium of ships found the importance of the topic to their chosen field and to the reality of their work in the future. In effect, these students were able to analyse and apply the correct approach to solve the problem unlike the control group who were uncertain what algorithms and formula to use. The use of context-specific word problems is not new to teachers and instructors who attempt to measure whether students can transfer their learning to other context aside from the one learned in class; however, this can sometimes do more harm than good to the students. In the class, the teacher must address the context and reality of the students which would allow them to extend their knowledge beyond the abstract and basic context found in textbook problems. The intention of the teacher to make students transfer their knowledge to novel context is hindered by the limited context of word problems in the textbook. Oftentimes the context of this textbook problems are not only novel and irrelevant to the reality of the students, but it could also be inappropriate and incorrect. In the future, establishing a framework that will allow teachers to construct problems out of students' reality and future career path can be very helpful in improving the quality of teaching and assessment in problem solving.

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