The Use of Case Analysis in Teaching Circular Motion

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Abstract

This paper presents the use of case analysis in teaching circular motion. The teaching sequence was developed based on the alternative conceptions found during the diagnostic phase of this study. It was implemented to twenty-six (26) students in their second year at the university taking up a program in Bachelor in Secondary Education-Physical Science and enrolled in a course in mechanics. Results revealed that the teaching sequence was helpful in correcting alternative conceptions and in increasing conceptual understanding. Inconsistencies in the conceptions were also minimized.

KEY WORDS: case analysis, circular motion, teaching sequence, students' understanding

1. Rationale

This paper reports the result of using case analysis in teaching circular motion. Circular motion is one of the topics in physics specifically on the field of mechanics. Past and recent studies revealed that circular motion is difficult to understand (Searle, 1985; Meyer, 2012) and it is not among the most important topics in physics as reported by teachers (Finley, Stewart and Yarroch, 1982). The diagnostic phase of this study have revealed that circular motion is not given enough emphasis by teachers in the field.

In response to this, there had been an increasing number of literatures revealing that carefully designed teaching sequences are found to be effective in maximizing the learning gains of students across ages, levels, and races. These studies proved that these teaching sequences were effective in correcting alternative conceptions and in strengthening correct conceptions across different disciplines and subject matter taught in the classroom. These works became the platform in conceptualizing the conduct of this study with an additional aim of removing inconsistencies in students understanding of circular motion concepts.

2. Theoretical Framework

The framework used in developing this study was the conceptual change model of learning. The said model is anchored on the theory of constructivism, which postulates that learners make their own sense of the world around them based on the interaction of prior knowledge, new knowledge, and ideas they come into contact (Resnick, 1989). Conceptual change model specifically describes and explains the process in which students learn in science. In comparison, there is a similarity of the said model with Kuhn's paradigm shift (Kuhn, 2012) and Piaget's principle of accommodation (Simatwa, 2010).

Along teaching and learning, the last few decades of the 20th century and up until today, a significant number of studies were done following the conceptual change framework. As such, it believes that students already have some knowledge about the things around them before coming to formal instruction in the classroom. Moreover, it poses that students start making sense of the things around them through daily experiences and interaction with the people around them. Finally, it argues that prior knowledge influences their formal learning and that it is highly resistant to change.

The work of Hewson (1992), Posner et al (1882), Inagaki and Hatano (2002) and Strike and Posner (1992) have given a clearer picture of conceptual change as applied in the classroom. They argued that if the students' prior knowledge is still capable of providing solutions within the given conceptual schema, students would not have a compelling reason to change the current conception. Hence, it is significant to diagnose their present knowledge of science concepts and make it the basis in selecting appropriate strategies and activities in the conduct of the lesson.

3. Literature Review

There had already been a number of studies related to circular motion that were conducted in the past. These studies can be grouped into three (3). The first includes studies related to conceptions and conceptual understanding which describe how students of different levels, ages and races understand circular motion. Among these were the work of Searle (1985), Ching (2001), Antwi et al (2011), Duman, Demerci, and Sekercioglu (2015), Vyas (2012), and Viridi, Mogharabi and Nasri (2013). One apparent findings of their studies were the existence of alternative conceptions on the different concepts of circular motion. Another group of studies were the ones that attempted the development of standardized assessment tools. Among these studies were the works of Gunes and Kizilcik (2011) and Erceg et al (2014). These tools were aimed at diagnosing students' understanding of circular motion concepts. Lastly are the group of studies focused on designing and implementing teaching sequences. This teaching sequences employed different strategies and approaches aimed at increasing conceptual understanding and addressing alternative conceptions on circular motion.

Seattha, Yuenyong, and Art-in (2015) developed a practical approach in teaching circular motion using science, technology and society (STS) approach to understand the context of science, technology, engineering and mathematics (STEM). Similarly, Stinner

(2001), in his strategy called ‘linking the book of nature and the book of science’ advocated in using more common and natural phenomena rather than focusing on textbooks to understand circular motion. Meanwhile, the use of computer and Internet technology (Zhou et al, 2011; Aravind and Heard, 2010) and inquiry-based strategy (McLaughlin, 2006) were also found to be effective and efficient in teaching circular motion. Although a number of studies have argued that it is nearly impossible to change preconceptions of students on physics concepts. According to Ozdemir (2004), misconceptions either would tend to coexist with the scientific conceptions or will reappear after sometime even after giving a successful teaching (Kim and Pak, 2002; and Kizilcik, Ondu Celikkanli and Gunes, 2015).

4. Statement of the Problem

The foregoing study attempted to find out the effectiveness of case analysis in teaching circular motion.

Specifically it sought:

1. What is the effectiveness of using case analysis in teaching circular motion?
2. What are the limitations if using case analysis in teaching circular motion?

5. Methodology

This developmental study was implemented to twenty-six (26) university students in their second year taking up Bachelor in Secondary Education majoring Physical Sciences and were enrolled in a course in Mechanics. The entire study is divided into four (4) phase namely diagnostic phase, developmental phase, implementation phase, and revision phase.

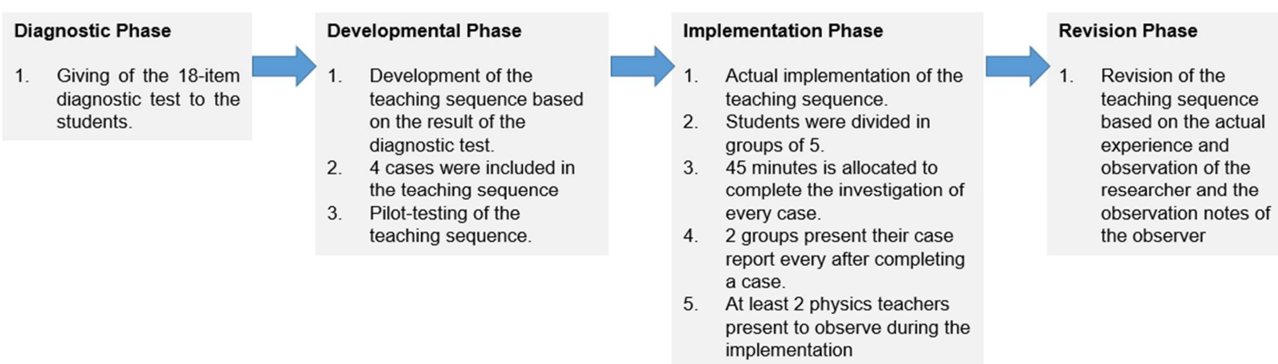

Figure 1. Detailed flow chart of the study

The diagnostic phase included the diagnosis of students’ understanding using an eighteen (18) carefully selected and adopted questions on different concepts related to circular motion. These questions underwent content-validation from four (4) physics teachers in the university.

The developmental phase included the development and pilot-testing of the teaching sequence in circular motion which utilized case analysis. The consideration of the activities included were based on the result of the diagnostic test. It included four (4) cases for analysis. These cases were entitled (1) Investigating the Merry-Go-Round; (2) David and Goliath (Whirling Stone); (3) Vehicle on a Circular Track; and (4) Moon's Revolution around the Earth. These were pilot-tested to a similar group of students enrolled in a general physics course.

The implementation phase was the actual implementation of the developed teaching sequence. It was implemented in two successive meetings since Mechanics is a four (4) unit course which requires three (3) hours lecture and three (3) hours laboratory every week. Every case were completed in forty-five (45) minutes. The entire class were divided into five groups. Four (4) groups have five (5) members while one (1) group has six (6) members. These grouping were decided by the researcher such that it is heterogeneous. The basis of which were the scores and result of the midterm examinations. The respondents were allowed to open references during the course of investigating the cases. Every after finishing a case, two (2) groups were asked to present their case report. The presentation included the procedure, the responses and explanations to the guide questions. During the implementation, group interactions were videotaped and observations were noted. At least two (2) physics teachers were also present to observe and take note of the proceeding. Individual and/or group interviews were conducted after the class as it was deemed necessary to verify and confirm observations made by the researcher. After the implementation of all the cases, a posttest was given.

The revision phase included the modification of the teaching sequence based on the observation and actual experience of the researcher during the implementation. It also included the observations and notations made by the other two (2) physics teachers who observed the actual implementation of the teaching sequence.

Results of the diagnostic test and posttest were analyzed using simple percentage and frequency count and t test. Simple Collaizi method was used in seeking for patterns and themes in the written explanations, interviews, video recording, teachers' observations and researcher's notes.

6. Results and Discussion

Results showed that a remarkable increase in the mean score of 8.73 was recorded upon comparing the result of the pre-test and the post-test. The table that follows summarizes the change in the individual scores of the respondents.

Table 1
Comparison of pretest and posttest scores

Student No.	Pretest Score	Post test Score	Student No.	Pretest Score	Post test Score
1	*4*	***16***	14	*8*	***17***
2	*5*	***18***	15	*7*	***16***
3	*7*	***15***	16	*2*	***11***
4	*9*	***17***	17	*4*	***12***
5	*7*	***17***	18	*8*	***11***
6	*4*	***14***	19	*5*	***15***
7	*5*	***10***	20	*6*	***14***
8	*6*	***16***	21	*5*	***11***
9	*5*	***14***	22	*6*	***15***
10	*6*	***16***	23	*3*	***17***
11	*7*	***15***	24	*7*	***12***
12	*2*	***11***	25	*7*	***14***
13	*3*	***17***	26	*5*	***9***

T-test result revealed that the value of computed t is 16.19. The value of p is < 0.00001, hence, the difference is considered significant at $p \leq 0.05$. Table 2 summarizes the t-test calculations.

Table 2

Difference Scores Calculations

Mean: 8.73

$\mu = 0$
$S^2 = SS/df = 189.12 / (26-1) = 7.56$
$S^2_M = S^2/N = 7.56 / 26 = 0.29$
$S_M = \sqrt{S^2_M} = \sqrt{0.29} = 0.54$

T-value Calculation

$T = (M - \mu) / SM = (8.73 – 0) / 0.54 = 16.19$

Summary of t-test calculations

The result of this study supports the constructivist theory of learning. As proven in this study, students are indeed capable of constructing new concepts, the way they understand it and reconstruct previously learned concepts if given the opportunity and the right condition to learn the intended concepts to be learned. Moreover, this study supports the conceptual change model of learning which explains the possibility of correcting previously learned concepts to a more viable one as soon as the learner discovers its limitations.

Upon thoroughly examining the responses and explanations made by the learners in the post test, it revealed more consistency and less guessing. Table 3 is a summary of the number of students who get the correct answer of every item in the pretest and its equivalent item in the posttest.

Table 3
Change in the number of respondents got a correct answer in comparable items of the pretest and posttest

Item No.	Pretest	Post test	Item No.	Pretest	Post test
1	*20*	***24***	10	*3*	***20***
2	*23*	***26***	11	*5*	***25***
3	*15*	***26***	12	*0*	***18***
4	*5*	***23***	13	*7*	***24***
5	*7*	***25***	14	*4*	***21***
6	*2*	***18***	15	*2*	***20***
7	*9*	***23***	16	*16*	***23***
8	*1*	***17***	17	*1*	***2***
9	*4*	***16***	18	*15*	***23***

The use of case analysis have allowed the students to interact with their co-learners and develop their investigative skills as they discuss results with each other, question their findings and explanations, browse and read references. Most importantly, it allowed the students to comprehend and synthesize the likelihood of different natural phenomena governed by the same principle/s which is one of the problems diagnosed during the first phase of the study. Inconsistency in the understanding was addressed during the course of the teaching sequence implementation as proven in the posttest result. The different cases investigated allowed the students to deduce that certain concepts in physics, centripetal force in the case of this study, its existence is possible in different context, hence, thorough analysis is required.

However, the use of case analysis in teaching concepts in science has some limitations as well. First, it takes time and careful preparation to identify cases which includes situations or natural phenomena manifesting the intended concepts for investigation, otherwise it will result to more confusion on the part of the students. Second, a longer time is needed to successfully implement case analysis in teaching. Finally and importantly, the teacher must be skilled enough in facilitating and processing students' interactions and discussions.

7. Implications

Based on the result of the foregoing study, the use of case analysis can be considered useful in teaching physics. In the case of teaching circular motion to university students enrolled in mechanics, it was found to be effective particularly in addressing alternative conceptions and developing consistency of understanding. Such strategy can be used especially in teaching physics concepts that are present in multiple context such as circular motion.

Case analysis is a highly student-centered strategy which allows students to be investigative giving them the opportunity to synthesize the similarities and likelihood of different phenomena and the presence of these concepts in real life situations. Using this strategy effectively will allow the students to develop sense of ownership of their learning through the investigations they conduct. Although, using this strategy requires greater amount of time and an effective facilitating skills and in depth knowledge of the subject matter is required from the teacher to ensure success in the utilization of case analysis as a strategy in teaching.

8. Recommendations

From the result of the study, it is highly recommended to extend the same study to all curvilinear motion such as projectile and rotational motions. Moreover, it is recommended as well to use case analysis as a strategy in teaching other concepts in physics and other related disciplines.

Meanwhile, along the study itself, it is recommended to use other methods of quantitative and qualitative analysis to verify the results and implications reported in this study. Other strategies in teaching circular motion is also recommended especially on the use of indigenous and improvised materials and integrating circular motion concepts in other disciplines. Moreover, it is suggested that other factors that might have affect the improved performance of the students must also be looked into. Further, it is suggested that case analysis be used to other topics in science across different levels.

REFERENCES

Antwi, V. et al. (2011). Students' Understanding of Some Concepts in Introductory Mechanics Course: A Study in the First Year University Students. International Journal of Educational Planning and Administration. 1 (1). 55-80.

Aravind, V. R. and Heard, J. W. (2010). Physics by Simulation: Teaching Circular Motion Using Applets. Latin American Journal of Physics Education. 4 (1), 35-39.

Ching, M. C. (2001). Form Six Students' Conceptions in Circular Motion. [Online] Available: www.ipbl.edu.my/portal/penyelidikan/2001/2001_11_mhcc.pdf (October, 11, 2015)

Duman, I., Demerci, N., and Sekercioglu, A. (2015). University Students' Difficulties and Misconceptions on Rolling, Rotational Motion and Torque Concepts. International Journal on New Trends in Education and Their Implications. 6 (1). 46-54.

Erceg, N. et al. (2014). Probing students' conceptual knowledge of satellite motion through the use of diagram. Revista Mexicana de Fisica E. 60. 75-85.

Finley, F. N., Stewart, J., and Yarroch, W. L. (1982). Teachers' Perceptions of important and difficult science content. Science Education. 66 (4). 531-538.

Gunes, B. and Kizilcik, H. S. (2011). Developing Three-Tier Misconception Test about Regular Circular Motion. Hacettepe University Journal.

Hewson, P. W. (1992). Conceptual Change in Science Teaching and Teacher Education, Research and Curriculum Development in Science Teaching. National Center for Educational Research, Documentation and Assessment. Madrid, Spain.

Inagaki, K. and Hatano, G. (2002). Young children's thinking about Biological World. Philadelphia: Psychology Press.

Kim, E. and Pak, S. J. (2002). Students do not overcome conceptual difficulties after solving 1000 traditional problems. American Journal of Physics.70 (7). 759-765.

Kizilcik, H. S., Ondu Celikkanli, N and Gunes, B. (2015). Change of Physics Teacher Candidates' Misconception on Regular Circular Motion by Time. Necatibey Faculty of Education Electronic Journal of Science and Mathematics Education. 9 (1). 205-223.

Kuhn, T. S. (2012). The Structure of Scientific Revolutions (4th Ed). USA: The University of Chicago Press.

McLaughlin, S. (2006). Rounding Up Students' Conceptions on Circular Motion. Iowa Science Teachers Journal. 33 (2). 7-15.

Meyer, C. (2012). Fixing our Physics: Circular Motion. The Physics Education Research Column. [Online] Available: meyercreations.com/Physics/articles/OAPTNewsletterJune2012.pdf (October 20, 2015)

Ozdemir, O. F. (2004). The Coexistence of Alternative and Scientific Conceptions in Physics. Doctoral Dissertation. The Ohio State University. USA. [Online] Available: http://etd.ohiolink.edu/!etd-send_file?accession=osu1086033358&disposition=inline (November 5, 2015)

Posner, G., Strike, K. A., Hewson, P. W., and Getzog, W. A. (1982). Accommodation of Scientific Conception: Towards a Theory of Conceptual Change. Science Education. 66 (2). 211-227.

Resnick, L. B. (1989). Introduction, In L. B. Resnick (Ed.).Knowing, learning, and instruction: Essays in honor of Robert Glaser. Earlbaum, Hillsdale, NJ. 1-24.

Searle, P. (1985). Circular motion concepts of first year engineering students. Research in Science Education. 15 (1). 140-150.

Seattha, P., Yuenyong, C., and Art-in, S. (2015). Developing STS Circular Motion Unit for Providing Students' Perception of the Relationship between Science, Technology, Engineering and Mathematics. Mediterranean Journal of Social Sciences. 6 (3). 268-275.

Simatwa, E. M. W. (2010). Piaget's theory of intellectual development and its implication for instructional management at pre secondary school level. Educational Research and Reviews. 5 (7). 336-371.

Stinner, A. (2001). Linking 'The Book of Nature' and 'The Book of Science': Using Circular Motion as an Exemplar beyond the Textbook. Science and Education. 10. 323-344.

Strike, K. A. and Posner, G. J. (1992). A revisionist theory of conceptual change, I. R. Duschl and R. Hamilton eds. Philosophy of Science, Cognitive Psychology and Educational Theory and Practice. Albany, NY: Sunny Press. 147-176.

Viridi, S., Moghrabi, T. and Nasri, M. (2013). An Observation of a Circular Motion Using Ordinary Appliances: Train Toy, Digital Camera, and Android based Smartphone. Prosiding of Simposium Nasional Inovasi dan Pembelajaran Sains. 3-4. 1-7.

Vyas, P. (2012). Misconception in Circular Motion. International of Scientific and Engineering Research. 3 (12). 1-4.

Zhou, S. et al (2011). Inquiry style interactive virtual experiments: a case on circular motion. European Journal of Physics. 32 (6). 1597.