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Situated Reformulation of Mathematical Problems in Schools

Pankaj Singh
Assistant Professor,
School for Life (SFL)
University of Petroleum & Energy Studies (UPES),
Dehradun

Abstract

This paper examines the reformulation of mathematical problems and their influence on a student's learning. Through question reformulation, the paper dives into how the situated approach to mathematics may be applied in classroom for mathematics learning. The argument for reformulating the textbook's mathematical problem to incorporate situated aspect may not appear original and ground breaking at first glance, as all good mathematics teachers try to connect the problem to the surrounding environment to make it more meaningful and interesting. The paper's focus is on the influence of problem reformulation on a cultural and situated element of mathematics learning.

Keywords: Mathematical problem solving, school learning, situatedness, education

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Introduction

There has never been any subject of knowledge where the human and social aspects have been as disregarded as mathematics. As a result, mathematics in classrooms has become dry and dull. Even today, many mathematics students acquire a phobia of mathematics as a result of their concerns about mathematics. This paper examines the reformulation of mathematical problems and their influence on a student's learning. Through question reformulation, the paper dives into how the situated approach to mathematics may be applied in classroom for mathematics learning. The argument for reformulating the textbook's mathematical problem to incorporate situated aspect may not appear original and ground breaking at first glance, as all good mathematics teachers try to connect the problem to the surrounding environment to make it more meaningful and interesting. Nonetheless, a few instructors with the correct creativity and pedagogy are insufficient to encourage and promote a good mathematics culture in schools. Regardless of their cultural setting, many instructors are still grappling with age-old textbook mathematics problems. For the sake of brevity and concentration, I will leave the debate of the need for reform in school-based mathematics education policy for another time, article, or book. The paper's focus is on the influence of problem reformulation on a cultural and situated element of mathematics learning.

Making a case for Situated Reformulation of Mathematical Problems

A picture of textbooks and teachers usually comes to mind when people talk about the source of math problems. It is obvious to deduce that source of good mathematics problems would come from a good textbook, or good mathematics teachers (Kilpatrick, 1987). Mathematical problem solver, the student is rarely thought of as the source of mathematical questions by teachers. Students in a school's mathematics culture are problem solvers, not problem formulators. Problem formulation receives little explicit consideration in the development of mathematics curricula. Teachers and students assume the problem to be passive, and solving the problem remains a part that assumes the active central stage. Students are deprived of the opportunity to explore and create their own problems when they use this approach to math problem solving. This loss of mathematical problem formulation leads in a lack of opportunity for students to embed their own experience in a mathematical question. If the students had been permitted to construct their mathematical problem, they would have added their cultural, social, and contextual components to the formulation of the mathematical problem. The contextualized mathematical problem would not only improve the student's experience, but it would also promote a healthy, inclusive mathematics culture.

Solving a mathematical problem is no longer a huge task thanks to the information technology revolution. Solving ordinary numerical, algebraic, and other related mathematical problems has gotten considerably easier with access to computers and the internet. I am not claiming that technology is a bad thing; rather, I am suggesting that it should be embraced when solving a mathematical problem. Concepts like a crowd sourcing, social machines are opening new avenues to mathematical learning (Hendler & Berners-Lee, 2010; Martin & Pease, 2013). I'm also not implying that solving a mathematical issue isn't significant. Solving a mathematical question in school is not the same as solving a problem in a mathematics project or higher research. The distinction is in the learning component of solving a mathematical problem. People working on advanced mathematical projects and in higher education have a different goal than a student tackling a mathematical problem in class. The goal of solving a mathematical problem in school should be to impart mathematical learning to the student; to make the student aware of the nature of mathematics as well as its real-world application; to develop the student's interest in mathematics; and to enable a mathematical culture that encourages students to further explore the real-life application of mathematical learning. While the scholar working in higher education mathematics and mathematical projects is already interested in researching a specific subject, their concentration on addressing that challenge should remain a primary priority. They have different mathematical cultures because they have already gained a grip on a formal and logical part of mathematics; recreating that mathematical culture is of limited benefit in the classroom environment. Students will be turned off to mathematics if they are solely introduced to it in a formal setting with few situations. As a result, uncontextualized mathematics will develop an unhealthy mathematical culture. This unhealthy culture fails to impart meaningful mathematical learning.

VanLehn and Brown (1980) also underlined the need of including problem formulation into the classroom mathematics curriculum. The propensity to neglect question formulation extends beyond instructors and into the realm of academics. Mathematical learning should be connected to the actual world outside of the classroom. A healthy mathematical culture cannot be fostered unless there is a connection to the surrounding culture outside of school. The integration of real-life problems from the student's surrounding culture in a mathematical formulation generated by the student bridges the gap between school culture and surrounding culture. This cross-cultural collaboration through problem reformulation makes mathematical problem solving and learning more fascinating, entertaining, and culturally contextual. Students should also participate in creating mathematical questions rather than be handed them in order to make sense of complicated and problematic circumstances (Schon, 1979). Karl Durcker (1945) proposed an intriguing approach of thinking about problem solving as a series of reformulations of an initial problem.

Exploration of the mathematical formulation of a situation plays a major role in enabling healthy mathematical culture. Students develop social, cultural, and higher cognitive abilities when they are exposed to the connection between mathematical learning and real-life application. In the event of a difficulty, background knowledge is always available (Lakatos, 2015). Formulating mathematical problems based on real-world examples necessitates a habit of noticing mathematical patterns. For example, the amount of crust (measured as its circumference) on a pizza is a linear function of its diameter, the amount of filling (measured as its area) is a quadratic function, and the price is neither (Kilpatrick, 1985). Formulations of mathematical problems comparing the crusts, fillings, and prices of two 9-inch pizzas to those of one 18-inch pizza become easier to understand, and the formulation of a similar problem becomes faster.

Recognizing mathematical patterns in order to develop questions based on real-life examples is dependent on the school's mathematical culture. Teachers' roles and involvement in assisting, encouraging, and educating students to discover mathematical patterns in real-life situations become critical. The creative act of problem formulation necessitates a climate and culture of mathematical concept exploration (Frederikson, 1984; Getzels, 1964). Creating such a culture may necessitate a rethinking of the assessment and reward system. In today's mathematical culture, students gain little benefit from problem-solving tasks. However, there has been little empirical study on the effect of a pupil reformulating a problem on their own, with what little data is available indicating a favorable influence (Cohen & Stover, 1981; Keil, 1965).

One should be careful in interpreting problem formulating ability as an individualistic activity done in isolation. The whole argument of situated reformulation of mathematical questions rests on the interaction of people with their surrounding environment. The interactive nature of mathematical problem solving also prompts collaborative problem solving. The design of the assignment should be such, which can prompt students to work on the formulation of sub-problem based on their real-life situated experience. These subproblems must be linked to the primary problem in order to motivate the learner to collaborate. Students can detect an issue that they might have overlooked if they worked alone by working together. Working together improves group discourse and communication. Students can assist one another in the creation of questions. Collaborative activity appears to aid students in learning to manage their problem-solving performance Schoenfeld (1985). The partnership will also assist students in developing a mathematical culture in which they will be able to create a language and habit of communicating with one another and teachers. A class structured to bring students together for mathematical study on an issue of their interest, as opposed to a lecture, provides a richer framework for inclusive mathematical development. It is not an utopian vision of the perfect classroom, but it is realistically attainable even without significant structural and policy changes. All that is necessary is for teachers to be ready to support students in building a collaborative mathematics culture.

Schoenfeld (1985) used this method of problem resolution successfully in his own class. His method purposefully aimed to get children to think mathematically by employing mathematical tools. In one instance, he and his classmates attempted to solve a magic square, "A magic square is a square array of numbers consisting of the distinct positive integers 1,2,…..n^2 arranged such that the sum of the n numbers in any horizontal, vertical or main diagonal line is always the same number" (Weisstein). Though the easy version of the problem is straightforward, the collaboration evoked by Schoenfeld for approaching the problem revealed to the class the way mathematicians look at the problem. The different students followed the different ways of formulating the problem. They worked together to compare their formulations. They spoke with one another in order to help one other fine-tune their strategies. Schoenfeld's goal was not to focus on the subject matter, but to develop a mathematical belief system of the class in reaction to the problem's response. The class's purpose was to help students comprehend the nature of magic squares, and in doing so, they became a part of a belief system (Brown, Collins & Duguid, 1989). The basic idea was to make students aware of the relevant possible technique of answers rather than directly solving the problem. Students of Schoenfeld were inspired to investigate other variants of magic squares after being exposed to this teaching technique. They began to see the broad patterns and ideas involved in the solution of a magic square. The students devised all of the solutions to the magic square by reformulating the problem. The teacher did not design or provide a plan. The example shows that the only way to instill the mathematical belief system is through the active participation of students. This way, students become part of mathematical culture, not of the traditional culture of schooling.

The key distinction is the significance of individual cognition vs collective community activities. A situated aspect of socio-cultural work was first highlighted by Vygotsky (Kozulin, 1999; Wertsch, 1985). Vygotsky (1979) gave primary importance to the social aspect of cognition and considered the individual dimension as secondary and derivative. According to this viewpoint, a student's mathematical notion is the outcome of interpersonal interactions to society and culture (Forman, 1996; Minick, 1987; Van Oers, 2013). Thus the focus shifted from any individual to the individual situated in the world. This approach is also called emergent perspective (Cobb, Jaworski, & Presmeg, 1996). Emergent perspective tries to dispel priority over the other attribution. It considers processes between the individual and socio-cultural environment of being reflexive. This approach situates individual mathematical endeavor in a social and cultural context.

The situated approach addresses the relationship between social, cultural, and individual processes in an indirect manner. Therefore the participation of a student in particular cultural practices enables their mathematical development but does not determine it. In this approach, the situated perspective of mathematics does not reject constructivist analyses of mathematical activities, but rather aims to coordinate such analyses with studies of the social and cultural processes in which mathematics students engage and contribute. In a nutshell, situated features of mathematics view mathematical learning as an enculturation process in which students adapt their intellectual inheritance.

One of exemplar of the application of the notion of situated and cultural consideration is present in the mathematical exploration of Lampert (1986). She attempted to contextualize mathematics learning within the cultural and social context of her surroundings. She designed a teaching strategy for fourth-grade students to teach meaningful mathematical learning of multiplication by employing kids' implicit grasp of the world beyond their classroom. She began teaching fourth-grade kids multiplication using coin puzzles. The community of fourth grade students had a solid, implicit, common grasp of currency. She invited students to make up their own multiplication stories based on their implicit understanding of currency. Then, using student-created coin tales, she attempted to assist her pupils in grasping the abstract understanding of algorithms underpinning those multiplication stories.

The first teaching phase began with easy coin problems as “using only nickels and pennies, make 82 cents” (Brown, Collins & Duguid, 1989, p.38). These simple tasks aided students in discovering their latent knowledge. After presenting simple problems in the first

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phase, she asked students to create their own stories of a multiplication problem in the second phase. After performing a series of decompositions, there is not a single magical right decomposition but more or less useful decompositions whose use is judged in the context of the problem to be solved and the interest of the problem solver. In the third phase, she introduced a standard algorithm based on the meaning and purpose of the algorithm in the community. Students eventually began to arrive at standard algorithms on their own through their experiences. This allows them to simplify the procedure while retaining the context's significance. Students developed four types of mathematical knowledge in this manner: (a) intuitive knowledge by inventing shortcuts in a situated manner; (b) computational knowledge through algorithms; (c) concrete knowledge of algorithms situated in student-created stories; and (d) principled knowledge of associativity and commutativity underlying algorithmic manipulations of numbers. Lampert's objective was to bridge the conceptual comprehension and problem-solving activity divide (Brown, Collins & Duguid, 1989, p.38). This example demonstrates how an intentional effort may create methods to inculcate mathematical knowledge while including an implicit grasp of their cultural and social environment.

Conclusion

The paper advanced an argument in support of reformulating mathematical problems in order to foster an inclusive culture of mathematics in schools, but there are many more concerns that remain unanswered. What influence does teaching have on problem formulation? What are the variations in problem formulation processes between expert and beginner problem solvers? What is the relationship between problem formulation quality and mathematical creativity? To make it an inclusive element of the school education system, much more empirical and conceptual work in problem formulation is required. However, one thing that mathematics instructors can certainly encourage is the utilization of students' contextual experience to make mathematical learning more entertaining and accessible. This might be mathematical idea gamification, leveraging novel asynchronous material such as OTT platforms to inspire students to participate in a reformulation of mathematical questions for engagement and experiential learning.

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