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SECONDARY MATHEMATICS PRESERVICE TEACHERS' CONCEPTION ABOUT AUTHENTICITY OF MATHEMATICAL TASKS

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Abstract. The teaching approaches of mathematics derived from humanity involve positive interactions that support meaningful and relevant learning. The main objective of the teaching approaches is to prepare students with the competence to solve daily life problems, and one of the most important tools is using authentic tasks. There are different opinions on "task authenticity" in teaching and learning mathematics. This study examines how secondary mathematics preservice teachers (PSTs) think of the authenticity of tasks. Drawing on a framework of tasks authenticity adopted from the research literature, we analyze secondary mathematics preservice teachers' response to the criteria of task authenticity. The results show that PSTs attended to the event feature and the tool feature of the task but overlook other features. Implications for teacher training are discussed. PSTs need to prepare with both understanding the knowledge about quantitative literacy and how to teach it efficiently. Especially, PSTs need to be equipped with selecting and adapting tasks that are suitable to develop students' understanding of how mathematics is used in a real-life situation.

Keywords. authenticity, preservice teachers, real-life situation

1. Introduction

Students need to develop their capacity to solve problems related to their life and to develop mathematical modelling competencies. Word problems are a popular form of mathematical modelling situations in schools. However, students tend to apply their knowledge inappropriately, which does not fit with realistic considerations in real-world situations [Tạ & Trần, 2015; Verschaffel et al., 2000]. Pseudo-realistic word problems lead to students' use of non-realistic considerations in the solution of the tasks [Verschaffel et al., 2000]. On the contrary, when encountering authentic situations (e.g., buying things at stores, designing a bus route), students utilize more sophisticated and realistic reasoning when solving problems [Kaiser & Schwarz 2010; Tran et al., 2018; Verschaffel et al., 2000]. Authentic tasks are implemented to

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shorten the distance between mathematics in schools and the problems of life, thereby stimulating interest in mathematics learning for students. Authenticity provides a framework for integrating both mathematical content and students' participation in meaningful learning situations [Palm, 2008, Tran & Dougherty, 2014]. However, the mathematics curriculum in Vietnam often lacks real-life connections. Students do not know the purpose of learning mathematics and do not see the connection of problems in mathematics and mathematics in everyday life [Ta & Tran, 2015; An Nguyen, 2013, p.13, 2014, p.14]. This might cause difficulties when students solve the problems that they encounter in their lives. Exposing students to real-world contextual tasks and mathematical modelling can provide students with the potential to apply mathematics in real life. They know how to apply the knowledge they have learned to solve problems in real life. Authentic tasks have received much attention from mathematics educators and are often used in research in mathematical modelling.

As a part of an innovation project on developing secondary mathematics preservice teachers' mathematical literacy and preparing them to teach mathematics contextually [Trần et al., 2018], this paper focuses on PSTs' perception about task authenticity before the innovation. This initiative is to address the incoming school reform curriculum, which will be implemented in 2019. It focuses on the competency-based learning [Vietnam Ministry of Education, 2018] and emphasizes the close relationship between mathematics and the real world. Teachers serve as an agent to make changes in their classrooms, and we argue that PSTs should be equipped with the skill sets to teach mathematics contextually. Teacher knowledge and beliefs are keys in effective teaching [Ball et al., 2008]. Task selection, task adaption, and task implementation are activities that teachers must perform. Therefore, we address the question: *How do secondary mathematics PSTs perceive the authenticity of tasks in mathematics when they first enter the innovation?* In the next section, we will discuss different ways to conceptualize task authenticity.

2. Conceptual framework and related literature review

2.1. Authenticity

There exist various views on the use of authenticity in teaching and learning mathematics. Vos [2011] adopted authenticity as a social construct, which lies in the interplay between objects and actors. The objects are authentic artifacts that have an origin and the actors should be authorized expert to attest the qualification of the objects. This conceptualization is similar to that of Niss [1992], who considered authentic tasks as those embedded in a true existing practice outside mathematics and those dealing with objects, phenomena, and problems that are genuine and recognized by people in the community. Vos [2011] pointed out the confusion of the word authenticity, referred to be true [cf. Niss 1992] and to simulations that correspond to conditions that happen in real life [Palm 2008, 2009].

Galbraith [2013] provided a comprehensive view of authenticity including four dimensions: *content*, *process*, *situation*, and *product*. The first dimension requires a problem to satisfy realistic criteria that involve genuine real-world connections and the solvers to have sufficient mathematical knowledge for a viable attempt. The process dimension refers to the "conduct of a modelling process that results in solutions that are defensible and robust in terms of the outcomes sought" [Galbraith, p. 33]. For the situation authenticity, Galbraith argued that the conditions need to be appropriate, similar to the workplace or environment that the modelling enterprise is conducted, for a valid modelling process to happen. Product authenticity refers to appropriate outcomes.

Authentic tasks

Newmann [1995] argues that an authentic task is a task that requires learners to solve similar problems that they have encountered or that the task is likely to occur in their lives. Authentic tasks are based on situations that, while sometimes fictional, represent the kinds of the problem encountered in real life [OECD, 2001, p. 23]. Authentic tasks are a situation from real life outside mathematics itself that has occurred or that might very well happen. In addition, the task situation is truthfully described and the conditions under which the task solving takes place in the real situation are simulated with some reasonable fidelity in the school situation. [Palm 2002, p. IV-7].

Focusing on the simulation aspect, Palm [2009] developed a local Theory of Authentic Task Situations, which focuses on creating school tasks that simulate conditions of real life. The theory calls for congruence between word problems with real-life situations regarding eight features: *event*, *question*, *information*, *presentation*, *purpose in the figurative context*, *solution strategies*, *circumstances*, and *solution requirements*. Palm [2009] stated that the event described in a school task should happen or has the potential to happen in real life and that the question asked in relation to the event has been asked in real-life settings. Information or data provided in school tasks should (a) exist – the same kind of data accessible in the school task as that in real-life situations, (b) be real – the values are identical or very close to those in real-life situations, and (c) be specific – about subjects, objects, and places in the task context. The language (presentation) used in the school task including terminology, sentence structure, and the amount of text should be similar to those in real-life settings. The purpose of solving the school task should be clear to students, as it would be in real-life situations. Students' solution strategies availability and experienced plausibility should match those in real-life settings. Likewise, the availability of external tools, guidance, consultation and collaboration, discussion, time, and consequence of task solving success should correspond to those of real life. Finally, solution requirements of a school task should be consistent with those regarded as appropriate in real-life settings. Tran et al. [2016] conceptualized the theory into two phases of task design (event, question, information, presentation, and purpose) and implementation (solution strategies, circumstances, and solution requirements).

2.2. Modelling hierarchy

Task authenticity can also be investigated from a hierarchy perspective. Three types of problems typically occur in curriculum materials: (a) word problems, (b) standard applications, and (c) true modelling problems [Niss, Blum, & Galbraith 2007; Tran & Dougherty, 2014]. The examples of each type illustrate how the types are similar to and different from one another in regard to authenticity and the modelling cycle.

2.2.1. Word problems

Word problems are merely the "dressing up" of a purely mathematical problem in words referring to a segment of the real world" [Niss et al., 2007, p. 11]. Consequently, the solution process includes a straightforward interpretation, as in this example:

Michelle invests $15,000 in a partnership that has four other partners. The total investment of all the partners is $240,000. What percentage of the business does Michelle own?

This is a word problem because the context is not an integral part of the solution. Students need only take the numbers from the problem, write the fraction that represents Michelle's investment as a portion of the total investment, and convert the fraction to a percentage. Even though the problem is written in words, it uses a numerical algorithm that does not depend on the context of the problem. It might appear that this problem could be an authentic task because its context could actually occur and the question would be reasonable for this event. However, the problem lacks the complexity found in real-world situations of this type. Referring back to the modelling cycle, we see that there is little to formulate and that the results require little or no interpretation or validation.

2.2.2. Standard applications

Standard applications are problems in which the solution strategy is immediately at hand "without further regard to the nature of the given real-world context" [Niss et al., 2007, p. 12] and the translation of the problem's information to the mathematical analysis is relatively straightforward. Standard applications reflect some level of translating from the real-world context to the mathematical problem and thus are different from word problems. An example is as follows:

All of the students in Thuan Hoa High School will visit some historical sites in Hue. You and the other members of the organizers will plan and arrange the bus. There are 360 students and each bus can carry 35 children. Fill in the order form, you will send to the Kha Tran garage to place the bus. [adopted from Tran & Dougherty, 2014].

Travel Bus Kha Tran - Booking form

First and last name:... ....

School: ....

Day of visit: ....

Number of vehicles booked: ....

Other requirements:.. ....

Figure 1. A version related to Travel bus – a standard application [Tran & Dougherty, 2014].

2.2.3. True modelling

True modelling problems involve the full cycle: Start with a question, then formulate a model, and finally solve, interpret, and validate within a mathematical and contextual situation.

For example, PSTs were asked to work on the task: "*Currently, on our university campus, there are five parking regions, which look quite messy. Could you design a parking lot for the university to solve the current issue so that it looks neat?*" PSTs were asked to work on this project for four weeks in groups (of 4–5 each) and report to the class at the end of week 4. Weekly reports were conducted so that the PSTs get feedback/questions from peers (not in their groups) and the lecturers to improve their reports. In the last week, they submitted their written report and also gave an oral presentation to the class.

3. Methodology

3.1. Data collection

The bigger project adopted a design-based research approach [Cobb et al., 2003] to investigate how PSTs' mathematical knowledge for teaching related quantitative literacy changes during the course of two years in the teacher education program. As part of the data collected at the beginning of the innovation, we surveyed PSTs' opportunities to learn about quantitative literacy as a baseline for the implementation. One part of the survey focuses on their perception of authentic tasks. PSTs were asked to write a response to the following question: "***When choosing a real-world situation involving mathematics, which criteria do you consider so that the situation is authentic and not contrived?***"139 responses were collected to form the data for this paper.

3.2. Data analysis

Using the Theory of Authentic Task Situations [Palm, 2009] and Galbraith's [2013] four aspects of authenticity, we adopt the criteria for an authentication task and list these criteria in Table 1. A brief description of the criteria for the authentic task is used in word problems.

Table 1. A description is provided for characteristics of authentic tasks

Features	Description
P1. Event	The event described in the school task must have happened or might happen in real life beyond school. This is a prerequisite for the authentic task.
P2. Question	The question must be one that has been posed or might be posed in a real-life out-of-school task situation for the school task to be concordant with such a situation.
P3. Goals	There is always a more or less explicit purpose of solving task situations in real life. This depends on the capacity of the student to provide clear and realistic descriptions.
P4. Language	The term, sentence structure and number of words used in the presentation of the task situation must ensure a reasonable level of honesty and do not include difficulties preventing students from addressing language situations.
P5. Information	+ Existence of information/data + Realism of information/data + Specificity of information/data
P6. Tools	Tools and instructions must be appropriate for simulations and learning situations. Knowledge and math skills are necessities for students to solve tasks.
P7. Circumstances	Tools, guidance/counseling, group discussion as well as enough time need to be provided for students to solve academic tasks must be relative as in real life.
P8. Solution requirements	The methods and the final answer must be appropriate to the actual situation.
P9. Process	The process dimension refers to the "conduct of a modelling process that results in solutions that are defensible and robust in terms of the outcomes sought" [Galbraith, p. 33].

In addition, we examined if the PSTs mentioned any criteria of the hierarchy in their responses to the question.

Data were entered into an excel spreadsheet (Figure 2), then each response was coded against the nine criteria specified above. We also noted other criteria the PSTs mentioned that are not captured in the framework. At least two researchers look at the response to ensure the reliability of coding. When disagreement occurred, a third researcher was consulted and discussion happened until the consensus was reached. Therefore, the results show the agreement among the group of researchers.

A	B	C	D	E	F	G	H	I	J	K
ID	Features / Content	P1: Event	P2: Quest	P3: Goals	P4: Lar	P5: Infor	P6: Tools	P7: Circu	P8: Solu	P9: Proc
97	Related to mathematics, high applicability benefits, consistent with reality	1		1			1			
99	Accurate and consistent with reality	1								
100	Creative apply not stereotyping, machines, imposing follow the old methods Solve problems creatively and effectively based on the existing knowledge of mathematics						1	1		
101	Practical and application. Is there an overview or is it related to high school math? When solving is there really satisfied people who know about math? Promoting creativity of students	1	1				1		1	
102	must be related to real life	1								
103	associated with daily life	1								
104	practice	1				1	1	1		
107	What kind of math is that situation belongs to? Apply knowledge of that knowledge to solve						1		1	
108	Exactly - in accordance with the situation, happened in reality	1								
109	Apply math in a real way, while relying on the purpose of solving the problem	1		1			1		1	
110	relevant, useful for life			1						
111	Is the actual situation related to how to solve the problem? Is the situation consistent with the problem content? What situation does that apply to?	1		1			1			
112	The situation must be practical and applicable to mathematical knowledge	1					1			
113	The actual elements that appear in the topic are the same as in real life	1	1							
114	Close to reality	1								
115	Whether that criterion applies to life or not	1		1						

Figure 2. Encoded PST's data from the survey.

4. Result

A summary of coding for each of the criteria is captured in Table 2.

Table 2. Summary of results regarding 10 criteria of authenticity

Features	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
Number	59	18	15	0	11	41	6	13	4	7
(%)	42.5	12.9	10.8	0	7.9	29.5	4.3	9.4	2.9	5.1

About 42.5% of PSTs referred to the events (P1) associated with a real situation: "*The situation must be related to the real life*", "*The situation could be likely to occur in the real life*" (see Figure 3). This is the first aspect that Palm [2009] has mentioned in the authenticity criteria of a task; the event described in the school assignment has taken place or is likely to take place. Similarly, Galbraith [2013] argues that the content and the situation in which reality must be connected

with real life, and conditions must be consistent, such as the place of work, and the model for the modelling process is reasonable. This suggests that PSTs realized the importance of the connection between reality and problems in the classroom.

ID	Name	Content
2	Bùi Thị Tố Trinh	Situation occurs, many algorithms are used?
11	Đoàn Lê Thảo Nguyên	Profits, Less risk, familiarity, affect us, knowledge of the situation
18	Hà Thúc Tân	Everyday
19	Hồ Minh Phong	close to reality
20	Hồ Ngọc Anh	That problem is likely to be true in practice
21	Hồ Thị Dâng	The situation is widely used in practice, Know how to solve the situation
23	Hồ Thị Nhược Nam	The situation is suitable for life and has practical value in life
28	Hoàng Phương Nha	The situation is likely to occur in practice and attached to reality
29	Hoàng Thị Hiền	Profits
31	Hoàng Thị Nhung Thủy	There are related mathematics, Objectively, close to reality, Useful for self and society
34	Hoàng Thị Xuân	Profits, common

Figure 3. PSTs' responses related to event criteria (P1).

Tool (P6) is the second feature that PSTs often mentioned. 41 in total 139 PSTs (29.5%) specified tool to be critical when choosing authentic tasks. For example, one PST responded: "…*Take consideration into the situation to which the field of mathematics belongs in order to apply the proper knowledge for solving the problem*". The PSTs indicated that to solve the task, students need mathematical tools that are appropriate for the situation.

Other features got little attention from the PSTs. For example, 12.9% of PSTs have the statements related to the second feature – question for an authentic task: *"It is hypothesized that the situation is relevant to mathematics as well as its resolution purpose"*, then *"Is that situation likely to happen in reality and attached to reality?"*

Similarly, 10.8% of the PSTs indicated the purpose of the situation to be important when designing authentic tasks: *"Consider using mathematics to apply to real situations, at the same time, base on the purpose of solving tasks."*

Although the question and the purpose of the situation are fundamental and important features when designing a task, they affect students' ability to access and solve problems. Two features (P2, P3): question and situation got little attention from the PSTs.

In addition, the 10th feature includes the responses of the PSTs that are not in Table 1 (9 features from P1 to P9). For example, 5.1 % of PSTs had answers such as *"objectivity of situation"* or *"logical situation"*.

In particular, no PSTs (0%) mention the language (P4) used for an authentication task. Meanwhile, when designing tasks, the language used including terms, sentence structure, and the number of words should not create any difficulties that prevent students from solving. This lack of attention to the language aspect can be explained by several reasons:

- PSTs do not often encounter mathematical modelling situations and authentic tasks in school. The school curriculum focuses more on pure mathematics but lacks a real-life connection.
- PSTs are not equipped with the knowledge and experience in the design of realistic tasks.

5. Conclusion

The results show that PSTs are aware of the importance of connecting the real world and the actual simulation tools when teaching mathematics. However, the study also found that the PSTs are not fully aware of other issues related to authentic tasks, such as how to design the problem close to reality, how to show the purpose of the task in clearly, and the way to provide data and using the language that does not contain the difficulties for solving problems. We argue that to teach meaningful mathematics that makes the connection between mathematics and real life, PSTs need to prepare with both understanding the knowledge about quantitative literacy and how to teach it efficiently. Especially, the PSTs need to be equipped with selecting and adapting tasks that are suitable to develop students' understanding of how mathematics is used in real-life situations. This research is a preliminary step in the study of authenticity. Ongoing research should focus on how such perception and knowledge about authentic tasks change as the PSTs participate in the innovation in teacher education and the training programme.

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