Towards a mathematics textbook for supporting 21st century learning: The student perspective

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Abstract. There is a need to provide 21st century learning through mathematics textbooks. To give valuable input to such an effort, students' perspective needs to be considered since the students are the ones that get impacted from the effort. Therefore, the present study aims to describe students' perspective regarding the effort in integrating 21st century learning and mathematics textbook. The study employed mixed methods with a survey approach to investigate the students' perspective. The findings of this study uncover critical components that should be considered in designing a mathematics textbook for supporting 21st century learning. Based on the findings, a set of recommendations is proposed for a textbook designer.

1. Introduction

Textbooks have an important role in mathematics teaching and learning. The textbooks not only shapes the students learning but also influence teachers in designing curriculum for their classroom [1]. The teachers often used the textbook in sequencing and choosing learning materials in their teaching practice. As a result, textbooks are an important influence on students' learning activities in the classroom. Further, the textbooks are often the main resources for students in learning mathematics outside the classroom. The students can read the textbooks' content as preparation before class or work on exercise provided in the textbooks to sharpen their skills.

As information and technology grow rapidly in recent decades, the shift on what and how student learn in the mathematics classroom is needed. Mathematics classroom should equip the necessary knowledge and skills for students to prepare their future in more complex life and workforce [2]. The notion of 21st century learning is often regarded as a means to that end. The 21st century learning promotes foundational, meta, and humanistic knowledge should be achieved by the students [3].

Given the importance of both textbook and 21st century learning in mathematics teaching and learning, it is necessary to provide access for students to experience 21st century learning through mathematics textbook. Before achieving this objective, it is necessary to understand students' perspective regarding the integration of mathematics textbook and 21st century learning. Therefore, the present study aims to describe students' perspective about the effort in facilitating 21st century learning through mathematics textbook.

2. Method

The current study used mixed methods with the survey approach in achieving the goals of the study. An electronic questionnaire was administered through Google Forms. Both quantitative and qualitative data were obtained from the student's response to the questionnaire.

Participants in the study were 215 students, 80.9% of them were female and the rest were male. The participants were students from 10 public and private universities in Indonesia. The age of the students

ranged from 18.1 to 33.7 ($M = 21.0$ and $SD = 1.7$). All the students were preservice mathematics teachers and most of them had experience in developing teaching materials (60%), e.g. textbook, workbook, handout, and others.

An electronic questionnaire was used to collect students' perception of mathematics textbooks. The questionnaire consisted of three main sections aiming to know: (1) student's expectations on an ideal mathematics textbook and their perceptions on mathematics textbooks; (2) student usage of mathematics textbook; and (3) the student's written opinions about the positive and negative aspects of the mathematics textbooks that they have read. The first section includes four aspects of the textbook [4]; four aspects regarding 21st century learning [5]; three aspects regarding technology use; and aspect about teaching practice [6–8]. A 7-point Likert scale was used in each item of the first section. The questionnaire has been validated by two peers that have experience in designing textbooks for teaching purpose. The questionnaire also has been tested to 11 students that representative for targeted participants. These process of validation and pilot testing produced feedbacks that were used to revise the questionnaire.

Before we analyzed the data, we performed data cleansing. We omitted 32 students' responses (14.9%) because of data duplication and the detection of unfocused students when they responded to the questionnaire. To detect whether students still focus on responding to the questionnaire, we used an item that asked the students to choose a specific answer for the item. As a result, 183 students' responses were obtained from the data cleansing. These responses were used for further analysis.

Both quantitative and qualitative data analyses were employed to analyze students' responses. The students' responses on the first and second sections of the questionnaire were analyzed by using descriptive statistics, paired-samples *t*-test, and correlation coefficient analysis. The thematic analysis with cluster analysis was used to analyze students' responses in the third section of the questionnaire. In conducting thematic analysis, we followed a procedure proposed by Nowell et al. [9]. In searching themes, first, we created codes co-occurrency table that was generated from initial codes. Second, we converted the table into the edges table so that we can analyze the codes co-occurrence by social network analysis (SNA). Lastly, we used modular class statistics of the produced networks to generate themes. The generated themes from the SNA, then, were reviewed and defined.

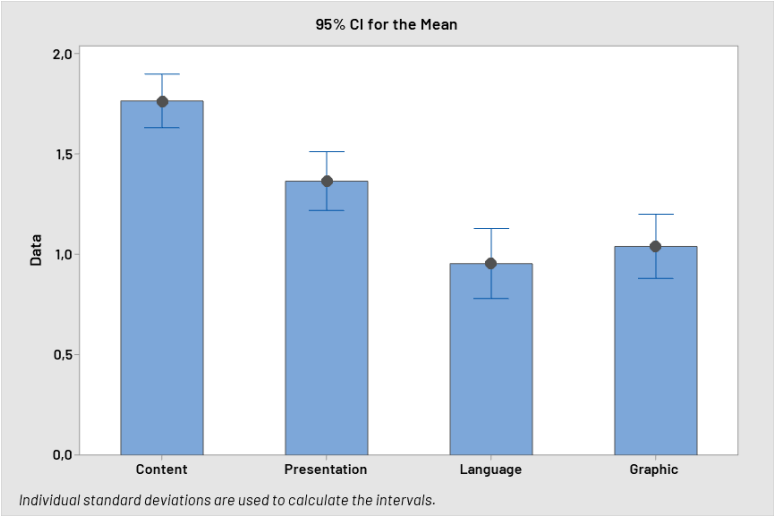

Figure 1. Student gap on textbook's content, presentation, language, and graphic

3. Result and Discussion

3.1. The Gap Between Student Expectations and Their Perceptions

The gaps between students' expectations on an ideal mathematics textbook and their perceptions on mathematics textbooks they have read regarding content, presentation, language, and graphic are

identified. By using dependent *t*-test, all the gaps are statistically significant with $t(182) = 26.156$, 18.359, 10.795, and 12.853 for content, presentation, language, and graphic, respectively. The 95% confidence interval for each gap is shown in Figure 1.

The wide gap between students' expectations and their perceptions on the content of mathematics textbook is an issue need to be addressed. Since our measurement of textbook's content consisted of mathematics content, 21st century learning, technology use, and teaching knowledge, all these issues should be considered in designing mathematics textbook, especially in supporting 21st century learning [10].

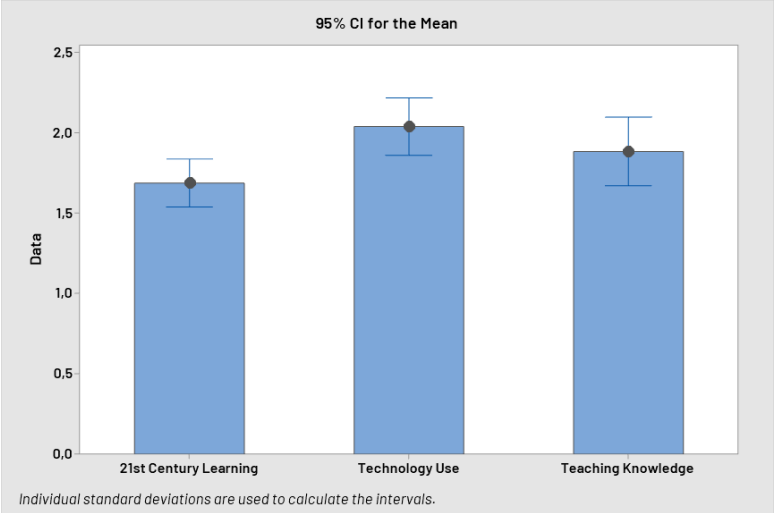

Figure 2. Student gap on 21st century learning, technology use, and teaching knowledge

The gaps between students' expectations and their perceptions on the mathematics textbook's features regarding 21st century learning, technology use, and teaching knowledge are also identified. The dependent *t*-test yields $t(182) = 22.288$, 22.468, and 17.454 for the gaps in 21st century learning, technology use, and teaching knowledge, respectively. The 95% confidence interval for each gap is shown in Figure 2.

Technology has an important role in mathematics teaching and learning. It serves multiple purposes, i.e. for management, communication, evaluation, motivation as well as cognition purposes [11]. On the other hand, the present study shows the wide gap between students' expectations and their perceptions on the use of technology in mathematics textbooks. This finding similar to the result of mathematics textbook analysis in a previous study [12]. The study found that the use of technology in mathematics tasks is relatively rare.

3.2. Student Usage of Mathematics Textbook

Most of the students in this study state that they read mathematics textbook before the examination. Further, they also often read mathematics textbook during and after class, as well as before the class. Interestingly, the students also read mathematics textbooks quite often when they work in a study group. The period in which students read mathematics textbooks are shown in Figure 3.

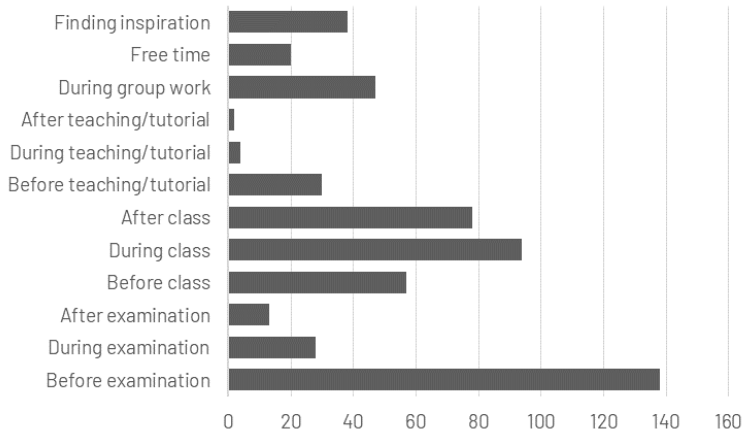

Figure 3. Mathematics textbook reading period

The finding of the present study regarding mathematics textbook usage by students aligns with previous studies [13–15]. The students tend to read the textbook as preparation for an exam, but they are relatively infrequent to read the textbook as a preparation for their class. This issue regarding textbook usage and study habits should be considered by the instructor in facilitating students' learning, as well as a textbook designer to design and organize the content of the textbook.

Figure 4 presents a list of students' considerations to buy a mathematics textbook. Unsurprisingly, the figure uncovers the critical role of teacher/lecturer for students to make a purchase of a mathematics textbook. The title of the textbook is also considered as an important impetus since, in general, it represents the whole content of the textbook. Price of the textbook is also an important consideration in purchasing a textbook. In addition, review and blurb of the textbook also affect student's decision whether they buy a mathematics textbook.

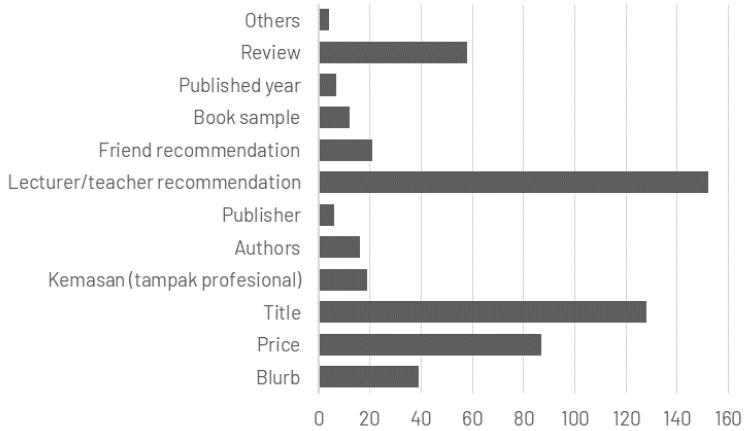

Figure 4. Student consideration in buying mathematics textbook

The students have different purposes in borrowing or buying a mathematics textbook. The main purpose is related to the role of the textbook in students' course, i.e. for mandatory or additional reference. Further, many students report that the reason they buy or borrow a mathematics textbook is to find a solution to a problem. Figure 5 shows a list of the students' purposes in borrowing or buying mathematics textbook.

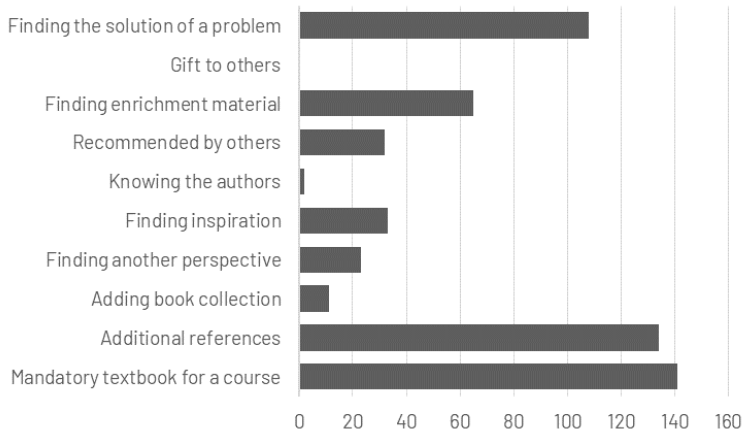

Figure 5. Main objectives in borrowing or buying mathematics textbook

The present study's findings with regard to student's consideration and objective in buying or borrowing can be insightful input for private sector entities, especially commercial publishers. Since the primary goal of the commercial publishers is the desires of their consumers [16], it is worthy to note that social influence and course-related needs are the main factors for students to consume mathematics textbook. However, these findings also useful for textbook designers so that the textbook they design can reach wider readers.

3.3. Results from Qualitative Data

The thematic analysis of students' written opinions on the positive and negative aspects of mathematics textbooks they have read yields six main themes. The themes are content understanding, exercise and feedback, organization, appearance and add-on, triggering learning, and mathematics and relevant knowledge. These themes are shown in Figure 6.

The first theme is *content understanding*. The students state that they read mathematics textbooks to understand mathematics contents they needed. They perceived useful if the textbooks contain comprehensive and in-depth contents that are presented in a straightforward manner. The students perceived that illustration (e.g. graph, diagram, and infographic) has an important role in helping them to understand mathematical ideas. A worked example is also often mentioned by the students on their comments. The students want the worked example varies so that it will help them to perform better in solving exercises.

The second theme is related to *exercise and feedback*. A set of exercise in a mathematics textbook is perceived helpful by the students because it allows the students to apply and test their understanding. The exercise is perceived useful when the students learn a topic independently, without guidance from teacher or tutor. Some students also stated that the difficulty level of the problems or questions in the exercise should gradually increase, from easy to difficult.

Many students claimed that the mathematics textbooks they have read did not have an answer key. They want the mathematics textbook should have the answer key so that they can confirm the accuracy of their answer. For cognitively demanding problems, they also suggest that the problems should have a clue or hint. The clue will help or guide them to solve the problem. Therefore, the students agree that both exercise and feedback mechanisms have a critical role in their learning.

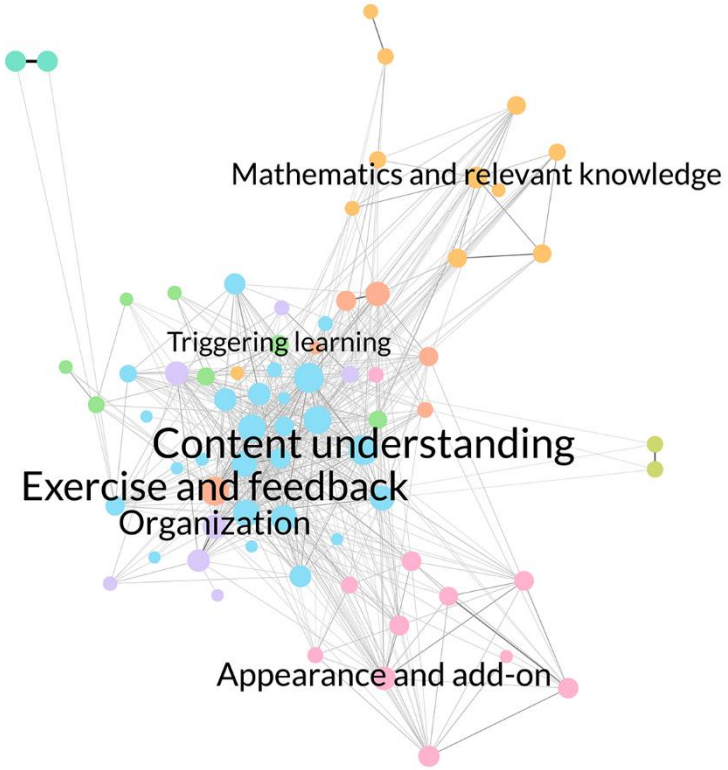

Figure 6. Themes of student's written response. This network graph connects 75 initial codes created in open coding phase. The size of each code represents its weighed degree, while the thickness of each edge represents how strength two codes are relate to each other.

The third theme refers to the *organization* of main and additional content of mathematics textbook. The students value mathematics textbooks that organize important information, e.g. definition, theorem, and rule, in an easy-to-find fashion. They illustrated that the box or different text formatting for presenting the important information helps them to find it easily when they need the information. Furthermore, the students found that table of contents and index of a textbook, as well as keywords list in each chapter, help them find specific information in the textbook easily and quickly.

The fourth theme is regarding the *appearance* or interface of mathematics textbooks and their technology *add-on*. The students perceived that the layout and typography of a mathematics textbook impacted their method, interest, and motivation in reading the textbook. As an illustration, a student stated that blank space in a textbook's pages often was used to make a note on important information.

Furthermore, the students also give comments regarding technology add-on. Some students have found technology add-ons in mathematics textbooks they have read. In this case, the add-ons are often in the form of QR codes or links that connect the content in the book to learning videos. However, many students found the lack of technology add-on in their mathematics textbooks. With regard to this situation, they suggest that mathematics textbooks should utilize technology for different reasons. First, they perceived that technology can enhance their learning and interest. Learning technology, such as video and interactive application, can provide multiple representations for mathematical ideas. Second, the students think that technology, especially for a companion website, can ease access to the additional resources of the textbook. This ease of access makes reading more flexible. Third, the students, which are also preservice mathematics teachers, think that technology use in mathematics textbooks give them information, media, and technology literacy. This literacy is important for their future career as a teacher.

The fifth theme refers to the role of a mathematics textbook's content as *triggering learning* or thinking. The students' want that the mathematics textbook should consist of presenting information that

generates their will or curiosity to learn or think critically. They suggest that contextual or applied problems should be used in introducing mathematical ideas. As an illustration, one student perceived that the use of contextual problems as an introduction can clarify the importance of mathematical ideas to be learned. If the students' thinking is successfully triggered, the subsequent mathematical contents in the textbook can be followed seamlessly.

The last theme that emerged from the students' written responses is *mathematics and relevant knowledge*. This theme consisted of the potential of connecting a mathematical idea to another mathematical idea or other relevant knowledge. Some students' think it is helpful if content in a mathematics textbook is presented by using a historical perspective, e.g. by using a story of a mathematician who invented a theorem. The students also suggest that quote from popular mathematicians is helpful in companying the content. Furthermore, it is also perceived informative if mathematics content can be connected to other science. This interdisciplinary approach can expand students' knowledge about mathematics.

3.4. Recommendations

The findings of the present study provide insight regarding the students' expectations and their perceptions on mathematics textbook, especially for supporting 21st century learning. Further, this study also gives awareness of how the students use their mathematics textbooks. Based on these findings, we will give a set of recommendations for mathematics textbook designer.

The first recommendation is related to teaching and learning in 21st century. The present study demonstrates a need for mathematics textbook's content that facilitates students in mastering 21st century skills. A set of skills that are critical for students to live in 21st century should be integrated [17]. Aside from its importance for students' future, 21st century context and themes can enrich mathematics textbook's content and potentially stimulate students' interest in learning mathematics [18]. Further, such contextually rich mathematics content can help students in connecting mathematics to their world [19].

Second, technology should be incorporated into the mathematics textbook effectively. Based on the findings in the present study, the technology integration at least has two purposes, i.e. for enriching content and for giving students' knowledge about educational technology. Compared to a paper textbook, integration of technology provides rich experiences for students in learning mathematics [20,21]. As a cognitive tool, for example, the technology "help transcend the limitations of the mind (e.g., attention to goals, short-term memory span) in thinking, learning, and problem-solving activities" [22]. Aside from enriching textbook content, the technology integration help students, especially for preservice mathematics teachers, knowing and understanding various educational technology for teaching and learning mathematics. Along with knowledge about pedagogy and mathematics content, this knowledge is critical for preservice mathematics teacher [23].

Lastly, the process of designing and developing mathematics textbook should be built on well-established theories. From the themes emerged from the students' written comments, both instructional design and cognitive load theories can be considered. From an instructional design perspective, for example, gaining students' attention and recalling their prior knowledge are important to be included in designing instructional strategies in the textbook [24]. As mentioned by the students, the organizational strategies [25], such as outlining and mapping, should be considered in presenting the content of the textbook. Further, worked example [26], exercise, and feedback mechanism [27] also has an important role in enhancing students' learning so that these components should be considered in designing a mathematics textbook.

4. Conclusion

The motives of the present study are the important roles of textbook and 21st century context in mathematics teaching and learning. The mathematics textbook should bring 21st century learning in the students' learning. The present study offers students' perspective on an effort in integrating 21st century learning into mathematics textbook. A set of recommendations are also proposed to support such an effort. Even though the present study's findings mostly are targeted for the textbook designer, some of them are also suitable for private sector entities and mathematics instructors.

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