DO DIGITAL TEXTBOOKS OFFER NEW OPPORTUNITIES FOR GEOMETRY EDUCATION? AN ANALYSIS OF TASK FEATURES

Dubravka Glasnović Gracin[1] and Ana Krišto[2]

[1]*University of Zagreb, Faculty of Teacher Education, Zagreb, Croatia;* *dubravka.glasnovic@ufzg.hr*

[2]*Primary school Petar Preradović, Zagreb, Croatia;* *ana.kristo10@skole.hr*

While the tasks in printed mathematics textbooks have been extensively examined worldwide, the requirements of the tasks in digital textbooks are yet to be developed and analyzed. The research presented in this paper utilises a framework developed for analyzing e-tasks and applies it to digital curriculum materials. The aim was to determine what features and potentials are present in the tasks in digital mathematics textbooks. The framework is applied to the content of the geometry chapters of the six digital textbooks for Grade 4 in Croatia. The results show that the geometry tasks in the digital textbooks do not provide a full range of digital potentials, such as dynamics, personalization and cooperation. These findings highlight the potential of digital tasks as an area to be explored and developed.

Keywords: digital textbooks, textbook tasks, task analysis, geometry

INTRODUCTION

In the past two decades, along with the development of digital technology, digital mathematics textbooks have been developed and published in many countries (Fan et al., in press). Digital textbooks, as a part of digital curriculum materials, may include new features such as dynamics and interaction, formative assessment and customization, and offer links to multimedia and viral communities (Choppin et al., 2014). These features, not available in printed textbooks, create opportunities for changing mathematics instruction and providing "new educational dynamics" (Pepin et al., 2017, p. 646). These new dynamics also include tasks in digital textbooks.

Textbook tasks create student opportunities for learning mathematics (Sullivan et. al., 2013) and may influence the way students think and "can serve to limit or to broaden their views of the subject matter with which they are engaged" (Henningsen & Stein, 1997). This may be applied to digital tasks as well, particularly because they "can extend and amplify pedagogical features present in non-digital environments" (Leung & Baccaligni-Franck, 2017, p. ix). Potentials such as dynamics are of special interest in geometry education because digital materials may support problem solving, exploring and learning geometry through visual and dynamic environments.

Research on tasks in printed textbooks in recent decades has provided many analyzing frameworks (e.g., Glasnović Gracin, 2018; Zhu & Fan, 2006). However, the new features of digital tasks present new challenges in terms of developing frameworks for the analysis of e-tasks. The aim of this study is to present a framework for exploring tasks in digital textbooks and in other curriculum materials and to apply it to e-textbooks developed for primary mathematics education.

THEORETICAL FRAMEWORK

Glasnović Gracin and Krišto (2022) provided the framework for the analysis of digital tasks in mathematics textbooks. It is based on the literature review concerning the special features of digital materials and contains the following categories: Interactive diagrams for exploring mathematics, Personalization in learning, Task form, Feedback, and Cooperation (see Table 1).

Dimension	Details and codes
Interactive diagrams for exploring mathematics	Yes – manipulating objects of dynamical geometry (D1) No (D2)
Personalization in learning	Yes (P1) No (P2) Which type of personalization? ________________
Task form	Multiple-choice questions (TF1) Fill-in-the-blank responses (TF2) Matching (TF3) True or False (TF4) Put in order (TF5) Other closed forms (TF6) Open-ended questions (TF7)
Feedback	No feedback (F1) Verification (F2) Correct response (IF1) Try again (IF2) Error flagging (IF3) Elaborated (IF4) Hints/cues/prompts (IF5) Other (IF6)
Cooperation	Yes (COO1) No (COO2)

Table 1. Framework for the analysis of digital tasks (Glasnović Gracin & Krišto, 2022)

Interactive diagrams for exploring mathematics refer to tasks which provide dynamics for exploring and understanding mathematical concepts, for example, figure transformations, change of function values, and changing parameters (Usiskin, 2018). Personalization in learning refers to customizing features according to individual student needs and for formative assessment (Pepin et al., 2017; Usiskin, 2018). Task form contains different ways in which a particular digital task is presented, for example, multiple-choice or fill-in-the-blank (Glasnović Gracin & Krišto, 2022; Pepin et al., 2017). Cooperation refers to the possibility for the student to share the workspace with others and provide collaboration (Pepin et al., 2017). The feedback category is organized according to Schute's (2008) categorisation of different feedback types in digital tasks: no feedback means that the student does not know whether or not the answer is correct. Verification feedback means giving a right/wrong response. Correct response means providing the correct answer for the specific task, without additional explanation, and try again refers to the possibility of trying until the correct answer is given. Error flagging highlights incorrect answers in the task, but does not offer the correct answer. Elaborated feedback means giving an explanation why a specific response is correct or incorrect. Hints/cues/prompts are part of elaborated feedback which guide students in the right direction by giving them, for example, examples or suggestions on what to do next. Still, the correct answer is not explicitly given.

This multi-dimensional conceptualization of task features in digital textbooks raises the question of to what extent the digital textbooks offer the full range of task types. Related to that, the following research question is formed for this study: What task features are present in the geometry lessons of digital mathematics textbooks?

METHOD

This empirical study encompassed analyzing the tasks of all six digital textbooks for Grade 4 in Croatia. According to the Textbook Standard (Ministry of Science and Education [MZO], 2019b), textbooks consist of both the printed and digital versions. Digital versions of textbooks contain at least one of the following features: (a) dynamical representation (sound, animations, videos, etc.), (b) simulation (virtual experiments, interactive videos, etc.), or (c) interaction student–student/teacher and student–content. Student–content interaction refers to interactive quizzes with feedback, didactical games, augmented reality, etc. (MZO, 2019b). In this study, a task is considered as a request for initiating student activity. The analysis encompassed all the tasks in the digital textbooks provided for acquisition and practice in the geometry chapters in which the student should give their answer in the digital space provided. The six textbooks were coded as A, B, C, D, E and F. Altogether, the analysis involved 562 tasks (175 in digital textbook A, 74 in B, 81 in C, 64 in D, 51 in E, and 117 in F).

The reason for considering only Grade 4 was because, according to the curriculum (MZO, 2019a), this grade contains the most geometry content in Croatian primary education. In Grade 4, students learn about angles, triangle types, the circle, radius, measuring area, units of area, and the square grid.

The analysis instrument is an extended version of the framework of Glasnović Gracin and Krišto (2022) given in Table 1. The extension refers to adding the Measuring response time dimension with its subdimensions focusing on whether the measured time is limited or not (see Table 2).

Dimension	Details and codes
Measuring response time	No – time is not measured (TM1) Yes – time is measured (TM2) Time is measured, but without a time limit (TM2.1) Time is measured and there is a time limit (TM2.2)

Table 2. The added dimension Measuring response time

The analysis encompassed 164 tasks in textbook A for this new dimension, as the other dimensions of this textbook were analyzed in 2021, and in the meantime some e-tasks had been removed from it. Also, the modified framework presented in this paper refers to refining the dimension Interactive diagrams for exploring mathematics (D1 – Yes) into D1.1 (dynamics is required, e.g. drawing, dragging, but without exploring requirement) and D1.2 (exploring is specifically required).

Each of the tasks was analyzed and assigned codes in each category (see Tables 1 and 2). One of the authors conducted the coding and the other author analyzed 10% of the tasks. The matching was high (99%), and the inconsistencies were discussed. The obtained data were processed using relative frequencies of codes within a particular category.

RESULTS

The examination showed large discrepancies in the number of digital tasks offered in the textbooks. Textbook A has the most tasks (175), textbook C has 81 tasks which is more than two times less than A, while textbook E has more than three times less tasks (51). The results are presented according to the framework dimensions.

Interactive diagrams for exploring mathematics

The results revealed that most of the analyzed digital textbook tasks do not involve interactive diagrams for exploring ideas and relations of geometry (see Table 3). Digital textbook C (DTxb-C) offers dynamics in 23% of geometry tasks for Grade 4, while textbook B has only one such task. The tasks in textbook C that refer to this dimension require drawing geometrical objects in dynamic geometry applications, but mostly without exploring requirements. The other four digital textbooks do not contain any tasks with interaction for exploring mathematical ideas.

	DTxtb-A (n = 175)	DTxtb-B (n = 74)	DTxtb-C (n = 81)	DTxtb-D (n = 64)	DTxtb-E (n = 51)	DTxtb-F (n = 117)
D1	0.00%	1.35%	23.46%	0.00%	0.00%	0.00%
D2	100.00%	98.65%	76.54%	100.00%	100.00%	100.00%
D1.1	0.00%	0.00%	17.28%	0.00%	0.00%	0.00%
D1.2	0.00%	1.35%	6.17%	0.00%	0.00%	0.00%
P1	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
P2	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
COO1	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
COO2	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

Note. D1 – opportunity for manipulating objects of dynamical geometry, D2 – no possibility of manipulating objects of dynamical geometry, D1.1 – dynamics without exploring, D1.2 – exploring is specifically required, P1 – personalization in learning present, P2 – personalization in learning not present, COO1 – cooperation present, COO2 – cooperation not present.

Table 3. Dimensions of Interactive diagrams for exploring mathematics, Personalization and Cooperation in digital textbook tasks

Personalization and Cooperation

The results revealed that none of the textbooks analyzed contains any tasks which support personalization or cooperation in learning (see Table 3).

Task form

Regarding task form, the results (see Table 4) showed that all the examined textbooks contain tasks with multiple-choice questions (TF1), fill-in-the-blank responses (TF2), matching (TF3), and true or false items (TF4). The overall results imply that the multiple-choice tasks are the most frequent in textbooks A, B, E and F, making 40-45% of all digital tasks in the geometry chapters. Analysis of the textbooks shows that these tasks occur mainly as parts of different quizzes, but also as separate tasks. Fill-in-the-blank tasks make between a quarter and a third of all tasks in each textbook examined, except for textbook D (11%). But textbook D puts strong emphasis on matching requirements, half of its geometry tasks take this task form. About 20% of all geometry items in textbooks E and F require True/False answers, while the other digital textbooks contain this task type to a much smaller extent. The task forms put-in-order and open-ended-questions are minimally or not at all present in the in geometry chapters of the examined textbooks. Interestingly, 17% of tasks in textbook C are other closed forms (see Table 4). These tasks refer to drawing geometrical objects.

	DTxtb-A (n = 175)	DTxtb-B (n = 74)	DTxtb-C (n = 81)	DTxtb-D (n = 64)	DTxtb-E (n = 51)	DTxtb-F (n = 117)
TF1	44.00%	45.95%	14.81%	23.44%	39.22%	44.44%
TF2	30.86%	31.08%	37.04%	10.94%	25.49%	28.21%
TF3	18.86%	12.16%	17.28%	48.44%	15.69%	7.69%
TF4	4.57%	8.11%	4.94%	12.50%	19.61%	19.66%
TF5	0.00%	0.00%	2.47%	4.69%	0.00%	0.00%
TF6	1.71%	0.00%	17.28%	0.00%	0.00%	0.00%
TF7	0.00%	2.70%	6.17%	0.00%	0.00%	0.00%

Note. TF1 – Multiple-choice questions, TF2 – Fill-in-the-blank responses, TF3 – Matching, TF4 – True or False, TF5 – Put in order, TF6 – Other closed forms, TF7 – Open-ended questions.

Table 4. Dimension of Task forms in digital textbook tasks

The results show that textbooks A, B, E and F have a similar structure and distribution of task types (see Table 4). Textbook C puts emphasis on fill-in-the-blank tasks and drawing geometrical objects in other closed forms, while matching and multiple-choice tasks are more prominent in textbook D.

Feedback

The results showed that all of the examined textbooks contain a high percentage of verification tasks, that is, tasks with feedback on the correctness of the student's answer (see Table 5). In all the textbooks examined, except for C, more than 97% of geometry tasks have feedback. Only textbook C has a significant amount of tasks with no feedback (25%). Consideration of the subcategories of different types of feedback show that all the digital textbooks contained features IF1 and IF3, although they differed in their proportions. Tasks providing feedback just to correct answers (IF1) are widely offered in textbooks B, D, E and F. From one hand, textbook E offered this feature in all of its geometry tasks, while, from the other hand, it was present in only 10% of textbook C tasks. Error flagging (IF3) only highlights students' incorrect answers and was highly present in all textbooks examined, except for textbook A (29%). All of the geometry digital tasks in textbooks D and E have this feedback feature. Subdimension IF2 (trying again and again until the student gives the correct answer) is differently distributed over the six textbooks: from no representation at all in textbooks C and D, very small proportions in E and F (less than 3%), 15% in textbook B, to more than half of all tasks (55%) in textbook A. Important and useful features for formative assessment, such as explanations as to why a specific response is correct or not (IF4) and giving hints/cues/prompts (IF5) are not present in the examined textbook tasks. Only textbook B contains 7% of IF4 tasks (see Table 5).

	DTxtb-A (n = 175)	DTxtb-B (n = 74)	DTxtb-C (n = 81)	DTxtb-D (n = 64)	DTxtb-E (n = 51)	DTxtb-F (n = 117)
F1	2.29%	2.70%	24.69%	0.00%	0.00%	0.00%
F2	97.71%	97.30%	76.54%	100.00%	100.00%	100.00%
IF1	22.86%	74.32%	9.88%	98.44%	100.00%	90.60%
IF2	54.86%	14.86%	0.00%	0.00%	1.96%	2.56%
IF3	29.14%	85.14%	76.54%	100.00%	100.00%	96.58%
IF4	0.00%	6.76%	0.00%	0.00%	0.00%	0.00%
IF5	0.00%	0.00%	0.00%	0.00%	0.00%	0.85%
IF6	1.14%	0.00%	0.00%	0.00%	0.00%	0.00%

Note. F1 – No feedback, F2 – Verification, IF1 – Correct response, IF2 – Try again, IF3 – Error flagging, IF4 – Elaborated, IF5 – Hints/cues/prompts, IF6 – Other.

Table 5. Dimension of Feedback in digital textbook tasks

Regarding different textbooks, the results show that textbooks A and B contain the greatest diversity according to feedback features, with four feedback types with proportions greater than 1%. The other textbooks mainly possess features IF1 and IF3 only. Textbook C lacks feedback in a quarter of its geometry tasks.

Measuring response time

The results showed that the feature of measuring response time was present only in textbooks A, B and D (see Table 6). All of these tasks relate to internet quizzes. In textbooks A and B, the time is measured in about a fifth of all tasks. Tasks with a time limit for responses are provided in quizzes with the aim of encouraging students' procedural fluency and make up 8% of all tasks in textbook A, 11% in B, and 6% in D.

	DTxtb-A (n = 164)	DTxtb-B (n = 74)	DTxtb-C (n = 81)	DTxtb-D (n = 64)	DTxtb-E (n = 51)	DTxtb-F (n = 117)
TM1	78.05%	79.73%	100.00%	90.63%	100.00%	100.00%
TM2	21.95%	20.27%	0.00%	9.38%	0.00%	0.00%
TM2.1	14.02%	9.46%	0.00%	3.13%	0.00%	0.00%

TM2.2	7.93%	10.81%	0.00%	6.25%	0.00%	0.00%

Note. TM1 – Time is not measured, TM2 – Time is measured, TM2.1 – Time is measured, but without a time limit, TM2.2 – Time is measured and there is a time limit.

Table 6. Dimension of Measuring response time in digital textbook tasks

DISCUSSION AND CONCLUSION

The results show that the tasks in the geometry chapters of digital textbooks do not provide a full range of features according to the framework applied. Personalization, cooperation and exploring requirements are not used in the textbooks examined. Still, textbook C contained dynamics within tasks with drawing or dragging points in the plane. Regarding the task form, all of the textbooks contained multiple-choice, fill-in-the-blank, matching, and true/false tasks. Most of the analyzed tasks did not have the feature of measuring response time. Regarding the Feedback dimension, all the examined textbooks contained a high percentage of verification tasks, but they differed in the proportions of their subcategories. Some textbooks put more emphasis on IF1 (providing just correct answers), and others on IF3 (error flagging).

These results imply that the potential of tasks regarding interactivity and dynamics is not being utilized in digital textbooks, even though these features are listed as important in the national Textbook Standard for e-textbooks (MZO, 2019b). This issue is particularly interesting and important in geometry education for visual comprehension of geometrical objects and their relations through dynamics and dragging (e.g., Arzarello et al., 2002). The Croatian curriculum for Grade 4 encompasses the drawing and distinguishing of angles and different types of triangles, measuring circumference of triangles and rectangles and understanding the concept of area by tessellation with unit squares (MZO, 2019a). Exploring with dynamical geometry would help understanding these concepts. The study showed the domination of multiple-choice and fill-in-the-blank tasks. These task types may be helpful in distinguishing and explaining terms, but the other dynamical digital potentials are lacking. Interestingly, the previous research (Glasnović Gracin & Krišto, 2022), which focused on textbook A through grades 1 to 4, showed that this textbook contained geometry tasks with dynamics only in grades 1 and 2.

The lack of personalization and cooperation features in tasks may be the consequence of the limited capability of the publishers' platforms provided for digital textbooks. These issues make the e-tasks closer to traditional tasks found in printed textbooks, rather than providing new opportunities (Glasnović Gracin & Krišto, 2022). These findings are in line with the results by Pepin et al. (2017), where the digital curriculum resources are found to be "still relatively rudimentary" (p. 652) and lacking focus on the educative nature of digital resources.

This paper deals with the development of the multi-dimensional framework for analyzing the features of digital tasks, as they have not yet been well investigated (Fan et al, in press; Pepin et al., 2017). Although the focus here was on geometry, the framework can be implemented to other mathematical disciplines, as well as for other school subjects in different countries. The instrument is yet to be further developed by adding new potential dimensions as well as refined within its dimensions. Such a framework may highlight the different types of new educational potentials in digital materials.

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