

TEACHERS' EXPERIENCES WITH DIFFERENTIATED LEARNING MATERIALS: PAPER VS DIGITAL FORMATS

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Abstract

Differentiated instruction enables teachers to apply flexible approaches that address students' diversity. Typically, four dimensions frame its implementation: content, process, product, and learning environment. In this study, 8th grade mathematics teachers ($n = 11$) used differentiated learning materials on paper and in digital format for approximately 2 months within the topic of polynomials. The aim of the study was to explore the use of differentiated materials in 8th grade mathematics, focusing on how their format shapes teaching practices and students' learning. Semi-structured interviews were applied to gain deeper insight into how differentiation was implemented. Inductive qualitative content analysis revealed that although the materials were primarily differentiated toward an easier level, teachers actively used them with all students in both, paper and digital groups. A new topic was often introduced using the differentiated materials, working with step-by-step approach, discussing examples, and then practicing new skills according to students' individual level. Students with learning difficulties kept using the differentiated materials, while other students switched between traditional textbooks. Teachers did not perceive major changes to their usual teaching methods, instead they emphasized a positive opportunity to vary levels and apply step-by-step approach more easily. The differences between format became more visible in regard to perceived changes in students' motivation and knowledge. Paper group teachers described increased motivation, while digital group emphasized knowledge change. In conclusion, the study suggests that differentiated materials can be effectively integrated into whole-class instruction rather than limit to students with learning difficulties, while not causing extra workload or major changes to teachers' regular practice.

Keywords: *Differentiation, differentiated instruction, mathematics, secondary school, algebra.*

1. Introduction

Since inclusive education promotes equal access to schools, the learning groups can vary greatly in terms of learners' cognitive abilities and socio-emotional skills (Hertberg-Davis & Brighton, 2006). Due to diverse settings a uniform whole-class approach to instruction might not give expected results anymore (Bondie et al., 2019). Hence, researchers and practitioners have started to consider differentiated instruction that promotes teaching on an adequate level and pace of the learner (Tomlinson, 2014). In reality, applying the principles of differentiation and considering every single learner can be a great challenge to teachers – especially in mathematics, which often presents rigid curriculum demands (Brändström, 2005).

Typically, four key elements of differentiation are considered: content, process, product, and learning environment (Tomlinson, 2014). Differentiating content means adjusting the concepts and skills that students are expected to learn. Specifically, in mathematics, level of number complexity can be varied (Malva & Kivirähk, 2023). Content differentiation could also mean differentiating the formats of learning materials, e.g., on worksheets on paper, digital textbooks, videos, supporting visuals, etc. Process differentiation determines how these materials are used and which learning activities are applied. This could mean varying individual work, paired-work and group work, but also discussions and hands-on practice. A commonly used method to support learners in mathematics is to expose them to material, pictorial, and abstract information to be able to scaffold new knowledge. Product differentiation refers to how learners present their knowledge gains. Typically, in mathematics, a written form is used to assess learning gains. However, also assessment types could vary from written to oral and from paper to digital. Finally, differentiation of learning environment includes adjustments in the workspace. This could mean providing

team and independent work zones but also making sure that all learners have a safe environment that supports their autonomy.

Despite some shortcomings in the study designs (e.g., small sample sizes, limited data analysis), differentiated instruction has shown potential in supporting the acquisition of mathematics (e.g., Rijal & Waluyo, 2025; Aguhayon et al., 2023). Typically, multiple key elements of differentiation are studied and students learning outcomes are measured. Smale-Jacobse et al. (2019) have pointed out that differentiated instruction is targeted from a broad point of view, limiting conclusions about specific elements. A recent study focused on the effects of differentiated learning materials and found that simplified content significantly improves learning outcomes of these learners who have low prior-knowledge. Additionally, the materials improved all learners' motivation (Malva et al., 2026). While one could argue that the application of differentiated learning materials also changes process and environment in addition to content, applying differentiated materials is as close as it gets to studying one element of differentiated instruction.

To apply differentiated instruction a teacher should be well aware of their learners' academic level, and their unique profile of learning considering strengths and weaknesses. However, the identification and catering of all individual needs can be complex due to large number of learners. As a result, due to different challenges (Brändström, 2005) differentiation is not something that every teacher wants or can apply. To enhance the use of differentiation, teachers should be provided with necessary resources, including appropriate learning materials, flexible learning environments, but also the resource of time to carry out high demands. Based on above, this study focuses on teachers experiences and possible challenges in using differentiated learning materials in teaching. The paper is an addition to previous empirical study (Malva et al., 2026), aiming to provide teachers' perspective on the use of differentiated learning materials.

2. Objective and research questions

The aim of the study is to explore the use of differentiated materials in 8th grade mathematics, focusing on how their format shapes teaching practices and students' learning. Three research questions were posed:

- 1) How are differentiated materials used in 8th grade mathematics, and how does their use vary by format?
- 2) How do teachers adapt their teaching methods when using differentiated materials, and how does this vary on the format?
- 3) How do differentiated materials influence students' motivation and knowledge in teachers' opinion, and how does this vary on the format?

3. Methods

The study applied an intervention that was followed by a semi-structured interview to get more insight into teachers' experiences and perspectives about differentiated learning materials. An approval from Ethics Committee of Tallinn University was obtained prior to the study (application 6-5/20, decision nr 25, dated 4th of July 2024). A signed consent form was signed by the participating teachers and the parents of the students who were part of the intervention. During the intervention, teachers had a possibility to use differentiated materials either on paper or in digital format to teach the topic of polynomials to 8th grade students (see more Malva & Kivirähk, 2023; Malva et al., 2026). The exact timing and ways of usage were not defined, instead, the teachers could make decisions themselves based on their professional judgement.

3.1. Sample

The sample consisted of 11 mathematics teachers from five general education schools following the principles of inclusive education. Out of all participants, seven teachers were randomly assigned to use differentiated materials on paper and four teachers in digital format. All teachers had a master's degree in the field of teacher education. Teaching experience was reported as follows: 5–10 years (n=6), 20–25 years (n=4), and 40–45 years (n=1). During intervention, the teachers taught 301 students. While the size of the learning groups was mostly between 12 to 27 students, one group consisted of three students. Majority of the learning groups included students who had been identified with learning difficulties. The lowest proportion of students with learning difficulties per group was 12% and the highest 100%.

3.2. Data collection and analysis

Around one to two weeks after the end of intervention, a semi-structured interviews were carried out either individually or in small groups of two or three teachers. The interview questions were designed

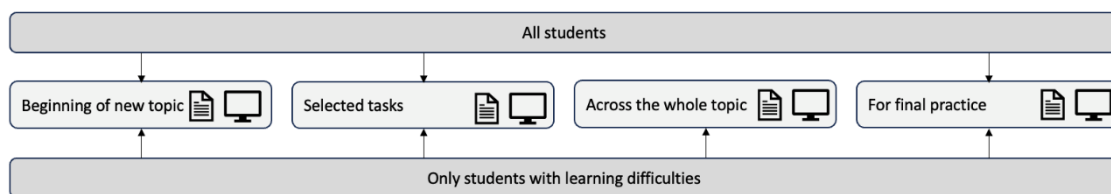
around three main topics: (1) the usage of the materials (4 questions); (2) changes in teaching methods (3 questions); and (3) feedback to the effectiveness (3 questions). The interviews were carried out by one researcher. The audio of the interviews was either recorded or if the teacher preferred, the answers were written down. Later, all interviews were transcribed and inductive qualitative content analysis was applied. Codes were assigned to relevant segments in regards to each research question. Then, the codes were grouped into broader categories. To be able to understand the role of format, the categorization was carried out separately for paper and digital groups. Finally, thematic maps were generated per research question.

4. Results and discussion

4.1. Use of differentiated materials

Regardless of the format, teachers reported using the differentiated materials either with all students in the learning group or selectively with those experiencing learning difficulties (Figure 1). The materials were used with all students during the beginning of new topic and for final practice. Also, during the practice period teachers chose certain tasks for everyone. While the previous also applies to those groups where the materials were used selectively among students with learning difficulties, these were the only groups that reported using the materials across the whole topic. The use of differentiated materials was the same despite their format.

Figure 1. Categories of the use of differentiated materials (with who and when).



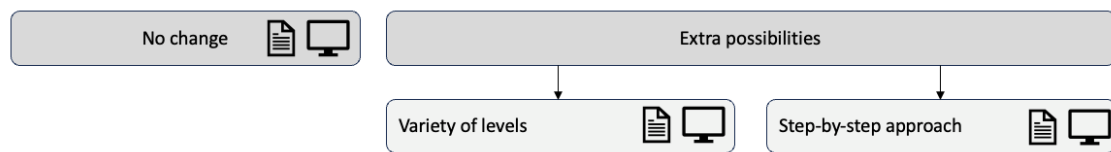
The results show that teachers vary the use of differentiated materials among all students in the classroom. In the interview some teachers specified that the materials were a good starting point of a new topic, but then *“faster students continued with our traditional textbook which has more difficult tasks, but the students who need more support continued practice with differentiated materials”*. One teacher from digital group also explained that the step-by-step approach in the introduction part helped the learners with procedural knowledge and that they often went through these steps as an all-class activity. In addition to that, teacher appreciated the opportunity to select tasks based on learners’ level: *“I already knew which example or which task would be suitable based on their level”*. This shows that teachers are aware of their students’ academic level and can make appropriate decisions in the process of differentiation. To facilitate this process even more, future studies could consider integrating artificial intelligence (AI) into digital learning systems to enable real-time assessment of students’ learning states (e.g., Hooshyar et al., 2026), and accordingly suggest individualized differentiated materials (Hooshyar et al., 2025). In case of learning difficulties, most of the teacher reported that these students used only differentiated materials throughout the topics, presenting the idea that whole-class instruction is not appropriate in the modern classrooms as suggested by Bondie et al. (2019).

Few teachers found an opportunity to use the differentiated materials for final practice: *“When we finished the topic, I told them that now again open this material and solve everything that is still undone. This increased their self-confidence”*. In addition, one teacher from the paper group added that they put together assessment test based on differentiated materials for those students who only used these for learning. This shows that in addition to differentiating content, the use of these materials could also change the element of product (Tomlinson, 2014). Another teacher brought out that while they used some tasks selectively, the digital environment did not support students’ attention: *“We prefer pen and paper tasks, not in digital format, keeps them more focused”*. Therefore, the differentiation of environment was not always easy to apply despite the availability.

4.2. Adapting teaching methods

The majority of teachers reported no change in their teaching methods when using the differentiated materials (Figure 2). However, if a change was noticed, it was described as something positive – either more possibilities to adapt the levels of learning content or more support to carry out step-by-step teaching. Teachers’ experiences were similar in both groups, paper and digital.

Figure 2. Categories of the adaptations in teaching methods.

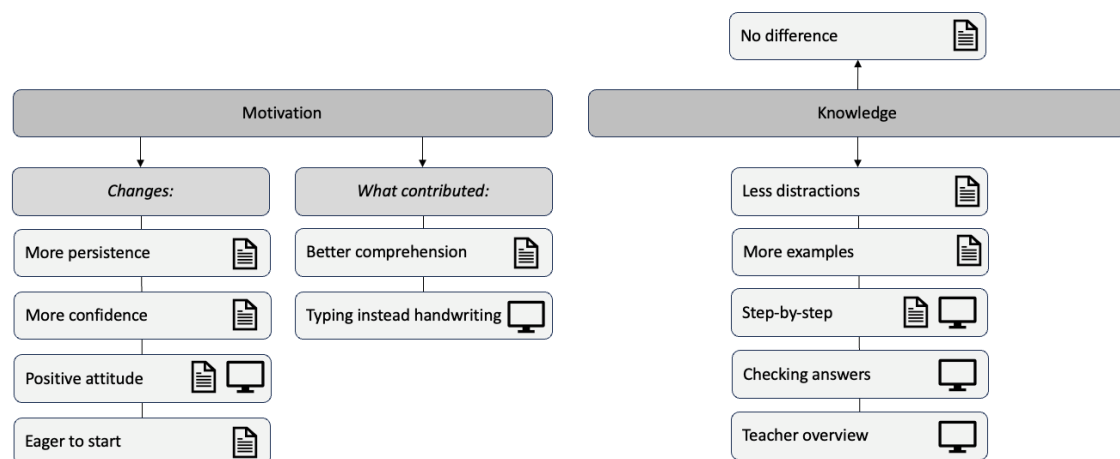


Differentiation does present multiple challenges to teachers which are often related to higher workload. The results of this study show that if appropriate materials are provided, teachers do not perceive extra change in their regular teaching methods. Even more, they saw this as a positive opportunity. As an example from one teacher, the process of learning was differentiated by applying methods that support independence: “For some topics some students used the material independently and put together the theory themselves. After that we discussed if they have understood it correctly”. The variety of tasks on an easier level made teaching easier as the material was always available, as well as clearly defined steps that supported subsequent learning. Therefore, while differentiation in general is often related to challenges (Brändström, 2005), the study shows that with enough resources its application is rather smooth and successful.

4.3. Changes in students’ motivation and knowledge

Teachers noticed a variety of changes in students’ motivation: more persistence, confidence, and positive attitude, but also that students were more eager to start the lesson (Figure 3). In teachers’ opinion, the positive change in motivation was a result of better comprehension and specifically in digital group, the fact that students could type instead of using handwriting. While some teachers reported that the materials made no difference when learning with the paper format, changes were mentioned in regards to students’ knowledge. Teachers reported that knowledge gains might be the result of less distractions, more examples, and step-by-step approach. The teachers who used digital materials noticed that the possibility for students to check their answers together with better overview for the teacher might have contributed to better learning outcomes.

Figure 3. Categories of the changes in students’ motivation and knowledge.



The perceptions of the changes in students’ motivation and knowledge are in line with the pre- and post-test results of students (Malva et al., 2026). The study showed significant motivation gain in paper group, particularly an increase in interest to learn and in persistence to finish all tasks, while the cost of time and energy decrease. Similar observations were captured by teachers: “If they can start from easier tasks, it is also easier to continue. They didn’t immediately give up, instead motivation to learn stayed longer”. The reason for positive changes was due to the content of the material. In one teacher’s opinion the topics were easier to understand and did not cause that much confusion, therefore, the motivation to learn was higher. However, most of these positive changes in motivation were captured in the paper group, while the digital group teachers only reported more positive attitude. The digital group, however, benefitted students with lower prior knowledge (Malva et al., 2026). The current study could provide explanation as teachers in the digital group recognized several aspects that are beneficial in digital materials: “It was very

useful, they checked their answers themselves and I could better monitor how far are they". In terms of motivation, one teacher pointed out the advantage of typing instead of handwriting, which resulted in more practice repetitions compared to regular pen-and-paper materials. In future, the application of responsible AI could be applied to further explore changes in knowledge and motivation (Hooshyar et al., 2025).

5. Conclusions

The study explored the use of differentiated materials in 8th grade mathematics, focusing on how their format shapes teaching practices and students' learning. In conclusion, teachers experienced the opportunity to use differentiated materials as something positive that does not require them to change their teaching methods too much. Teachers found the materials to be useful for all students and in all stages of learning, only with the difference of when and what to use. The use of differentiated materials did bring some differentiation in the process and product in addition to content, however, differentiating the learning environment was perceived rather difficult. This shows that the elements of differentiated instruction affect each other and therefore limit empirical studies by not allowing the researchers to provide evidence per element, as also suggested by Smale-Jacobse et al. (2019). While the perceptions of teachers were not different in regards to when and how to use the materials, a difference appeared within students' motivation and knowledge – paper group reported more positive changes in motivation, while digital group recognized changes in students' knowledge. In conclusion, differentiated materials can be effectively integrated into whole-class instruction while not causing extra workload or major changes to teachers' regular practice.

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