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Mini-quiz as a teaching model to support adult learners in their mathematics studies

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Abstract

Teachers from Municipality Adult Education (MAE) have identified a need for hands-on teaching models supporting students in organising their studies, strengthening their self-regulation, and determining whether they are on track with the mathematical content taught. In this action research project, a team of researchers and experienced teachers in MAE explore a teaching model called mini-quiz. The model contains weekly automatically corrected digital multiple-choice quizzes with immediate feedback. Through semi-structured interviews with 30 students, mini-quiz was evaluated by examining students' views on its use. The analysis, following thematic analysis, identified three main themes: Support for monitoring and evaluation, Support for planning, and Support for responsive teaching. The findings suggest that mini-quizzes increase students' self-efficacy, help them confirm their understanding and plan their studies. Mini-quizzes also provide teachers with valuable insights to adapt their teaching at

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individual and group levels early, a factor important in complex educational settings like MAE.

Keywords: adult education, mathematics, action research, retrieval practise, self-efficacy

Introduction

Many adults in Sweden, as well as in other countries, need to study mathematics at the upper-secondary level to meet formal requirements for higher education (Ashcraft & Krause, 2007; Dahlberg, 2021). However, the dropout and failure rates are high. In 2024, 30 % of the 26,000 adult students in Sweden who took the mathematics courses required for formal admission to, for example, nursing and teacher education, achieved a passing grade (Swedish National Agency for Education [SNAE], 2025a). This indicates a need for refining or developing new teaching models (Pettersson & Liljekvist, 2023).

The study is situated in mathematics courses at Municipality Adult Education (MAE) in Sweden and is conducted by a research team of researchers and experienced teachers in MAE. In line with Ruthven and Goodchild (2015), the overarching goal is to use proven experience and scholarly knowledge to systematically improve teaching to help students succeed in their mathematics studies. Research related to practice in adult mathematics education is scarce. In a comprehensive review of over 2,300 publications, Gal (2024) identified only 39 empirical studies, of which merely seven were directly connected to educational practice.

The teachers in the research team have identified a need for teaching models to help students recognise the pace they need to keep, as well as whether they are 'on track' in relation to the mathematical content taught; that is, to identify students' progress, provide formative assessment, and keep track of whether the students are actively studying (i.e., according to 'the three-week rule'; no activity in three weeks discharges a student from the course (SFS 2011:1108, 7 Chapter 1 §)). In the Swedish steering documents, it is stipulated that the education must be flexible regarding, for instance, pace, on-site, online or hybrid mode, and when students may start the course (SFS 2011:1108). Hence, teaching models must also have the potential to reach beyond an educational setting where teachers and students meet in a classroom at the same place and time, engaging in the same thing. Further, many adult students bring negative experiences from their previous mathematics studies (Reilly et al., 2025), and they often lack good study habits and need support in structuring their studies (Andersson et al., 2023). Therefore, the development of teaching models that also support students' study techniques and help them improve their learning strategies is important.

An intrinsic goal of learning mathematics is to solve mathematical problems. To achieve this, students need to develop several competencies, including reasoning and communicating in, with, and about mathematics (Niss & Højgaard, 2019). This includes developing some basic mathematical skills. At the upper secondary level, this can involve simplifying expressions and solving quadratic equations. According to our experience, building such knowledge is an important step in the learning processes of MAE students and supports their self-confidence in mathematics. Mastering basic facts and skills frees up working memory for more complex tasks (Sweller, 2011).

It is well known from cognitive science that testing (compared with for example, rereading or concept mapping) advances the students' possibilities to retrieve information

from their memory (Perry et al., 2021; Roediger & Karpicke, 2006). Supporting study habits incorporating 'the act of accessing information from memory' (Roediger & Abel, 2022, p. 1) is suggested as a productive component in teaching. In diverse study groups, such as those in MAE, some students may possess scattered prior knowledge and lack effective study habits. Regular quizzes with immediate feedback have shown positive effects at college level when classes contain students with different levels of prior knowledge (Pennebaker et al., 2013) and testing students frequently may boost achievement independent of educational level (Roediger & Abel, 2022). In summary, there are promising results from cognitive science regarding connections between teaching and learning. However, there is a need to investigate further how teaching models using retrieval practice-based learning can be utilised to improve practice in mathematics education in MAE.

Taking an action research approach

Action research is useful when investigating and developing new teaching models based on teacher-defined problems (Mertler, 2024; Rönnerman, 2012). Findings from action research focus on developing everyday practice, acknowledging the importance of contexts for practice (Cohen et al., 2000), for instance, to enhance teaching and studying practices (Bergmark & Graeske, 2022; Pettersson & Liljekvist, 2023). Action research is cyclic in its nature, and contains processes of planning, acting, observing, and reflecting 'more carefully, more systematically and more rigorously than [the participant] usually does in everyday life' (Kemmis & McTaggart, 1992, p. 10), and can function as a strategy to develop teaching practices and enhance learning in a MAE context (Krogh, 2001; Ngwenya et al., 2021).

Given the problem stated by the teachers in the research team and based on relevant findings from education research and cognitive science, we use action research to investigate how a specific action: *a teaching model containing automatically corrected multiple-choice quizzes*, providing learners with immediate feedback and teachers with overviews on individual and group level. We call the action *mini-quiz*. It is a short, weekly recurring intervention in the MAE students' studying process that covers delimited mathematical content. The long-term objective is to advance teaching practice to better support students' self-regulation and mathematical self-efficacy.

Several studies have shown that collaboration and teamwork are important aspects of action research (Lambirth et al., 2019; Madsen et al., 2020). Our team has worked together throughout the study, formulating the problem, doing the action, analysing data, and writing this article. To guide our action research, we formulated the following research questions:

- *What aspects of studying mathematics do mini-quizzes support?* Here we focus on the MAE students' views on how the model may help them structure their studies, understand (and cope with) the study pace, and if, and how, the model helps them realise what subject matter they need to review.
- Do mini-quizzes have the potential to support a more productive disposition toward mathematics and a higher perceived competence among MAE students? Here, we focus on the students' views on whether, and how, the model has changed their views towards both themselves as mathematics learners and mathematics itself.

We limited our study by focusing on mathematical content relating to students' basic skills after they have studied a specific topic. By testing a new teaching model and reflecting on its outcome, we seek to contribute to the scholarly knowledge from *within* MAE. Through semi-structured interviews, we evaluate mini-quiz by examining students' views on using it.

In order to apply action research methodology, we planned the action based on results from previous cycles (see Pettersson & Liljekvist, 2023) and studied relevant literature. We performed the action in five different educational settings. Cycles of observing-reflecting were conducted. *During* the action, we had recurring meetings to discuss how the action unfolded in practice, shared experiences, and adjusted quizzes. *After* the action, we conducted interviews with students, analysed, reflected upon the outcome, documented, and shared findings in this article.

In the following, we first present relevant literature on which we have based the action. Thereafter, we describe the context of the study, the methods used, and the analysis procedure. Finally, we present and discuss our findings.

Relevant literature and theoretical framing

Self-regulated learning and self-efficacy from an adult learner perspective

Adult students face different circumstances compared to younger learners. This primarily concerns the challenge of balancing external factors, such as finances and family responsibilities, with internal factors, such as motivation, to pursue further education and coping with the organisation of MAE itself (Assarsson & Zackrisson, 2005). There is often less teacher contact in MAE than in other schools, especially as many students study online (Fejes et al., 2020). Continuous intake, low attendance, and a strong, often instrumental focus on individual studies shape MAE as an educational setting with limited opportunities for collective learning (Fejes et al., 2018). This means that MAE students need to be more self-driven and audit their learning themselves. They must actively plan, monitor, and evaluate their learning to achieve the specific learning goals, and they need to be both proactive and reflective when working on educational tasks. This process is described by Zimmerman (2011) as *self-regulated learning*; that is, to be metacognitively, motivationally, and behaviourally active in one's learning process.

Research shows that it is fruitful to support self-regulated learning (Hattie & Timperley, 2007; Safford-Ramus et al., 2016; Wiliam, 2015). For example, if a mathematics course contains teaching models that support proactive and reflective practices, Zimmerman et al. (2011) found that students more often develop a productive disposition, viewing test results not as an endpoint but as opportunities to learn more. In Bandura's (1986) terms, it is a matter of activating cyclical processes of observing, judging, and reacting upon the possibilities given in the educational context, reaching for insights on what needs to be done. Student behaviour is context dependent and relies on reciprocal interactions, where learning is shaped through the dynamic interactions between personal factors (such as perceived self-efficacy), behaviour (such as engagement and planning), and the environment (such as feedback practices) (Bandura, 1986; Schunk & DiBenedetto, 2020).

A student's level of self-efficacy, that is, her beliefs about what she can do when it comes to a class of tasks, affects the student's degree of self-regulation (Schunk & DiBenedetto, 2020). Students form their beliefs as they consider the number and patterns

of success, task difficulty and what effort needed, and available support from peers and teachers. Self-efficacy is highly influenced by earlier experiences of 'doing well' and 'doing poorly' in similar situations. Since many MAE students have negative experiences of mathematics (Safford-Ramus, 2016; Pettersson & Liljekvist, 2023), teaching needs to include activities that encourage self-observation, self-judgement, and self-reflection to change students' beliefs of their ability, supporting experiences of 'doing well' (Safford-Ramus et al., 2016; Zimmerman et al., 2011).

Studying processes in which retrieval practice occurs enhances retention of the current learning object (Pennebaker et al., 2013; Perry et al., 2021; Roediger & Karpicke, 2006). This is in the literature termed the testing effect; that is, information retrieved from memory leads to better outcomes on later tests (Roediger & Abel, 2022). Students taking quizzes receive tools to activate self-regulating processes, assessing what they know and what they need to work more on. Hence, students can nuance their experiences of 'doing poorly' and may look upon it as a learning opportunity where the environment (the quiz) supports a behaviour concentrating their study efforts on deficient knowledge with the potential to (re)build their self-efficacy.

Responsive teaching and formative feedback from teachers' perspective

It is a reciprocal relationship between self-efficacy and academic performance (Talsma et al., 2018). When deciding which teaching method to use in a particular situation, teachers need to consider its effects both on students' self-efficacy and learning. For adults, Talsma et al. (2018) found that self-efficacy and performance are linked in a way that makes it meaningful to target self-efficacy directly, while also providing opportunities to cope with ordinary educational tasks. However, it is not guaranteed that a method promotes both learning and self-efficacy; for example, helping students to extensively support learning may promote their learning in class, but not their ability to perform well on their own later on (Jonsson et al., 2014).

When teachers' reflections are grounded in their subject didactic[2] knowledge and take their starting point in how students' knowledge develops and recurrently pay attention to how exercises and activities in lessons contribute to learning, it is favourable for students' development of knowledge (Hirsh & Lindberg, 2015). This aligns with students' perspective on high-quality MAE teaching (Andersson and Muhrman, 2024); It is a matter of handling both students' need for flexibility in their day-to-day lives, having high levels of interaction and support, and providing different kinds of feedback.

Teaching practices that focus on students' learning and shaping their learning opportunities can be described as formative (Hirsh, 2017). Hattie and Timperley (2007) show that formative teaching is a strong explanatory factor for student achievement. However, there will not be such great effects if the formative elements in the teaching are not well adapted to the current situation (Black & Wiliam, 1998; Hattie & Timperley, 2007). The teaching needs to include relevant responsive strategies. Such strategies are driven by teachers' reflection on the interaction between students and subject content, which Kansanen and Meri (1999) call the didactic relationship, to assess how well the teaching aligns with students' learning processes. Reflecting on the didactic relationship provides a practice focusing on both *what* and *how* in teaching (Hudson, 2016).

The context of the study

Overview of the Swedish MAE context

Municipal Adult Education (MAE) in Sweden[1] enables adults to study at the compulsory and upper secondary levels, offering a wide range of general subjects as well as vocational courses. Education is free of charge and individually adapted. When teaching in MAE in Sweden, teachers meet students with different backgrounds (Andersson & Muhrman, 2024). According to SNAE (2025b), 35% of the students study online, and many of them combine work and studies. There is also a demand for continuous enrolment with flexible start and varying course lengths. This means that in an MAE classroom, there may be a mix of students taking different courses with different lengths. Taken together, this means that groups may vary over time, which can make it hard to arrange groups studying the same course simultaneously (Fejes et al., 2018).

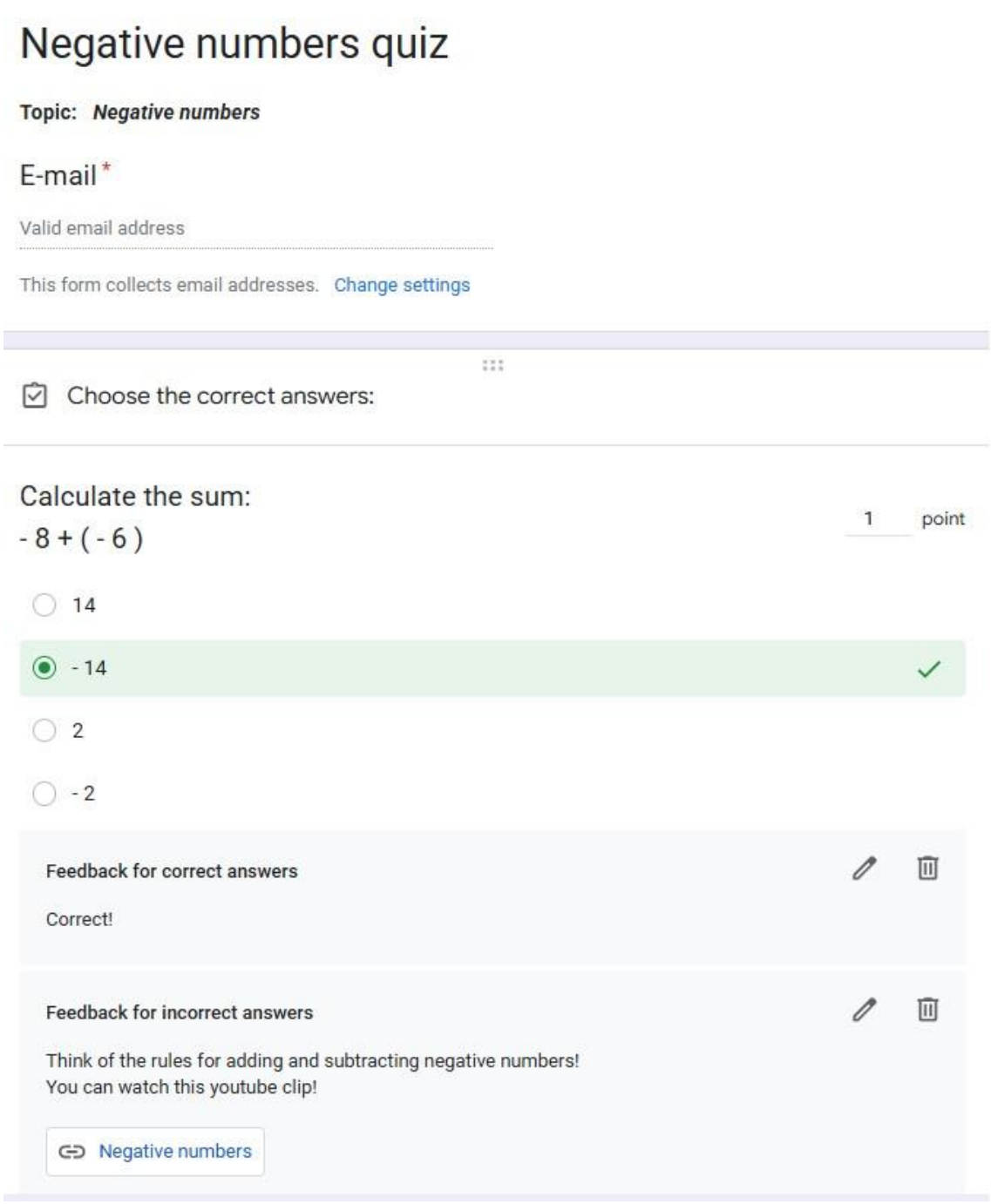
Description of the mini-quizzes

Mini-quizzes are used with on-site and online students. Teachers in the team use them differently in time and place, either immediately after a lesson (Miftari) or later online (Pettersson, Eliasson, Harsanyine, Lindqvist).

Mini-quizzes are designed to test a specific mathematical topic that students have studied during a part of the course and are aligned with the intended learning goals. From the students' perspective, the aim of the quizzes is to help them recognise the pace of the course and give an indication of whether they are on the right track in their learning trajectory. From the teachers' perspective, the quizzes are a tool to supervise students' activity (the 'three-week rule'), and a tool for formative teaching, that is, for making decisions on what to do next; focus more on a specific content during a lesson; give individual feedback and so on.

The quizzes are made in Google Forms with five questions and four alternative answers specifically chosen to reveal common misconceptions. The format follows so-called *hinge questions* (Wiliam, 2015). Figure 1 shows an example of a question used by the teachers. Positive feedback for a correct answer is given as 'well done' or a similar encouraging remark, while feedback for an incorrect answer is provided in the form of a video or a written hint. From Google Forms, the teachers can generate an overview showing results at the student and group level. The focus of this study is on mini-quizzes as a teaching model; we have not analysed the content of specific quizzes. We all operated within the Google environment, so the quizzes were distributed to the students via Google Classroom.

Figure 1. Example of a mini-quiz (Source: authors)



Educational settings for the students using mini-quizzes in the study

Each Municipal school authority decides upon the organisational terms of MAE, so there is a wide diversity in when and how students meet mathematics in their courses. In our research team, some teach on-site, some online, and some teach on-site and online simultaneously in what we call hybrid learning (Table 1). We have chosen the word *lesson* for a session where the teacher and a group of students are simultaneously engaged in a specific course. Typical activities are lectures, group activities, and discussions. We also have Q&A sessions. This is an in-school activity, and the students participating in Q&As come from different courses. The students are working individually with their course

material, and the teacher answers questions raised by individual students. Outside these sessions, email correspondence and spontaneous meetings between teacher and student occur.

Table 1. Overview of the diversity of educational settings in the study

	On-site	**Online**	**Hybrid**	**Course length (weeks)**	**Teacher-led sessions (weekly)**
Pettersson	Day	Yes	Yes	20	2 x 80 min lessons and 2 x 80 min Q&A sessions
Eliasson	Day/ Evening	Yes	No	10/20	8 h Q&A sessions
Harsanyine	Day	Yes	No	10*/20	2 x 90 min lessons and 2 x 90 min Q&A sessions
Lindkvist	Day	Yes	No	10	8 h lessons 5 h Q&A sessions
Miftari	Day/ Evening	No	Yes	20	3 x 2,5 h lessons (day) 2 x 2,5 h lessons (evenings) (Students can follow both tracks if they want)

* online courses

Data generation

Participants

The study participants are 34 students who volunteered in response to a call directed at approximately 100 students enrolled in relevant courses. Students with passing grades, non-passing grades, different gender identities, native speakers, and non-native speakers, of various ages, and from all five schools participated. As this is an action research project, where the teachers are authors of this paper and the schools are easy to track, we will not describe the individual participants in further detail. In this study, the voices of the participants rather become a choir telling a story about using mini-quizzes in MAE mathematics courses.

Interview guide

In this study, we evaluated mini-quiz by examining students' views on using it, and we used interviews as a method for data generation. The interview guide was semi-structured and included fixed questions and some follow-up questions. The items in the interview guide aimed to find out how the students experienced using mini-quiz, and if and how it helped them in their MAE studies. We also wanted to know whether they had noticed if

and how the teacher had used the quizzes. The main question was formulated as follows: 'Now that you have had the opportunity to use mini-quizzes as part of the teaching in the mathematics course. Can you tell us about your experience with this approach?' Depending on the answer, we used follow-up questions like: 'In what way did they [the mini-quizzes] help you? How did you use the provided feedback? Have you noticed that your teacher has seen your results?'

Transcription

The interviews were held in Swedish and transcribed verbatim. The excerpts used in this article are translated into English by the authors in a way that students' language difficulties or other kinds of differences, such as social markers, cannot be traced.

To perform the transcription, audio files were sent to Amberscript, which uses artificial intelligence to transform audio into text. However, since automated transcription can sometimes be inaccurate, the text was reviewed and edited manually to correct errors and omissions. The procedure has been approved by Sunet (a Swedish university network for research and education). The data generated is not stored by Amberscript or any third party, only on the researchers' storage to protect the confidentiality and privacy of study participants, and to comply with data protection regulations.

Ethical considerations

To conduct the study in accordance with ethical guidelines, considerations of doing research in one's own practice, and using interviews with students as a method, were discussed within the research team and at seminars where the study design was scrutinised. Collected data from the students is used with informed consent. The interviews were conducted after the students had received their grades. The first eight interviews were conducted by Liljekvist, and the rest by Pettersson. Pettersson attended all interviews. The study's design and how data is generated and managed have been reviewed according to the ethical guidelines at Karlstad University.

Analysis procedure

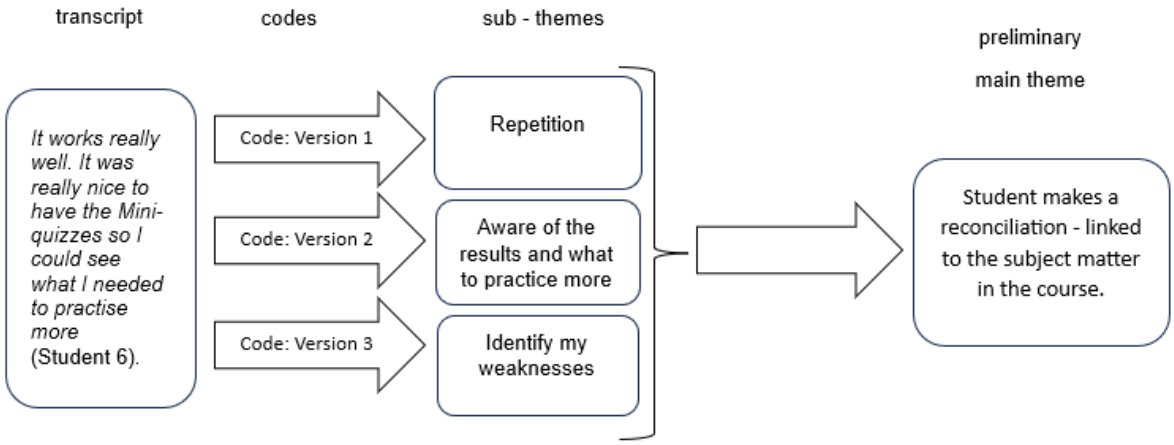
In the first step, the transcripts were read through by authors Pettersson and Liljekvist. All sequences concerning mini-quizzes were collected in an Excel file. The data set comprised 99 excerpts.

All team members met in a physical two-day meeting and worked according to the first three of the six steps of thematic analysis (Braun & Clarke, 2006) to uncover sub-themes in the data.

As a first step, each team member made a preliminary thematic coding of the dataset. We then continued to code the material in pairs, resulting in three different coding versions with different labels of the sub-themes. Pettersson and Liljekvist compiled the sub-themes and checked for consensus. As for 72% of the excerpts, the coding was equal or close to equal. For example, one student answered the question of how to use mini-quiz: 'It worked really well; it was really nice to have the mini-quizzes to see what I needed to practice more'. The pairs labelled the excerpt differently, pinpointing the same aspects: (1) Repetition, (2) awareness of the results and what to practice more, and (3) identifying my weaknesses. After a joint discussion, this became a preliminary main

theme, labelled: Student makes a reconciliation, linked to the subject matter in the course (Figure 2).

Figure 1. Process from transcript to preliminary main theme (Source: authors)



Finally, the team met in a digital meeting and worked through all 99 excerpts one more time. After this meeting, we agreed upon nine sub-themes, from which three main themes were derived (see Table 2).

Table 2. Overview of sub-themes, main themes, and description

Sub-theme	**Main themes**	**Description**
Identifying my weaknesses Have I kept up? The student makes a reconciliation – linked to a supposed subject matter knowledge. The student explicitly relates mini-quizzes to their learning. To learn from their mistakes. Repetition.	Support for: Monitoring and evaluation.	How the quizzes served as checkpoints for students to assess their progress in keeping up with course content and learning goals. Students explicitly linked the mini-quizzes to their learning, using them to identify mistakes and determine areas requiring further practice.
Inner and outer driving forces support planning, initiating, and completing. The structure (recurrent) and the format (of the mini-quiz) support the student (feedback) on their progress. Structure and content of the test environment.	Support for: Planning.	How the structure, format, and content of the quizzes supported inner and outer driving forces and supported students planning how the quizzes affected the students' studying technique.
Results are used to follow up and adapt the teaching.	Support for: Responsive teaching.	Students' views on how their teacher used the results from the quizzes in their teaching.

Findings

In the interviews, the students shared their views about how they perceived using mini-quizzes. The first theme: *Support for monitoring and evaluation*, shows that the quizzes provided a checkpoint for students, whether they had kept up with the course content and pace in alignment with the intended learning goals. The students related the mini-quizzes to their learning (explicitly), both in terms of learning from one's mistakes and identifying areas that need more practice. In the second theme: *Support for planning*, students' views of how the design of the quizzes affected their choices in upcoming work, and how it influenced their study technique, are displayed. The students discuss the recurring nature and the importance of getting immediate feedback. Finally, in the third theme: *Support for responsive teaching*, we find the students' reflections on how their teacher used mini-quizzes as a tool for following up and adapting their teaching to the results of the mini-quizzes.

Support for monitoring and evaluation

The mini-quizzes allowed students to confirm whether they had sufficient knowledge regarding specific mathematical content, actively monitor their learning progress, and identify areas requiring further attention. This approach was used either after studying a specific content, as demonstrated by Student 9: 'Yeah, they were good to see so that I, yeah, if I [...] so that I understood something. I saw really clearly what I needed to study more' (Student 9), or before studying, as shown by Student 15:

> Yeah, but if, let's say, I haven't done the calculations and just do the mini-quizzes, then I can see where, like, it's exponents that I don't know. Then I can go back and spend extra time on that, or I can see, oh, I'm really good at this statistics part, so I don't need to focus on that as much. (Student 15)

Students expressed that mini-quizzes helped them confirm their understanding, and they talked about how it helped them keep up with the pace in the course. Completing a quiz could also give a feeling of being finished with a certain assignment:

> Cause I've still tried to study only Monday to Friday, so I get the weekend to be with my family. I've sent in all the mini-quizzes on Friday evening. [...]. And that's because I want a break [...]. But I'm gonna do five assignments next week, yeah, then I can take time off already on Wednesday, then I'm done. (Student 6)

Moreover, immediate feedback is important as it provides students with information about their progress. As one student noted:

> I really like that you get immediate feedback. So, I think it has increased my confidence in mathematics. And with increased confidence, it's also easier for me to find it more enjoyable. [...] It has also made me realise that these more complicated things, I do actually understand. (Student 19)

The student compared the current course structure to previous experiences studying an earlier mathematics course, explaining: 'In that course, we did not have frequent automatic feedback right after completing quizzes, so I felt like it was less structured. I didn't have the same control over what I knew or didn't know' (Student 19).

The fact that the quizzes offered an alternative way to engage with the subject affected how students evaluated their study strategies. They were triggered to think

differently when working with the quizzes. It also seemed that the format, compared with the textbook, encouraged deeper reflection on their answers: 'When working with the quizzes, you are trying to calculate and understand simultaneously. If I had only been using the math book, I would have simply checked the answer key to see what it should be' (Student 6). 'If an answer is incorrect, it is sometimes possible to figure out the mistake, like a missed sign' (Student 25).

Overall, the structure of the quizzes seems to encourage students to engage with the mathematical content more thoughtfully and actively. The quizzes are low-stakes, aiming to provide a safe space for practice without the pressure of formal assessments. However, the quizzes seem to build up some pressure, as a poor result may negatively impact self-efficacy. There is a sense of pressure to achieve a good result:

> Sometimes it happened that I got a lot of wrong answers because I had missed something. And then it was like, 'Oh,' and I felt a bit like: Damn, I don't know anything. Sometimes I was a bit scared to do the mini-quizzes because there was a chapter, I found difficult, and I didn't want to disappoint [the teacher]. (Student 20)

Support for planning

The students talk about how the mini-quizzes affect their planning of the course. The fact that mini-quizzes are scheduled and recurring supports students' discipline, and the structure helps them organise their studying. They felt a need to complete the quizzes when they had an assignment to submit. Student 3 said, 'It gave me discipline, when you have a submission, you just have to do it', or as another student more bluntly put it: 'Mini-quizzes kick you in the butt to do the work. I find it frustrating to leave them undone. If you have a deadline, you must complete it' (Student 15).

The structure of the feedback seems to help students. They planned what to study based on incorrect answers on their quizzes and used both the immediate feedback and the attached written feedback. They returned to the textbook to look up similar tasks and explanations or watched the feedback video to learn more: 'If you answer incorrectly, you see the correct answer. And then, you often have feedback on a video, which is also very helpful' (Student 25). 'If you don't know something, you get, like, tips in the mini-quiz about what you should practice more or look up' (Student 30).

The accessibility of the feedback was important: 'You could see on the mini-quiz that your answer was wrong, and you could see the correct answer. [The extra material] was easy to find; you just had to click, and the video feedback helped a lot' (Student 25).

However, not all students liked that some of the feedback pointed back to material already used and proposed new videos instead.

We noticed that the immediacy of feedback is important. In one school, we tried some quizzes that did not provide immediate feedback because the teacher wanted to include open-ended questions that required manual grading and therefore delayed the feedback. One of the students specifically reflected on this, stating: 'On three or four quizzes, I couldn't see which ones were correct or incorrect. I was curious, was it right or wrong?' (Student 23).

The feedback was also helpful for students who could not attend the lessons. This student combined work and studies and could therefore not attend lessons that often: 'It helped me a lot because I didn't have that many lessons, so it was good that I got tips and help from [the feedback video]' (Student 32).

Overall, mini-quizzes seem to support students' planning and study habits. However, there are still challenges to handle, as some students have stopped doing the quizzes regularly. We could detect two types of reasons for not doing the quizzes. First, we could

see students relate to a high workload: 'I haven't completed every single mini-quiz because I have two other courses at the same time. So, I just haven't had the time to do absolutely everything' (Student 18).

Second, not all students were helped in the long run to structure their studying and change their study habits:

> I did them a lot in the beginning [when the teacher posted them]. But then I kind of fell off a bit when it came to doing the mini-quizzes. I don't know why. There's no reason for it; it just happened. I think I just forgot about them a little. (Student 13)

Some students offered suggestions for improving the mini-quizzes and their usage. One student proposed allowing the tests to be reopened so they could be completed multiple times (Student 19). Other suggestions for improvement focused on individualising the quizzes to match each student's skill level and specific content needs (Student 29) or adjusting submission timelines to help reduce stress (Student 26).

Support for responsive teaching

When the students reflected on how the mini-quizzes affected the teaching, they described how teachers used the results from mini-quizzes to check if students were keeping up with the course pace and to decide how to adjust their teaching, reshaping learning opportunities both on the individual and group level.

Student 19 describes her experience of how the teacher used the quizzes:

> [The teacher] said from the start that since half the class was studying from home and half the class was attending in person, [the teacher] was very clear that [the teacher] uses those mini-quizzes to see if one is keeping up with the course or not. And if [the teacher] notices that someone is not keeping up, [the teacher] will call for a meeting and look at, like, how should we proceed? Does it still work for you to study from home, or do you need to come [to school] instead? And [the teacher] has followed up on that when we've met [the teacher] and said that it seems like it's working well for you. So, it's been a good kind of check-in thing, I think, both for myself, but I believe that [the teacher] has benefited greatly from it too. (Student 19)

From a student's perspective, the use of mini-quizzes seems to be an effective way for teachers to monitor each student's engagement and progress. The teacher could open up a discussion about whether online learning works for individual students or if they would benefit more from being on-site. The quizzes become a practical tool in both assessing and adjusting learning formats, according to each student's needs.

The quizzes were not merely used in alignment with the 'three-week rule' but also helped when supporting students' individual concerns with the mathematical content. For example, the results of some quizzes made a student use Q&A sessions to get support with the topics s/he found difficult:

> But the [mini-quizzes] I struggled with a bit more, [the teacher], offered some extra help and focused on exactly what I had more trouble with. That's why I attended those two sessions, because I gathered everything I found difficult, and [the teacher] sat with me and helped me specifically with those parts. (Student 33)

Students noticed that the results gave teachers information on whether a certain topic needed extra attention or not. If a quiz revealed that a group of students struggled with a certain mathematical content, the teacher revisited that topic in the upcoming lesson. When lessons were adapted based on the results of the quizzes, it was initiated either by

the teacher or by the students themselves: 'If there were any tasks that most people had struggled with, we went through them [...] And then we took an extra look at them, and [the teacher] explained how to solve them' (Student 27). 'On some occasions, we asked [the teacher] about a question on the quiz, and we solved it together' (Student 23).

In summary, the students experienced how the teachers adapt the teaching when using mini-quizzes, and thus perform a more responsive teaching practice.

Discussion

Findings from action research focus on developing everyday practice, acknowledging the importance of contexts for practice (Cohen et al., 2000). In this action research study, we have explored how a teaching model based on retrieval practice, in the form of mini-quizzes, may support adult learners in mathematics education within MAE. In this paper, we have presented the findings from the research phase in which we used the previously developed teaching model (mini-quiz) containing digital, automatically corrected multiple-choice quizzes with immediate feedback as an action in five different MAE settings. By examining students' views on using mini-quiz, we can construct a deeper understanding of the teaching model and its relevance for mathematics teaching in MAE.

The point of departure for this action research is that teaching models must work in relation to different aspects of teaching that are typical in MAE study groups and feasible for both teachers and students (cf. Bergmark & Graeske, 2022; Mertler, 2024). The purpose of taking an action research perspective is to advance the teaching practice, making use of craft knowledge and scholarly knowledge within the team. Ruthven and Goodchild (2015) advocate close cooperation between teachers and researchers to nurture their complementary knowledge domains. The teachers in the research team have pinpointed the need for teaching models supporting both students' self-regulated learning (e.g., keeping the pace, knowing what to do, and monitoring one's own learning) and their self-efficacy (e.g., nuance students' experiences of 'doing poorly' and rather looking upon test situations as formative learning opportunities).

The findings show that the model (mini-quiz) has the potential to help students structure their studies, understand (and cope with) the study pace, as well as help them realise what subject matter they need to review. When teaching practices support self-regulated learning by encouraging students to be metacognitively, motivationally, and behaviourally active in their own learning, they are more likely to develop a productive disposition (Zimmerman, 2011; Zimmerman et al., 2011). In such educational contexts, students have the opportunity to develop productive beliefs about what one can do when it comes to a class of tasks, which improve their self-efficacy (Bandura, 1986). We believe that a strength of the model lies in its ability to illustrate the pace required and the knowledge needed when completing even a small portion of the course. Our findings indicate that the model is particularly relevant in an MAE context, where the demand for self-regulated learning is high (Assarsson & Zackrisson, 2005; Fejes et al., 2020; Safford-Ramus et al., 2016). Since this is a situation not specific to the Swedish MAE (Gal, 2024; Ngwenya, 2021; Reilly et al., 2025), we believe the findings have explanatory power beyond the local context. However, there are still challenges to handle in relation to some of the students stopping doing the quizzes regularly. The findings suggest it either depends on a high workload overall, or that the model is not enough to change behaviour for some students. A working hypothesis for the coming action research cycles is to inquire if and how the stopped use of the quizzes is related to drop-out from courses.

The model is grounded in retrieval practice-based learning, that is, based on the idea that retrieval practice in the form of testing is an efficient way of learning (cf. Roediger

& Abel, 2022). Mini-quizzes support students' self-regulated learning by providing regular feedback; the model visualises and supports both students' self-observation and self-judgement. The fact that the quizzes are low-stakes and divided into small, content-specific sections, such as negative numbers or fractions, planned for a specific week, seems to make students less nervous about completing them and more likely to use them as a learning tool. Students also expressed that they experienced success, which, according to Talsma et al. (2018), can lead to behavioural change and increased self-efficacy. This is especially important in MAE, where students often have varied prior knowledge and low confidence in mathematics (Reilly et al., 2025; Safford-Ramus et al., 2016).

The triadic reciprocal causation between the environment, personal factors, and behaviour for student learning is well described (Bandura, 1986; Schunk & DiBenedetto, 2020). Since we base the model on retrieval practice-based learning (Roediger & Karpicke, 2006), it shapes both the teaching environment, the students' behaviour towards relevant mathematical content, and promotes a more productive disposition regarding one's own capacity. Hence, we argue that the model has the potential to alter a student's level of self-efficacy when it comes to a specific class of tasks, since we know from other studies (e.g., Talsma et al., 2018) that there is a reciprocal relationship between self-efficacy and academic performance.

The teachers in the research team have used the model in their own educational setting. These settings show a wide diversity in when and how students meet mathematics (see Table 1). Hence, the students' views on mini-quizzes originate from various study contexts. The design of the study indicates the model's usefulness, as it seems to support self-regulated learning and self-efficacy among adult learners in MAE across different educational settings. In all settings, the model allowed students to track their progress, identify knowledge gaps, and plan their studies. Moreover, mini-quizzes enable responsive teaching. The choice to use hinge-questions (Wiliam, 2015), where the incorrect options reflect common misconceptions, provides insights into students' thinking and supports lesson planning. Teachers receive information both at the individual level, identifying students who need support and at the group level, indicating how teaching may be adjusted. Such information is important for teachers, since teaching well adapted to the actual educational setting and responsive to students' learning processes has a strong explanatory factor for student achievement (Black & Wiliam, 1998; Hattie & Timperley, 2007). In line with formative teaching principles (Hattie & Timperley, 2007; Hirsh, 2017), the quiz results are not tied to grading but are used to support learning and teaching, aiming for a learning culture focused on progress rather than performance.

Implications for MAE teaching

Our study provides important insights about using mini-quizzes in MAE to support students' self-regulation and self-efficacy, as well as provide responsive teaching. We want to highlight two aspects:

- When using mini-quizzes, students can take a more active role and be more responsible for their studying, which is especially important for those with negative past experiences and high reliance on teacher guidance.
- By gaining an early and clearer understanding of students' progress, teachers can intervene timely at both the individual and group level, which is crucial in fast-

paced adult education. This proactive approach provides support and strengthens the teacher-student relationship.

Limitations and suggestions for further research

The results show that the model (mini-quiz) may be a valuable tool for supporting self-regulated learning and self-efficacy among adult learners in MAE, as well as a tool to enable teachers to adapt their teaching to the needs of the current student group. However, in this study, we have not measured the effect in terms of students' mathematical progress. Instead, we have let the voices of the students unfold the experiences using the model as a learning tool.

We need further studies to uncover under what conditions it is most valuable to conduct mini-quizzes in order to help all students use them regularly in a productive way. In a complex educational setting like MAE, where students have diverse backgrounds and study under varying conditions, mini-quizzes can only form *a part* of a broader support structure. In this study, the model (mini-quiz) is created to enhance students' basic mathematical skills, and not more complex competences such as problem solving or mathematical reasoning. To further improve MAE teaching and influence students' views of mathematics, complementary models and continued development are needed.

Notes

[1] For an extensive overview of MAE in Sweden, see Andersson and Muhrman (2024).

[2] In this article, we use the term *didactic* in the same way as in German, French, Spanish and Scandinavian languages, not the connotations attached to the term *didactical* in English.

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The authors declare no potential conflicts of interest with respect to the research, authorship or publication of this article.

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