"FRACTIONS MY WAY": HOW AN ADAPTIVE LEARNING ENVIRONMENT AFFECTS AND MOTIVATES STUDENTS

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An adaptive learning environment entitled "Fractions My Way" was developed and introduced to 206 fourth- and fifth-grade students who used it to study fractions over one academic year. Follow-up questionnaires and interviews (with students and teachers) revealed that the method enhanced their sense of ability, their responsibility toward their own learning, and their enjoyment in learning (leading to higher motivation). They claimed they learnt and understood the material better. Post-course assessment indicated an overall improvement in knowledge. Two drawbacks were mentioned: the stress associated with knowing the teacher was constantly monitoring performance and the sense of competition between peers.

INTRODUCTION

Attitudes to learning and how they affect student performance

Students' attitudes toward a subject can profoundly influence their achievements in that subjects (Awofala et al., 2014). This is especially true with mathematics given the widespread perception that mathematics is a difficult subject, the psychological fear often associated with it, and a profusion of poor teaching methods (Sezgin Memnum & Akkaya, 2012).

Socio-emotional learning refers to how learners regulate their emotions regarding thinking and self-management to achieve success in school (and in life) (Paolini, 2020). Recent research has shown that good socio-emotional skills lead students to better performance and can predict success in academia or careers (Gehlbach & Hough, 2018) and lead to consistent achievement in studies (Kanopka et al., 2020). As a result, many educational systems are looking for ways to improve students' socio-emotional learning.

The traditional teaching method does not always increase student motivation and achievement, especially when one teacher must stand in front of a heterogeneous class, relays the same material to all, tends to use the same teaching approach, and sets the pace of progress the same for all. Given the limits of human ability and time, it is difficult for that one teacher to take into account the personal needs of every student.

Multimedia can bring concepts to life through sight and sound. Students can receive instant feedback during their experience. A study examining the impact of multimedia showed that students exposed to multimedia during the learning process were more likely to be independent in their learning (Chipangura & Aldridge, 2019) and its use in

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mathematics can improve student engagement and motivation (Chapman & Wang, 2015).

Learning in the technological age: personalized teaching

There is currently an increase in the use of a digital tools and approaches based on artificial intelligence (AI) that can support the learner's experience based on personal needs, learning preferences, and abilities. Learning systems are becoming more developed and gaining momentum due to their ability to adapt to the individual needs and goals of students (Kabudi et al., 2021; Sampayo-Vargas et al., 2013). They are based on a model of the learning process from the students' point of view and analysis of data from previous users allows it to adapt itself and provide well-suited, high-quality learning material to the learner (Kurilovas et al., 2015). They simulate the knowledge and experience of a teacher to instantly judge situations and provide each student with personally tailored support or guidance (Xiao & Yi, 2020).

AI-enabled learning systems offer many advantages: an improved learning experience, flexibility time-wise and in managing the learning experience, and tailored progress (Hwang et al., 2020). They provide personalized automated support (Jadhav & Patil, 2021) and they offer content and questions, assign tasks, and provide clues, making learning smoother and more enjoyable. This will naturally lead to an improvement in the students' attitudes towards learning mathematics (Ma et al., 2014).

The adaptive learning environment: Fractions My Way

One such system is the Adaptive Learning Environment (ALE). This system creates a personal learning track adapted for the user, the aim being to monitor and maintain a state of maximum development. It can provide tasks based on each student's abilities and interests (Walkington, 2013). Research on such in the subject of mathematics indicates that it can greatly improve student performance (Cordova & Lepper, 1996).

The system is based on an computerized algorithmic “engine” model that uses statistical functions to adapt itself for each student and offer them a personal learning track appropriate to their knowledge, pace of learning, and abilities. In the case reported herein, an ALE entitled “Fractions My Way” (FMY) was developed in collaboration with Microsoft for the purpose of teaching fractions to fourth- and fifth-graders based on the requirements of the Ministry of Education.

Each student works on their own at a computer terminal, learning and practicing the subject matter through videos, exercises, enrichment tasks, quizzes, online assistance, and a digital “lab” for personal exploration. The engine determines the sequence of tasks needed to keep the pace of learning challenging and even what tasks can be “skipped.”

While the students are at the terminals, the teacher has access to a “dashboard” by which he or she can see a "performance breakdown" overview of the status of the class or each individual: the number of students working in each unit, their levels of success

in real time, overall class progress, what tasks seem to be difficult for some, quiz scores, etc.

Studies show that the adaptive learning system can significantly improve learning efficiency and student performance (Chen et al. 2020; Xie et al., 2019), and that they are effective in adapting to the knowledge and learning needs of individual students, thereby developing higher-order thinking skills in ways that even the most skilled teachers cannot (Wang et al., 2020; Voskoglou & Salem, 2020).

Study's purpose

The report presented herein is part of a broad, ongoing study to track the development and implementation of an ALE for teaching primary school mathematics. It specifically explores the attitudes of fourth- and fifth-graders learning fractions via the FMY ALE.

METHOD

Research question: How do fourth- and fifth-graders perceive the contribution that working in an ALE makes for them with respect to their ability in and enjoyment for learning fractions and mathematics?

Study population: 51 fourth- and 106 fifth-graders studying in the FMY ALE. Students spent approximately 1.5 hours a week (60 hours total over the year) in the ALE. The study also included the class mathematics teachers of each class (20) and a supervising teacher (ST).

Research and data analysis

Stage one: Observations. The supervising teacher (ST) carried out a total of 48 observations in classrooms in which the ALE was integrated and recorded the conduct of the lesson and their impressions in a journal: teacher's decisions based on observation of the dashboard, sitting alongside students working independently, responding to questions raised during the lesson, etc. In parallel, the teachers also observed and recorded their views of the lesson (in their journals).

Stage two: Questionnaires. The observations from the teachers' and ST's journals were used to produce an online "attitudes" questionnaire to be answered by all the participants. It included 17 closed questions (satisfaction in working in the ALE, differences between learning in the ALE and the traditional classroom, responsibility for learning, quality of learning, sense of ability, etc.) and two open questions ("What do you like?" "What would you change/add?"). The questionnaire was embedded in the task sequence in the ALE.

Stage three: In-depth interviews. These were conducted with two groups of three students each. The interviewees were chosen based on their progress such that each group comprised one "very," one "moderately," and one "poorly" successful student. Some of the questions repeated those in the questionnaire to enhance understanding of the answers. The answers were recorded and transcribed for analysis.

Analysis: Systematic content analysis was used for the answers to the open questions (from questionnaires and interviews). Answers were divided into "units of meaning" and sorted into “themes.” The number of students who indicated each theme in their answers was noted. In addition, the ST’s and teachers’ journals were scanned for statements supporting each theme.

FINDINGS

Three major themes emerged: a sense of ability, pleasure in learning, and responsibility for learning. Table 1 shows the number of students who mentioned these themes in answer to the open questions/interviews or who indicated their agreement in the closed questions to a great or very great extent. Table 2 presents some representative statements that emerged from the ST’s journals, teachers’ reports, and student interviews for each theme.

Table 1. Percentage of students who agreed to a “great” or “very great” extent to closed question statements (n=157).

	Statement	%
Sense of ability	The FMW ALE allowed me to learn and understand more about fractions than textbook learning. I worked better.	73
	I understand fractions better this way.	69
	I do better learning with FMW than with a textbook.	69
Respon-si bility	It is important to work in FMW according to the guidelines received from the teacher	78
	It is very important for me to try to answer the exercises on my own when working with the computer.	78
	I needed help when solving the exercises on the computer.*	12
in learning	The animation in FMW is engaging and fun.	80
	The possibility of skipping questions on the computer makes learning more enjoyable.	62
	I enjoyed learning about fractions with FMW than with the textbook.	83
	Computer learning is simpler, easier, and more convenient.	80

* During the in-depth interviews with the students, they noted that the help given to them in the FMY ALE was varied, significant, important, and helpful.

Table 2: Statements given by the participants for each theme.

Theme	Statements
Sense of ability	**ST's Journal** • I feel it is important to note that as we progress in the material, the students need less and less mediation and intervention. • Students who had difficulty sitting in class were able to sit in front of the adaptive for a long time and progress. **Teacher's reports** • I was able to instill in the students the ability to follow instructions. The path of minimal mediation proves itself. • The system provides a solution for all students, both advanced and those with difficulty. Every student works at their own pace and it's great. **Student interviews** • It's fun. It teaches more about fractions than the teacher. • On the computer it is also more convenient because if you are in class and you do not listen then you have no other way, in the "Fractions My Way" you have a video and if you have to, you can go back and watch it again.
Responsibility	**ST's Journal** • Many students use "test," not to try but for understanding. • I feel like it affects learning, most children are not embarrassed to ask for help and that may be why I feel progress in this class. **Teacher's reports** • This system has given them some kind of peace and they manage to manage on their own in the system. • Using a computer makes learning independent. They move at their own pace. **Student interviews** • If there is a video at that point I go and watch it again and then there is also some hints at the side that help. • In class (traditional learning) there is the teacher. If I can't or don't understand something, I can ask her, but on this computer it's me and the computer and that's it. The teacher is not always available and I try even if I do not know and not do "reveal the answer" (a possibility that exists after two attempts).
Enjoyment in learning	**ST's Journal** • I was very happy to see that the children love the system very much, and they are in a different and independent experience. • Students who have difficulty sitting still in class were able to sit with the adaptive environment for a long time and progress. **Teacher's reports** • The visual stimuli facilitated learning and contributed to the students and applied to all the children in the class, no matter what their level. • When I had to postpone a lesson, one of the students expressed disappointment that the "most loved and fun" class had been postponed. **Student interviews** • I love having videos and it's fun when the ghost jumps out [the feedback] that says, "well done you've succeeded in the mission." • It's really good [to learn with the adaptive environment], because if the teacher lets you work on the page you can't go to the next page until you finish it and here it also takes you in stages.

Drawbacks. Two main drawbacks emerged. The first was that some students felt stressed knowing that the teacher was tracking their actions. The second was the sense of competition that emerged between students that were demonstrated during breaks or after school regarding how "quickly" they were progressing through the ALE. However, this could also have a positive impact: "Competing with a friend about who gets to a milestone first, helped motivate me to work harder."

Although some students still felt the need for teacher support, the teachers claimed that this decreased as students became accustomed to studying in the system and became increasingly independent.

Overall, students reported that FMW ALE improved their understanding of fractions, made learning more enjoyable, gave them an increased sense of worth, improved their capabilities, and increased their sense of personal responsibility for their own learning. They continuously expressed that the method was "fun," which led to anticipation for the FMW classes. The pass rates of students on the tests and their grades increased.

DISCUSSION AND CONCLUSIONS

Increased interest and motivation are the cornerstones of effective personalized teaching (Potvin & Hasni, 2014). The ALE instituted here contributed greatly to increasing motivation by stimulating students who have difficulty learning traditionally. This corroborates studies that found the use of multimedia for learning mathematics purposes improves student engagement, interest, and motivation (Chapman & Wang, 2015).

The "skipping" effected by the ALE proved to be another advantage. This was based on each student's personal learning data, enabling each to learn according to their specific abilities. Students experienced the "skips" as positive feedback regarding their abilities, which encouraged learning. In fact, they make an effort to get them.

Regarding the concern students felt regarding the consistent monitoring of their actions by the teachers, it might be prudent to explain to them that the information transmitted to the teacher assists the process. Regarding competition, it would be important to address the issue of social responsibility and explain how competition may adversely affect students who are not so proficient in the subject (Kanopka et al., 2020).

In conclusion most students perceived learning in the ALE as instructive, efficient, understandable, enjoyable, and motivating. It promoted personal responsibility while adapting to their needs and seems to be a positive addition to the curriculum.

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