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The contribution of online mathematics games to algebra understanding in Grade 8

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This study explores how online mathematics games contribute to Grade 8 learners' understanding of basic principles and more sophisticated aspects of algebra. This project documents the trajectory of a purposive sample of 30 Grade 8 learners doing mathematics and one mathematics educator. The study is premised on the argument that learners with the guidance of the teacher can grasp algebraic concepts better and learn to manipulate these imaginatively and independently, by integrating new online mathematics games into standard classroom teaching of mathematics. The study was located within the interpretive qualitative research paradigm and used a case study approach. Data were collected by means of (1) lesson observations, (2) questionnaires and (3) semi-structured interviews. The data collected were analysed through the lens of the sociocultural theory, social constructivism and the activity theory. This study supports the view, set out in the literature reviewed, that the way in which resources are utilised can substantially improve the teaching and learning of algebraic concepts. Teachers should encourage learners to venture into the world of online mathematics games to learn algebra because they help learners to be creative, look for patterns, make conjectures, collect data, express their own thoughts, accept the ideas of others and establish structured forms of cooperation. The teacher's role is to show and guide the learners how to use online mathematics games to solve mathematics problems. This study's main recommendation, among others, is a revision of the curriculum to integrate online mathematics games into all subjects in classrooms at all levels.

Keywords: Online mathematics games; algebra; paradigm; pedagogy; curriculum; case study.

Introduction

As the result of complex historical, socio-economic and political factors, post-liberation South Africa presently is embroiled in a predicament in mathematics education, especially in algebra, which has resulted in the country positioned last in the Third International Mathematics and Science Study (Smith & Hardman, 2014, p. 22). The scenario points to a need for novel, more attractive and engaging methods for teaching and stimulating its learning. Learners who experience difficulties in grasping basic mathematics concepts often have poor prior knowledge in the subject. Learners who are introduced to online mathematics games often gain self-motivation and intense interest (McLaren, Mayer, Adams, & Forlizzi, 2017, p. 49).

Although algebra provides access to forthcoming studies and mathematically significant ideas, it often acts as a wall that blocks the path of many learners. As Drijvers (2003, p. 2) points out, the use of a formal algebraic system creates confusion to many learners who struggle to grasp the basic first steps and subsequently fail to later catch up.

Online mathematics games introduce learners to fundamental steps of learning where they easily attain knowledge without consciously sensing that they are being taught through gameplay guided by the teacher. An online mathematics game enables learners who would otherwise have given up to flourish in mathematics. The aim, therefore, is to assess how and why online mathematics games attract, educate, engage and stimulate learners to find out more about algebra. There is limited literature on how online mathematics games advance learners' understanding of algebra. Becker (2005, p. 2) corroborates that while the potential value of online mathematics games is high there is limited in-class research focusing on the use of online mathematics games, partly because of considerable resistance from more conservative educators. Most teachers demand proof of the effectiveness of online mathematics games as learning tools before attempting or adopting them in the classroom. To convince more teachers, it would be necessary to try online mathematics games through pedagogy – connecting elements of existing game designs with

accepted learning and instructional theories (Becker, 2005, p. 2). South Africa is currently having a crisis in mathematics education, especially in algebra, which has seen it amass a lower aggregate score (379) compared to Asian countries in the Third International Mathematics and Science Study (2019). Given the potential benefits of online mathematics games to mathematics education nationally, including stimulating learners' interest in the subject, placing this new technology in schools could arrest the deepening crisis in an affordable, democratic and timeous manner. Additionally, this will enable shifts in pedagogical practices and potentially benefit learners' learning.

This study, therefore, aims to investigate how online mathematics games help Grade 8 mathematics learners understand algebra. Many authors argue that algebra teaching in South Africa could be improved by providing suitable and well-designed online mathematics games that address learners' weaknesses in algebraic concepts (Jupri & Drijvers, 2016, p. 2). The research question guiding this study is: How do online mathematics games contribute to algebra understanding in Grade 8? In order to answer this general research question, the study asked the following sub-questions: (1) What aspects of Grade 8 algebra are improved through learners' exposure to online mathematics games? (2) How does an online mathematics game contribute to learners' understanding of algebra in Grade 8?

Literature overview and conceptual framework

There is substantial evidence in the literature on the advantages of online mathematics games for teaching mathematics (Barkatsas, Kasimatis, & Gialamas, 2009; BECTA, 2001; Bokhove & Drijvers, 2012; Drijvers, 2003; Jupri & Drijvers, 2016; Van Ameron, 2003). Learners live in a world experiencing the 4th Industrial Revolution where online mathematics games expose them to electronic information at a more rapid pace than when educators teach them. In that regard, the use of online mathematics games is a shift from the traditional instruction model of knowledge to an autonomous, active and collaborative learning process through learners' engagement (Paraskeva, Mysirlaki, & Papagianni, 2010, p. 499).

Online mathematics games

Wiersum (2012, p. 24) defines online mathematics games as activities that are (1) governed by rules, (2) have a clear underlying structure and (3) show specific mathematics cognitive objectives. The proponents of technology use in mathematics teaching point to studies that indicate that computers and calculators can support and enhance problem-solving environments. Computers can decrease the amount of time required to master skills, allowing for more time to be spent on developing conceptual understanding (Hardman, 2005, p. 1). By using online mathematics games, teachers would create a rich concrete learning environment as it is believed that we understand better where visuals are included. The use of online mathematics games is effective only when the games are used to encourage learners to think and make connections between objects and an abstract mathematics idea (Murray, 2001, p. 28). Focus should be on ensuring that learners are fully engaged mentally rather than seeing it as just a game.

Previous research on online mathematics games

Zoltan Dienes's work (1969 cited in Moyer, 2001, p. 177) convinced researchers that the use of 'multiple embodiments' was needed to support learners' understanding. Online mathematics games have been proposed as a potential learning tool by both educational researchers (Barab, Thomas, Dodge, Carteaux, & Tuzun, 2005; Gee, 2003; Squire, 2003) and online mathematics games developers (Adrich, 2004; Prensky, 2001). These scholars have argued that using online mathematics games in education invoked intense engagement in learners. They also argue that active learning is encouraged among the learners (Garris, Ahlers, & Driskell, 2002). For Ricci, Salas and Cannon-Bowers (1996), there is empirical evidence that online mathematics games may be effective tools for enhancing learning and understanding of complex subject matter.

On the other hand, other scholars such as Mahmoudi, Koushafar, Saribagloo and Pashavi (2015, p. 423) argue that there is no clear causal relationship between academic performance and use of online mathematics games. Their view is that there is a lack of an empirically grounded framework for integrating online mathematics games into the classroom (Mahmoudi et al., 2015, p. 423).

This study used two online games, namely Dragon Box Algebra and Algebra Meltdown. With Dragon Box, algebra concepts are simplified into a simple game and it is an innovative educational game that through gameplay teaches learners concepts relating to solving algebraic equations. Dragon Box covers the following algebra concepts: addition, multiplication and division. By controlling cards and attempting to confine the Dragon Box on the other of the online game, the learner progressively learns the tasks required to confine x on the other side of the linear equation. When playing the online game, the cards transform into variables and mathematics symbols. As learners progress through the levels, they earn dragons. Algebra Meltdown is an online mathematics game that can be used to solve linear equations. In this online game, learners unravel linear conditions by controlling them through the reactor. The game teaches learners to understand linear equations by using the number machine concept.

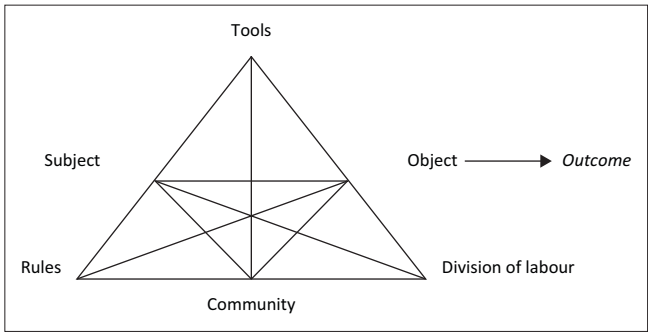
These online mathematics games were designed to reinforce algebraic concepts. They are both intuitive and engaging and contain fun elements. Learners develop skills to solve equations in a playful and colourful game environment, where they are encouraged to experiment and be creative (Pearce, 2013).

Theoretical framework

In order to have in-depth information on whether online mathematics games contribute to learners' understanding of algebra, the study used the following theories: activity theory, socio-constructivism theory and sociocultural theory. These theories are relevant and help us comprehend the development of learners' understanding in the process of learning mathematics. In addition, the chosen theories agree on the notion that knowledge is inseparable from practice. Learners understand better by doing and mediating through tools and signs.

The activity theory views the human mind as the product of our interaction with other people, objects and artefacts in the context of everyday activity (Kaptelinin & Nardi, 2006, p. 345). Moyer (2001, p. 176) postulates that the abstract thinking processes of learners are closely anchored in their concrete perceptions of the world. The point is that the active use of online mathematical games allows learners to develop a repertoire of images that can be used in the mental manipulation of abstract concepts.

Engestrom (1987) used the model shown in Figure 1 to explain how a wide range of factors work together to create an activity. Activity theory can form a solid basis for developing online mathematics games that create concerted learning conditions, for example networks of practices, where mathematics learners cooperate with different subjects, articles and instruments of the online mathematics game, under stated guidelines, and make networks through division of labour. When learning algebra, the subjects used artefacts or instruments such as the Dragon Box online mathematics game. In the process, the learners were required to follow the rules for Algebra Meltdown and Dragon Box to understand algebra. Dragon Box covers the following algebra concepts: addition, multiplication and division. According to Pearce (2013) when playing Dragon Box, the levelled puzzles start simple and easy, with graphics only. Then gradually some of the images are replaced with numbers, letters and mathematics operators as well as adding complexity until learners are solving algebra without the need of graphics. When playing Algebra Meltdown at the beginning of each level, the researchers line up at the generator's outlets, with discourse over their heads to demonstrate the iotas (number)



Source: Foot, K.A. (2001). Cultural-historical activity theory: Illuminating the development of a conflict monitoring network. *Communication Theory, 11*(1), 56–83. https://doi.org/10.1111/j.1468-2885.2001.tb00233.x

FIGURE 1: Activity theory diagram.

they want. The player is given an equation and the player needs to find the correct number of atoms to put in the reactor. If the player chooses the wrong answer or takes too much time, the player will lose points.

Engestrom and Sannino (2010, p. 4) state that learners acquire something new when they figure out the concepts by themselves. The basic relations in action hypothesis as deliberated in this research are sketched out beneath:

- Subject: This is the focal point of the examination; for our motivations the subject is the learner.
- Mediating artefacts: These are apparatus that the subject utilises to follow up on the item space. Altogether, the apparatus intervenes thought during the cooperation between the subject and the setting within an activity. Crucially, apparatus are not non-partisan. They have built-up history of utilisation and convey inside them social implications (Kaptelinin, 2005, p. 10). It is critical to consider the object as both material and ideal, that is, the item contains inside it both the subject's inspiration (for going about) just as genuine material issue space is followed up on (Kaptelinin, 2005, p. 11). First, as the item embodies the rationale for the presence of the activity, and as it is the subject's inspiration that drives this, the researcher used interviews because they can be helpful apparatus for unloading thought processes. Second, what the instructor says and does in the classroom empowers us to build up an image of what it is that the person is dealing with in the exercise; subsequently, recognisable proof of the devices utilised by the educator empowers one to recognise the item in the framework.
- Rules: These are standards, conventions and social collaborations of the schoolroom, which drive the subject's activities (Hardman, 2005, p. 259).
- Community: The subject is an individual from a network who takes up interest in following up on the mutual item. There is division of work inside the network, with obligations, assignments and control unceasingly being negotiated (Hardman, 2005, p. 260). In this research, the network contains the educator and the learners who cooperate on a mutual issue in the mathematics classroom. In a wider sense, the teacher and learners are individuals from the network of the school.
- Division of labour alludes to the arrangement of duties, errands and force relations inside a mathematics classroom just as all through the school. The introduction of the online mathematics games can possibly compel a move in the job of the instructor and learners, with learners working more as instructors of other learners in the mathematics classroom.

The sociocultural theory is rooted in the concept that learning takes place in cultural contexts and is mediated by language and other symbol systems (John-Steiner & Mahn, 1996, p. 191). Teachers need to be aware that the way in which learners think is largely influenced by their discrete culture, which informs each learner's learning approach. Individuals and their daily life environment are intertwined. The focus should be on activity within socially assembled, recognised situations

(John-Steiner & Mahn, 1996, p. 191). Constructivism was used to examine the ways learners built on their cognitive structures through online mathematical games. The online mathematics games were selected to generate cognitive disequilibrium within the learners' existing conceptual structures. Learners were required to accommodate new conceptual understandings, potentially attaining cognitive equilibrium. According to Hein (2007, p. 1), constructivism is a theory of learning based on the idea that knowledge is constructed by the knower, based on mental activity.

Research design and methods

The study follows a qualitative approach using an interpretive paradigm, with a case study design. Qualitative research encompasses the study of groups of people so the researcher can guide and support the creation of a hypothesis (Frederick, 2013, p. 1). A key element of qualitative research is that it generally draws from inductive reasoning processes to interpret and structure the meanings that can be derived from data. In inductive reasoning, the researcher uses the collected data to generate ideas (Thorne, 2000, p. 68).

According to Adendorff (2007, p. 50), research applying the interpretative approach involves socially meaningful action through detailed observation of people in their natural settings. The goal is to arrive at understanding, and interpretation of how people create and maintain their social worlds. The interpretative paradigm was used to gain deeper understanding of why learners fail to understand algebra (Cohen, Manion, & Morrison, 2011, p. 116). A case study was used as it provides a chronological narrative of events relevant to the case. This approach makes it possible for a single researcher to undertake the study without the need for a team. Additionally, the results are easily understood by a wide audience as they are frequently written in everyday, non-professional language, mix a portrayal of occasions with an investigation of them, give an ordered account of occasions, permit researchers to hold the comprehensive and important qualities of genuine occasions, and focus on individual participants looking to comprehend their view of occasions and the researcher is necessarily associated with the case (Cohen et al., 2011, p. 182).

The study was undertaken at a high school in the Metro North Education District in Cape Town, Western Cape. The school accommodates all learners from different social backgrounds. The school employs English as the language of teaching and learning. The researcher chose a Grade 8 class because that was the foundational class for high school mathematics. The school climate was conducive to learning which made it easy to engage learners. The school has limited technological resources: mathematics learners are not readily exposed to technological aids during lessons. The site was chosen because it was easily accessible and logistically convenient. In line with Wegner's (2007, p. 214) argument, convenience sampling was chosen as it allowed the researcher to select convenient sampling units. The choice of a single school allowed for an in-depth case study and addressed time constraints and accessibility problems.

The participants for this study comprised 30 Grade 8 learners and the Mathematics teacher. The class was large enough to facilitate in-depth comprehension of the contribution of online mathematics games on algebra understanding in Grade 8. Thus, the sample consisted of 31. The composition of the sample is described below:

1. Grade 8 Mathematics learners $N = 30$
2. Grade 8 Mathematics teachers $N = 1$
3. Total sample size: $N = 31$

Data collection

Data collection lasted four weeks in the month of August 2018. The principal and the teacher were informed about the study, and permission was granted. All participant learners provided informed consent with their parents signing the parent consent forms. The online mathematics games were used as supplement to the class instructions. No additional time was provided for playing the online mathematics games. The games were played during the regular class time for 15 minutes per period to reinforce the concept taught during that lesson and to make abstract concepts clear to the learners.

Learners were directly observed as they played online mathematics games during the lesson. As noted by Creswell (2014, p. 190), the process of qualitative observation entails the recording of observed behaviour and activities of individuals at the research site. Lessons were observed to determine the extent of the contribution of online mathematics games to learners' understanding of algebra. The interactions and the enthusiasm of the learners during the lessons were also observed.

A questionnaire was also used to gather data from the participants. Through the questionnaire, participants' perspectives and perceptions on the use of online mathematics games when doing algebra were recorded. According to Van Vuuren and Maree (2002, p. 281), the use of questionnaires is economical, ensures anonymity, gives participants enough time to think about the answers they want to give and provides room for uniform procedures. The questionnaires were completed by all 30 participants in the research. They became the lens through which to measure and understand how the participants viewed their own development after using online mathematics games (Schmidt et al., 2009, p. 130).

Moreover, interviews were conducted to generate feedback on the contribution of online mathematics games to learners' understanding of algebra. Participant learners were interviewed individually, with the researcher audio recording the conversations. The interviews focused on their views on online mathematics games. The interview questions for the learners were developed based on their experiences

during the lessons. Random sampling was used to choose six participant learners from a sample of 30 learners to take part in the interviews (Creswell, 2014).

The study utilises the inductive data analysis approach by employing data triangulation as it combined field observation and interviews. Themes were identified and analysed to capture the essence of online game-based learning through the voices of those who have participated directly in its implementation.

The study attained ethical clearance from the Cape Peninsula University of Technology's Ethical Committee for the Faculty of Education and the Western Cape Education Department. All ethical measures were complied with. The study granted anonymity to research participants to ensure confidentiality. This contributed to the researcher gaining the trust of the participants thereby ensuring that the data are trustworthy.

Analysis of results

Table 1 shows the participants' perceptions on the contribution of online mathematics games to understanding algebra in Grade 8 mathematics.

The results in Table 1 uncovered the accompanying discernments concerning the contribution of online mathematics games to better understanding algebra in Grade 8 Mathematics by participant learners.

Statement 1: Do you think learning without online mathematics games is boring?

The results in statement 1 revealed that the majority (97%) of participants agreed that learning without online mathematics games was boring while only (3%) disagreed with the statement.

TABLE 1: Participants' perceptions on the contribution of online mathematics games.

Statement	Number of respondents and percentage (%) response			
	Yes		No	
	Number	%	Number	%
Do you think learning without online mathematics games is boring?	29	97	1	3
Do you feel comfortable playing online mathematics games?	25	83	5	17
Do online mathematics games contribute to understanding abstract concepts?	20	67	10	33
Do you feel the use of online mathematics games helped you in understanding algebra better?	20	67	10	33
Do online mathematics games increase concentration levels of learners during lessons?	24	80	6	20
Do online mathematics games arouse your interest in class?	24	80	6	20
Is algebra difficult when taught without online mathematics games?	24	80	6	20

Statement 2: Do you feel comfortable playing online mathematics games?

In statement 2 the results revealed that most of the participants (83%) agreed that they felt comfortable playing online mathematics games while (17%) disagreed with the statement.

Statement 3: Do online mathematics games contribute to an understanding of abstract concepts?

Statement 3 uncovered that most of the members (67%) agreed that online mathematics games contributed in understanding abstract concepts while (17%) disagreed with the statement.

Statement 4: Do you feel the use of online mathematics games helped you in understanding algebra better?

In addition, the results in statement 4 revealed that most of the participants (67%) felt that the utilisation of online mathematics games helped them understand algebra better while (17%) disagreed with the statement.

Statement 5: Do online mathematics games increase concentration levels of learners during lessons?

Statement 5 revealed that most of the members (80%) agreed that online mathematics games increased concentration levels of learners during lessons while (20%) disagreed with the statement.

Statement 6: Do online mathematics games arouse your interest in class?

In statement 6 the majority of participants (80%) agreed that online mathematics games aroused their interest during lessons while (20%) disagreed with the statement.

Statement 7: Is algebra difficult without being taught online mathematics games?

Statement 7 showed that most of the participants (80%) agreed that algebra was difficult when taught without online mathematics games while (20%) disagreed with the statement.

Looking closely at the learners' questionnaire responses, the following game effects were observed:

1. The online mathematics games had an experiential nature. That allowed learners to interact with familiar environments in the games and construct their mathematics concepts through completing game missions.
2. The online mathematics games changed learners' perceptions on mathematics.
3. The learners understood the relationship between mathematics and real life. As a result, their mathematics phobia was diminished (Paraskeva et al., 2010, p. 499).

Six learners were interviewed after they had used online mathematics games to solve algebra. Each interview took 20 minutes and was audio-recorded followed by transcription. Various themes emerged that indicated the fluidity of the teacher's and learners' perspectives and understanding of online mathematics games. In-depth probing was employed to obtain additional relevant information. The main themes identified from the analysis of interviews related to learners' beliefs on online mathematics games and learner motivation.

The following are some of the participants' comments during interviews.

Learner 2 said that:

> 'I didn't really understand what equivalence was. The Dragon Box really helped me a lot because it simplified the algebraic concepts into a game. I now understand that both sides of the equal sign have the same value.'

$$2x - 4 = 6$$
$$2x - 4 + 4 = 6 + 4$$
$$2x = 10$$
$$x = 5$$

The gameplay simplified the difficult algebra concepts as echoed by Learner 2. As argued by Star and Seifert (2006, p. 290), algebra is a source of considerable confusion and negative attitudes among learners. This is because learners seem to find algebra difficult to understand. When learners find something difficult to understand, they become confused and bored.

Learner 3 said that:

> 'For an expression like $2(a + b)$, I did not know that a and b are used to generalise a pattern. I used to get $4ab$ as my answer. But now after gameplay, I now understand the context $2(a + b) = 2a + 2b$.'

This narrative confirms Van de Walle's (2013, p. 257) view that the variables used in algebra take on different meanings depending on context. For instance, in the equation $4 + x = 6$, 'x' is the unknown and 2 is the solution to the equation. But in the statement $A(x + y = Ax + Ay$, 'x' and 'y' are being used to generalise the pattern. Failure by learners to understand the contexts lead to difficulties in solving the algebraic expression and equations.

The questions asked during the interviews were important as they allowed the researchers to understand whether learners were familiar with the online gameplay as well as understanding the reasons for using online mathematics games. Interviewing the learners helped to cross-validate data from observations made during the lessons. The learners were of the view that the online mathematics games positively affected their algebraic understanding, focus skills and motivation. The narratives below support the views noted above.

Learner 2 stated that:

> 'When our teacher introduced gameplay in our algebra lesson, I started looking forward to the next lesson. The lessons were now vibrant, accommodating and inspiring. I now understand mathematics concepts more than I did when we depended on textbooks only. Gameplay during lessons is the right way to learn mathematics.'

The interviews confirm that the learners' achievements and motivation were positively impacted by the online mathematics games. Further, the comments express feelings of increased enthusiasm and eagerness towards learning through computerised games.

Learner 5 commented that:

> 'The first week the gameplay made me feel embarrassed. Most of the learners were advancing to the next levels whilst I remained at the first. Though the teacher kept on guiding and explaining on how to play, as I kept on playing, I ended up being angry with myself.'

This isolated incident revealed by Learner 5's comment shows that although learners can face challenges, they may continue to play until they win or advance to the next levels of the game. This determination by the learners, coupled with the frustration, can cause low self-esteem or aggressive behaviour, especially if the child keeps losing the game (Annetta, Minogue, Holmes, & Cheng, 2009, p. 80).

Although a few learners expressed negative responses regarding the online mathematics games, the interviews showed that to a greater extent the online games positively influenced the learners because online mathematics games help learners to 'be creative, look for patterns, make conjectures, collect data, express their own thoughts, accept the ideas of others and establish forms of cooperation' (Siemon et al., 2016, p. 6). The common challenges learners experienced such as failure to understand basic algebraic concepts, namely variables, algebraic expressions and equations, were perfected. The games stimulate cognition, motivate the learners to remain engaged and promote learning in an integrated manner. The responses were varied but reflected individual progression in terms of how each participant developed their skills, knowledge of game play and confidence in their abilities.

Recommendations

This research provides a starting point for looking into the integration of online mathematics games into the teaching and learning environment for mathematics. This research

provides a platform for integrating online mathematics games into the teaching and learning environment for all conventional mathematics topics. Based upon the findings and caveats of this research, teachers may safely encourage learners to use online mathematics games in the learning of algebra because online mathematics games help learners to be creative, to look for patterns, make conjectures, collect data, express their own thoughts, accept the ideas of others and establish forms of cooperation (Siemon et al., 2016, p. 11). There is need for further research to be conducted on a larger scale, with many schools and in different areas to test the findings of this study on the contribution of online mathematics games to algebra understanding in Grade 8 mathematics.

These findings indicate that learners spend a considerable amount of time playing digital games and tend to identify with the characters they adopt or take on in the course of playing the game. Thus, we need to further examine what boys and girls prefer in games in order to develop educational online games that suit different personality types and, more importantly, exploit multiple skills and intelligences, in true reflection of real-life collaborative environments, in the context of learning algebra specifically and mathematics in general.

According to Paraskeva et al. (2010, p. 503) online mathematics games must negotiate the difficult area between engaging the initial interest of learners, without becoming addictive and detrimental to academic performance. I have suggested that the above concern can be averted by integrating elements that limit play sessions and oblige learners to engage actively in an external educational task before continuing play, ideally in collaboration with other learners. Alternatively, the online mathematics game itself can function as the basis for an innovative and motivating homework assignment.

Conclusion

The relation between online mathematics games and self-esteem cannot be clearly defined yet, since research so far has yielded conflicting or ambiguous results (Paraskeva et al., 2010, p. 503). Given the crucial role of self-esteem in academic performance and social adjustment, however, it is worthwhile to investigate the issue further. Finally, the suggested potential of online mathematics games with regard to improving mathematical understanding and development of algebraic concepts is an encouraging finding and should be more fully exploited.

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Competing interests

The authors have declared that no competing interests exist.

Authors' contributions

T.M. was responsible for initiating and formulating the research, identifying the sample and collecting data, and writing up the research. SA.A. advised and guided the conduct of the research, proofread, edited and gave recommendations on the write-up, supplied resource materials and finalised the article.

Ethical considerations

Education Faculty Ethics Committee (EFEC), CPUT (certificate number EFEC 1-6/2018).

The researchers made it clear that participating in the research was voluntary and that if for some reason participants wanted to withdraw from it, they had the right to do so at any time. Participants were informed that they would be protected from physical or psychological harm, discomfort or danger that might arise due to any research procedures. Participating learners were told that the information gathered would be confidential and no one would know their identities except for the researchers. The names of the subjects were removed from all data collection forms as pseudonyms were used. The researchers obtained permission to conduct the research from Western Cape Education Department, Cape Peninsula University of Technology, and the principal of the participating school.

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Data availability

Data lists and summaries, figures and tables can be obtained from T.M.'s MEd thesis.

Disclaimer

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