Preferences of Grade R-12 Learners in South Africa for Digital Game-Based Learning

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Abstract: Evidence from the literature suggests that Game-based Learning (GBL) can help students learn better. A gamified environment can provide a blend of serious learning and fun for students. Some researchers have observed that GBL could stimulate valuable educational outcomes and positively impact a child's life. However, evidence shows that students in poor communities in South Africa are performing poorly academically due to poor student engagement and lack of motivation. Although GBL platforms are being used widely in some developed countries, they have not been widely adopted in South African schools. This paper provides insight on the preferences of learners in South African schools with respect to GBL. We conducted a survey involving participants from four South African Schools (2 Primary schools and 2 Secondary schools) to determine the type and mode of GBL that Grade R-12 learners prefer. A total of 193 learners participated in the survey. The study found the learners' preferential order of type of games are puzzles, video games, simulation games, word games, and card games. The aspects of visual aesthetics, musical scores, and incentive appeal to most learners. At the same time, there is also a preference for games that involves a challenge, enable competition with peers, and promotes curiosity. Based on our findings, we argue that multiplayer game platforms that have rich social interaction features would suit learners in South African schools, while single-player game platforms that can stimulate logical thinking and reasoning will also be helpful to aid learners in identified difficult subjects like Mathematics, Mathematical Literacy, Pure Science, accounting, and Geography. The study provides a solid foundation for understanding the requirements for developing GBL solutions to support education in South Africa. Furthermore, the study's findings could guide government policy on the adoption of GBL and software developers in making design choices during the development of GBL platforms.

Keywords: game-based learning, game design, computer games, game requirements, games development, child education

1. Introduction

These days more and more learners grow up using technology devices such as computers, smartphones, and play-stations to perform all sorts of activities (Katerina, 2020). The one activity that is common is playing games on these devices. In a week, it is said that young people spend an average of 7 hours playing games (Forbes, 2019). Therefore, it is important to take advantage of young people's interest and excitement in playing games to motivate them for serious learning.

The use of digital games has been proven to be efficient and effective in student learning. Without even realising it, students use digital games to learn, which makes these games the perfect tool to use in student learning (Katerina, 2020). Hence, there is a shift towards using digital learning in classrooms rather than traditional learning. These digital learning environments offer an opportunity to transform the teaching process using game elements to help motivate goals, stimulate users' attention, facilitate effective teamwork, promote competition, and help in communication (Subhash & Cudney, 2018).

The use of a digital learning environment through games is called Game-based Learning (GBL). GBL has evolved to help student learning (Subhash & Cudney, 2018). It is defined as the use of game mechanics by learners where they engage in a comprehensive learning experience through interactive cycles of assessment and feedback (Nadolny, 2019). Research has proven that digital game-based learning (DGBL) can help students to learn better, improve academic performance, motivation and interest, as well as facilitate more acquired knowledge by learners (Grivokostopoulou et al, 2019; Hwang & Chang, 2020; Bhandari, Hallowell, & Correll, 2019; Chang et al, 2020; Kao, 2020; Lee et al, 2016).

GBL as an approach has gained popularity in many different countries but has not been widely adopted in South Africa (Oliver, 2018). Many learners in South Africa (SA) schools that come from poor economic background are performing poorly in classrooms, which raises concern (Spaull & Kotze, 2015). Annual testing

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in numeracy and literacy within SA public schools showed poor performance and has raised many concerns regarding the SA education system (Ramrathan, 2017; Morrison, 2018). The score in international studies, including Trends in Mathematics and Science (TIMSS), places the Grade 8 learners in South Africa at the bottom of the 50 participating countries. Mathematics is an issue for South African learners as the international statistics show that they perform poorly in Mathematics compared to other learners of the same grades in other countries (Bosman & Schulze, 2018).

We argue that the adoption of digital game-based learning, which takes advantage of the love and passion that young people have for playing games, could be a solution to some of the challenges of learners in SA public schools. However, it is essential to have a clear understanding of learners' preferences if GBL were to be adopted so that government and education policy planners can formulate a suitable implementation strategy for GBL in South African schools. Thus, this study investigates the research question: *What types and modes of GBL are relevant to grade R-12 learners in South Africa?*

To answer this research question, we conducted a survey to determine the preferences of South African learners for GBL. The study involved 194 students in four South African schools (two primary schools and two secondary schools). We analysed the collected data using descriptive statistics to summarise our findings. The study is vital because it constitutes one of the first attempts to determine the preferences of South African learners for GBL. It will also provide a solid foundation for determining the requirements that a GBL platform for SA learners must satisfy in terms of its features, capability, and the critical design considerations for developing such a GBL platform. Furthermore, this study makes an academic contribution because it provides insight into the prospects of GBL adoption in South Africa and the preferences of SA learners for GBL, which hitherto has not been previously investigated. The study has positive implications for SA and other developing countries.

The rest of this paper is as follows. Section 2 presents background and related work. In Section 3, we describe the methodology adopted for the study. The analysis and results were presented in Section 4, while the discussion is presented in Section 5. Finally, the paper is concluded in Section 6 with a summary and an overview of our future research direction.

2. Background and related work

This section presents an overview of key concepts relevant to our study and a review of related work.

2.1 Challenges of R-12 learners in South Africa

There is an ongoing crisis in South African education, and the current education system has failed to address the needs of most South African youth (Spaull, 2015). Based on independently conducted assessments, Spaull (2013) reported that excluding the wealthy minority, a bigger part of the South African population is functionally illiterate and innumerate, while most South African pupils cannot read, write, and compute at a level equivalent to their grade.

In 2004, 72% of grade 6 learners failed the national literacy test. The figure was substantially higher in Mathematics, where 88% of all the Grade 6 learners failed to achieve the curriculum standard (Taylor, Fleisch & Shindler, 2007). The score in international studies, including Trends in Mathematics and Science (TIMSS), places the Grade 8 learners in South Africa at the very bottom of the 50 participating countries. Mathematics is an issue for South African learners as the international statistics show that they perform poorly in Mathematics compared to other learners of the same grades in other countries (Bosman & Schulze, 2018).

Furthermore, there is a high dropout rate of learners in schools and the fact that in South Africa, the overall progress in schools is slow. As much as 52% of learners repeat a grade at least once before they reach Grade 10 (Grossen, Grobler & Lacente, 2017). The majority of Black and Coloured learners still perform poorly compared to poorer African countries (Burgess et al, 2018).

During the Covid-19 lockdown, most schools shifted to online learning (Burgess & Sieverten,2020; Thomas, 2020). In terms of internet availability and affordability, African countries are ranked in the bottom third of countries, making online instruction a distant prospect for most people. As a result of such circumstances, the

strategy to move education online worsens inequality (Thomas, 2020). There is a substantial amount of evidence on the education crisis in SA, particularly in the disadvantaged communities.

2.2 Game-based learning

Gaming as a tool for learning is not a new concept in the education space, but in recent decades, it has evolved as computer technology and has become more common (Williams, 2019). Upon its release, Prensky's book (2001) had an impact on the discussion of GBL, and to date, it has still an impact. The author strongly supports the idea that the traditional teaching methods should be replaced, and learning should be centred on digital platforms and games; he claims that the earlier generations, compared to the future generations, which he calls digital natives think differently (Lindgren, 2016). More than 20 years later, in education research, digital game-based learning (DGBL) is no longer a new teaching tool (Tay, 2022).

Game-based learning (GBL) is the terminology that incorporates all types of learning that involves games, including gameplay, game design and gamification (Bolstad, 2018). Gamification is when game design elements are used in a non-game context, while GBL is when games are used in educational contexts to aid learning objectives (Subhash & Cudney, 2018). The most important feature of GBL environments is their capability to create effective and engaging learning environments (Emerson et al, 2020). Research suggests that DGBL has led to increased learning engagement (Annetta et al, 2009), increased flow experience (Liu et al, 2011), and improved course content understanding (Braghirolli et al, 2016; Wand and Abbas, 2018). It has also led to problem solving improvements (Hwang et al, 2012; Sanchez and Olivares, 2011) and higher academic achievements (Hwang et al, 2012; Philpot et al, 2005; Topalli and Cagiltay, 2018). GBL is important because of the key elements such as perseverance, player engagement, adaptivity, and graceful failure, which help in encouraging players to persevere when playing the game, think out of the box, and learn from their mistakes and adjust accordingly (Williams, 2019).

Major issues teachers face in schools are poor student engagement and a lack of motivation (Lee & Hammer, 2011; Subhash & Cudney, 2018; Robberts & Van Ryneveld, 2022). Thus, GBL has evolved as a measure to help student learning (Subhash & Cudney, 2018).

GBL can help South African grade R-12 learners by creating a positive influence in particular subjects like Mathematics and Science and introducing learners to various digital platforms to learn. However, to use digital game-based learning (DGBL) to help address the educational crisis in SA, an understanding of the preferences of grade R-12 learners for DGBL is necessary.

2.3 Related work

Although GBL is acknowledged as a successful learning platform, in the meta-analyses on GBL, some authors conclude that "the important question is not if but how game-based learning can support learning" (Clark et al, 2016). The authors argued that games could indeed support productive learning, but the game's design will determine and influence the efficacy of the learning environment (Clark et al, 2016).

According to Bolstad (2018), in his research study on GBL practices in New Zealand, he says the questions which come into play when researching GBL is: what game design features are particularly good for a specific learning type? He suggested that use of an ecological approach to understand GBL. The ecological approach is defined as relationships between any complex system and its environment and surroundings (Bolstad, 2018).

In the most recent study on mobile game-based learning in Science, Technology, Engineering and Mathematics (STEM), the authors concluded that instead of asking the question of whether mobile GBL is effective as an approach, what is essential is to identify how and why specific designs work in a particular circumstance (Gao, Li & Sun, 2020). Dimitra, Konstantinos & Christina (2020) looked at the types of GBL in education and advised that when looking at construction education games, the game must follow specific rules to be suitable for the group of learners it is addressing. The authors further advised that the game's purpose and type must be determined and tested by teachers to see if it meets the learning objectives.

In a more recent study by Tay et al (2022), which looked at designing DGBL for professional upskilling, the authors advised that it is vital to consider the type of games used in education and research. Each game type is

meant for a specific audience and objectives. For instance, some researchers chose to use off-the-shelf types of games instead of developing digital games for a particular purpose. This can result in issues such as relevance and the relationship between the game type and instruction objectives (Nousiainen et at. 2018; Sanchez et al, 2010). As advised in the literature, design is important in GBL because it influences the effectiveness of GBL in a learning environment. Furthermore, the type of game needed is also important, as each game type must be meant for a particular audience, for a specific learning objective.

GBL has not been widely adopted in South Africa as an alternative tool to enhance education (Oliver, 2018). Instead, e-learning platforms are used by many elite schools and universities. Thus, Oliver (2018) proposed implementing Technology-enhanced learning (TEL) and Digital Game-based Learning (DGBL) within theology in universities in South Africa. The author encouraged lecturers in South Africa to contribute to research on TEL and DGBL and experiment with and implement TEL and DGBL as part of their curriculum development endeavours. Also, M-Thuto is a mobile learning system in South Africa that supports learners in learning other languages that are not their first language (Jantjies & Joy, 2014). The tool is used to learn mathematics using other languages such as Tswana and English. Similarly, Kotnana et al (2010) conducted a study in SA on techniques to enhance GBL outcomes in Deaf and Dumb illiterates, while Kritzinger (2015) proposed the use of offline games to create cyber security awareness for R-12 learners in South Africa. Since GBL is not yet prominent in South Africa, thus far, no investigation on learners' preferences for digital game-based learning has been conducted, making our study vital for increased adoption of GBL in the South African educational system.

3. Methodology

3.1 Research approach

This study adopts a quantitative methodology and uses a deductive reasoning approach. Although the literature already states that GBL can aid students' learning (hypothesis), we sought to test this hypothesis in the south African context using empirical data.

3.2 Data collection

We collected data through a survey involving four schools (2 Primary and 2 Secondary schools) in the Western Cape Province of South Africa. We distributed a questionnaire to learners in the school with between 20 -50 participants from each school.

We sampled learners drawn from the foundation phase (Grade 1-3), intermediate phase (Grade 4-6), senior phase (Grade 7-9), and the further education and training phase (Grade 10-12). The teachers in the four schools were also surveyed, but information on this is not included in this paper. No specific type of learners was targeted in terms of gender or race, but all learners who agreed to participate were enrolled in the study. Before data collection, we obtained ethics clearance from the Ethics Committee of the Cape Peninsula of Technology, South Africa. We also got the approval of the Western Cape Department of Education to collect data from the schools. We obtained the informed consent of the management of each school and that of individual learners before they participated in the study. They also had the right to discontinue their participation at any time during the study. They also had the liberty to refrain from answering any question they were uncomfortable with (see Table 1).

Table 1: Participants of the study

School Names	Role	Total Participation	
		Selected	Responded
Group A	Learners in Primary School	50	50
Group B	Learners in Secondary School	50	44
Group C	Learners in Secondary School	50	50
Group D	Learners in Primary School	50	50
Total Respondents			194

The Survey questions aim to determine the preferences of the Grade R-12 learners to know the type and mode of GBL that suits them. Thus, the questionnaire items embraced the following aspects:

- The personality of the learners
- Learning Style of the learners
- The type of digital resources available to the learners
- The level of computer literacy of the learners
- Disposition of learners to game playing
- Frequency of playing games by learners
- The type of devices used to play games
- Type of games preferred by the learners
- Aspects of a game liked by the learners
- Elements of a game liked by the learners

The collected data was stored in a Microsoft Excel file to enable the data analysis.

3.3 Data analysis

We used descriptive statistics to analyse the collected data using frequency count and percentage score. We had 193 responses because one learner who agreed to participate in the study did not submit the questionnaire. Thus, there was a 99.5% response rate among the learners. We performed a theoretical analysis of recorded data and made deductions from observed patterns in the data.

4. Results

The results obtained from analysing various aspects covered by our questionnaire are presented as follows. Table 2 shows the different personality types and preferred learning styles of learners based on their responses. Almost half of the learners described themselves as friendly (49.22%), and many learners acknowledged that they were talkative (33.16%). In contrast, some others described themselves as shy (19.17%), quiet (15.02%) and thoughtful (13.98%), respectively. Also, more than half of the sampled learners (53.36%) described themselves as verbal learners that prefer to learn by reading or listening. A significant few see themselves as social learners (21.76%) that love to learn through social interactions while working in groups and teams. Some prefer working alone and self-study (20.76%). A few learners also describe themselves as visual (13.47%), kinaesthetic, logical, and aural learners.

Table 2: Personality and learning styles

Personality	**Percentage**
Action-oriented	4.14 %
Outgoing	6.21 %
Reserved	7.77 %
Social	8.8 %
Thoughtful	13.98 %
Quiet	15.02 %
Shy	19.17 %
Talkative	33.16 %
Friendly	49.22 %
Learning Styles	**Percentage**
Aural	6.73 %
Logical	7.25 %
Kinaesthetic	7.77 %
Visual	13.47 %
Solitary	20.72 %
Social	21.76 %
Verbal	53.36 %

Figure 1 captures the type of access to digital resources that the learners have, while Figure 2 shows the disposition of learners to game playing. The result indicates that fewer learners have access to computers and cell phones at school while more learners have access to computers (64.43%) and cell phones at home (69.94%). In addition, few learners did not respond to the questions about access to digital resources. Also, the learners that play computer games (77.72%) are significantly more than those that do not play computer games (21.24%).

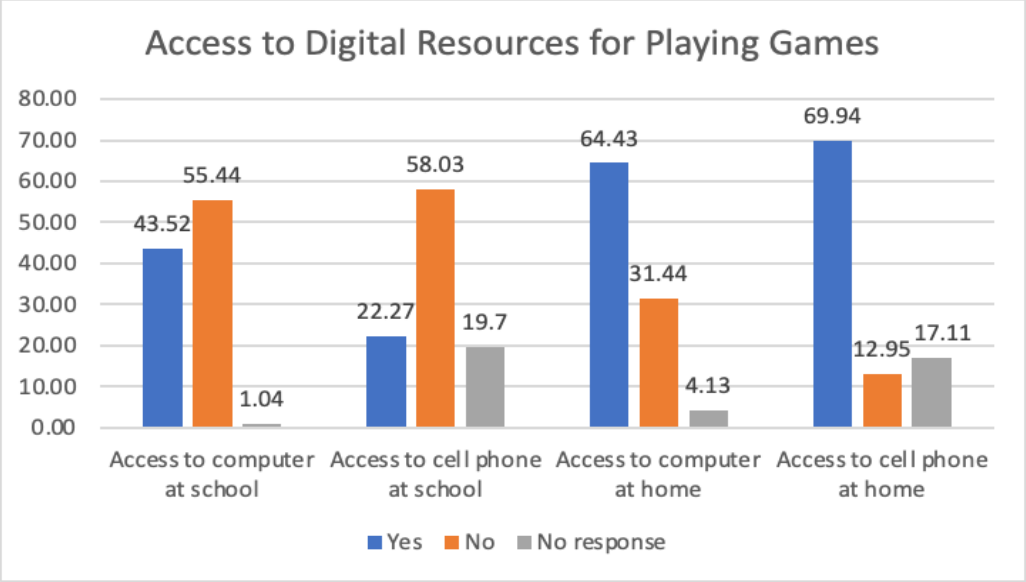

Figure 1: Learners' access to digital resources

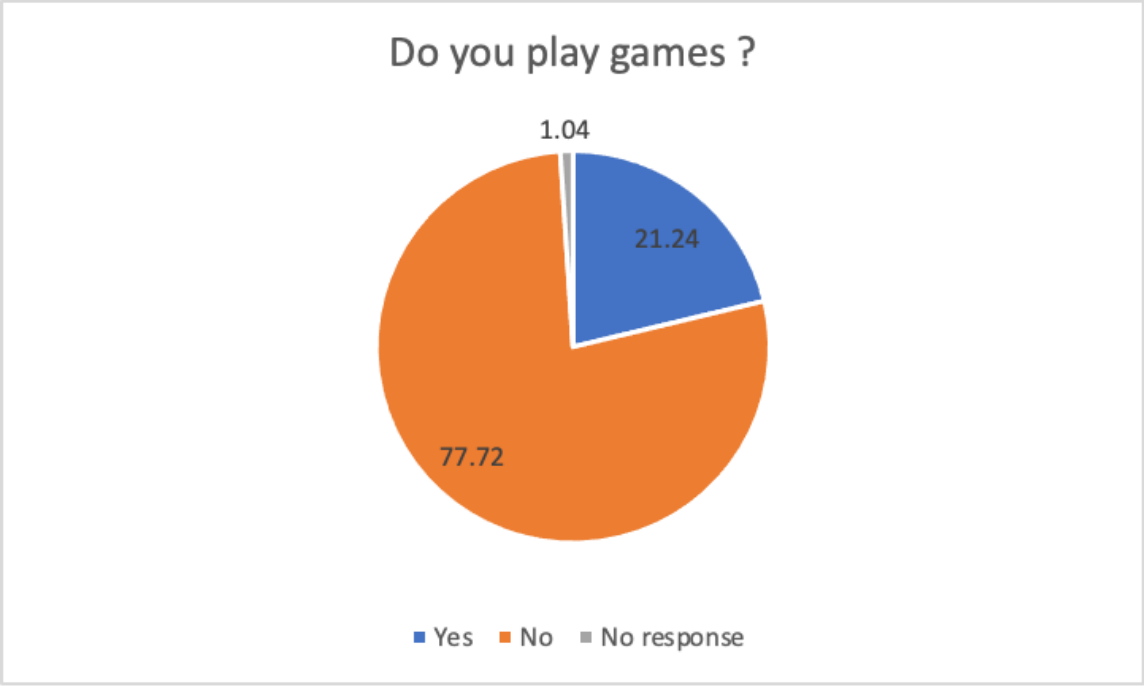

Figure 2: Disposition of learners to game playing

Table 3 shows how frequently the learners play games and the types of devices used to play games. More than 38% of the learners claim to play games almost every day, while others play games once or twice a month (30.56%), and a small number of learners play games once a week (26.94%). The result also showed that most learners use smartphones to play games.

Table 3: Frequency of playing games and devices used

How often do you play	Percentage
Once a week	26.94 %
Once or twice a month	30.56 %
Almost Every day	38.34 %
Devices used to play games	**Percentage**
Video game devices	4.14 %
Computer tablet	6.21 %
Computer	6.73 %
Console - PlayStation	9.84 %
Smartphones	73.05 %

Table 4 reveals the preference of learners in terms of the type of games they like, the specific aspects of a game that they like, and the elements of a game that they find interesting. More learners indicated that they like puzzles (34.71%) and video games (31.6%). At the same time, some learners showed that they liked word games (26.42%), simulation games (20.20 %) and card games (13.98%), while a small group liked board games (8.29%) and role-playing games (8.8%)**.** In addition, most learners like aspects of a game that involves rewards in the form of visual aesthetics (36.26%) and musical scores (35.75%), while some like aspects of the incentive systems (28.49%) and the game narrative (22.27%). A small group of learners indicated that they like the game mechanics aspect (8.8%).

We also found that key elements of a game liked by learners are challenging games (36.21%), as well as games that enable competition with others (31.08%) and trigger curiosity games (20.72%). Fewer learners liked collaborative (15.02%) and fantasy games (10.88%). We also found that 84.45% of the learners believe that playing games can help them learn better, while 83.41% think that playing games can help them learn subjects they perceive as difficult. Some of the learners listed Mathematics, Pure Science, Commercial subjects (Accounting), Mathematical Literacy, and Geography as difficult subjects.

Table 4: Game preferences of learners

Type of games preferred	Percentage
Board games	8.29 %
Role-playing	8.8 %
Card games	13.98 %
Simulation	20.2 %
Word games	26.42 %
Video games	31.6 %
Puzzles	34.71 %
Aspects of the game liked	**Percentage**
Game mechanics	8.08 %
Narrative	22.27 %
Incentive systems	28.49 %
Musical score	35.75 %
Visual aesthetics	36.26 %
Elements of the game liked	**Percentage**
Fantasy	10.88 %
Collaborative	15.02 %
Curiosity	20.72 %
Competing with others	31.08 %
Challenge	36.21 %

5. Discussion

Based on the results obtained from the study, we shall discuss our findings as it relates to the personality types of learners, access to digital resources, the disposition and frequency of playing games, the type of games liked by learners and the attributes that they find interesting. We also discuss the implication of these for difficult subjects and the adoption of digital GBL in South Africa.

- **i. Personality of learners:** since most learners describe themselves are either friendly or talkative or both (see Table 2), game-based learning platforms that can stimulate social interaction such as multiplayer games for learning should be encouraged. Considerable effort should also be made to invest in single-player game platforms since a significant number of learners (one-third of the percentage of learners) believe that they are quiet or shy. This will ensure that all personality types are catered for adequately. According to Oliver (2018), GBL has not been widely adopted in South Africa as an alternative tool to enhance education. Thus, designing game platforms that suit learners' personalities will aid the diffusion of GBL as a tool for improving learning in SA schools.
- **ii. Learning style of learners:** our results show that verbal learning is the most preferred form of learning among the learners (1 out 2 learners), while social learning (1 out of 5 learners), solitary learning (1 out of 5), and visual learning (approximately 1 out 8 learners) are moderately preferred (see Table 3**)**. This observation justifies the need to focus on the design of GBL platforms that will encourage social interactions and multiplayer games. Since very few learners identify themselves as logical learners that love solving problems either by explaining and interpreting texts or solving mathematics, GBL platforms that can stimulate logical thinking and reasoning are also needed in SA schools.
- **iii. Digital game resources, disposition to games, and frequency of playing games among learners:** more learners have access to digital resources at home than at school. Many schools have computers, but the ratio of available PCs to learners is high, which means that the computer systems in schools cannot be sufficient to support learners' quest to play games. The majority of the learners play games almost every day. Some play games once a week or more than once a month (see Table 3). Learners do not have access to use cell phones while in school, but they have access to cell phones and smartphones a home. The smartphone penetration in South Africa is over 80%, the highest in Africa (Gilbert, 2019). Since most learners love to play games, the high number of smartphone owners in South Africa makes it possible for many learners in South Africa to have access to digital resources for digital game playing. This is a good foundation for the wider adoption of GBL in South Africa.
- v. **Types of games and aspects and elements of games that learners like:** Since most learners like puzzles and video games, while word games, simulation games, and card games are also fairly popular, game designers need to invest more effort in developing game platforms that possess these characteristics (see Table 4). Features such as visual aesthetics and musical scores rank high on the scale of preferred game requirements from the learners' perspectives; hence GBL platforms for SA learners must have these aspects. Games that demand solving a challenge and facilitate competition among multiple players are attractive to most learners. These types of games can stimulate the development of problem-solving skills of learners. Games that are based on curiosity (1 out of 5 learners like this type of game) and those that encourage collaboration (liked by approximately 1 out of 7 learners) and fantasy (liked by 1 out of 10 learners) are also viable options to explore in developing GBL platforms for SA learners.
- **iv**. **Game-based learning and difficult subjects;** Most learners find it difficult to learn Mathematics, Mathematical Literacy, Pure Science, Commercial subjects (such as Accounting), and Geography. Considering that very few learners indicated a preference for a logical learning style, many learners experience difficulty in learning subjects that require calculations. GBL can be used to promote more logical reasoning and learning among learners. The fact that most students love puzzle games provides a good rationale to explore further the implementation of games that can train learners in logical thinking and logical reasoning that will aid their abilities in the difficult subjects, which agrees with the perspective of Grivokostopoulou et al (2019). The impact of this over the long term will be the improvement of the performance of SA learners in Mathematics which, according to Bosman & Schulze (2018), has been poor over the years.

6. Conclusion

In this paper, we have presented the preference of learners in South Africa for game-based learning (GBL). Digital GBL is not yet prominent as an alternative for enhanced student learning in South African schools.

Therefore, an understanding the type and mode of GBL preferred by learners is essential to guide the implementation of GBL in SA schools. After analysing survey data collected from four schools in the Western Cape Province of South Africa, we found that most students identify themselves as verbal or social learners, friendly or talkative in terms of personality and preferred learning style, respectively. There was also a fewer but significant percentage of learners with shy or quiet personalities in the sampled population. They were also learners that identified themselves as solitary learners who prefer to study alone, while a few indicated their preference for visual learning. Most learners play games and love to play games, mainly using smartphones. Puzzles and video games are the most popular among learners, while simulation, word games, and card games are also popular. Games that incorporate aspects of visual aesthetics, musical scores and incentive systems are liked by most learners. There is also a preference for games that involves a challenge, enable competition with peers, and promotes curiosity. Thus, generally, multiplayer game platforms that are rich in these social interaction features are desirable for SA learners. There is also a need for single-player game platforms that can stimulate logical thinking and logical reasoning, which can help learners develop logical abilities that will make difficult subjects such as Mathematics, Mathematical Literacy, Pure Science, Accounting, and Geography easier to learn.

As a contribution, this paper has provided insight into the type and mode of GBL that is preferred by SA learners, which is a topic that has gained limited or no attention before now. Thus, the insight from the study provides a first empirical basis for understanding the requirements of a digital GBL for learners in SA, which is also relevant to other developing countries that share contextual characteristics with South Africa. We shall focus on eliciting the key requirements that a platform for digital GBL for South African learners must satisfy in future work.

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