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Digital Game-Based Learning for Information Technology: An Exploratory Analysis

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ABSTRACT

Keeping students engaged and motivated is a challenge. Digital game-based learning is considered an approach that can help towards achieving this goal. The study aimed to understand the influence digital game-based learning (DGBL) has on students learning to code in Information Technology. This study used an intervention of digital game-based learning to teach grade eight learners programming in three schools prior to COVID-19. Questionnaires and focus group interviews were used to gather students' backgrounds and learning experiences. 89 students and three educators participated in the study. The overall attitude towards DGBL is positive with a high mean score of 4.77. Learning real-world skills, in developing simple games, as was done in this in this study, can equip one with the tools essential for success in a workplace.

Keywords: *digital game-based learning (DGBL), programming, computational thinking learning motivation*

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INTRODUCTION

There is a sense of excitement that seems to permeate through formal educational settings when learners discover that their educators' approach to work is 'play'. Many would argue, that the notion of play within a high-school classroom environment is counter-productive to the business of teaching and learning.[1] However, in his seminal paper, Piaget (2013) positions play as a central tenet in a child's holistic development.[2] Learning through play can enrich the learning experience and collective problem-solving to a degree that brings children to a new level of learning.[3] But many complex issues need to be addressed before successful implementation can be realised within a formal classroom setting. The idea behind this research is to present a plausible alternate teaching approach — as a means of enhancing the skills and motivation levels of the current digital citizens. As indicated in Bertram's

[1] James Paul Gee, *Good Video Games+ Good Learning: Collected Essays on Video Games, Learning, and Literacy* (Peter Lang, 2007); Molly E O'Riley, "The Question of Digital Game Based Learning: An Investigation into the Potential Promises and Perils of Education's Golden Goose" (2016).
[2] Jean Piaget, *Play, Dreams and Imitation in Childhood* (Routledge, 2013).
[3] James Paul Gee, "What Video Games Have to Teach Us about Learning and Literacy," *Computers in Entertainment (CIE)* 1, no. 1 (2003): 20; Yasmin B Kafai, "Playing and Making Games for Learning: Instructionist and Constructionist Perspectives for Game Studies," *Games and Culture* 1, no. 1 (2006): 36–40; Ching-Huei Chen, Kuan-Chieh Wang, and Yu-Hsuan Lin, "The Comparison of Solitary and Collaborative Modes of Game-Based Learning on Students' Science Learning and Motivation," *Journal of Educational Technology & Society* 18, no. 2 (2015): 237–48; O'Riley, "The Question of Digital Game Based Learning: An Investigation into the Potential Promises and Perils of Education's Golden Goose."

study, DGBL is believed to increase students' interest and motivation.[4] More specifically, attracting students in this digital age to study Information Technology(IT) and related fields at school is crucial as it is regarded as a scarce skill. With this in mind, and using this investigative intervention as a vehicle, this research looks to address the following question:
How can DGBL be used to enhance the teaching and learning of IT?

RELATED LITERATURE

In general, children are grouped based on age and ability.[5] This philosophy of education limits potential and creates an environment where children are left feeling inept should they fail to achieve a high grade, resulting in a form of exclusivity. This is more apparent within the Information Technology and Computer Science faculty of research than in any other field. Anecdotal evidence suggests that the primary reason for learners not wanting to elect Information Technology as a subject, or as a field of research, is their perceived difficult nature of the subject. It is believed that IT requires a high level of technical and coding abilities. However, Digital Game-Based Learning (DGBL), when employed using an intuitive environment such as the one Scratch provides, presents a visual platform that can reduce the level of technicality and perceived difficulty. An important aspect of coding is the effect of developing computational thinking: a primary proponent of Computer Science.[6] Moreover, DGBL also presents the potential to use commercial games that have been designed specifically for learning.[7] Educational games that offer many of the benefits of games created for entertainment, in terms of design quality, are also designed to meet specific learning outcomes so that the game goals align with the learning goals. However, these games can be expensive to purchase and may be difficult to customize if they do not meet the exact requirements of the learners or curriculum.[8]

Proponents of DGBL advocate the positive effects its deployment has on both teaching and learning. The process of making mini-games is often flaunted as being the best method for deploying DGBL.[9] Moreover, using Scratch to create games, animation, music or art applications is easy since Scratch was purposefully designed to make introducing programming easy.[10] It has been ascertained in the literature that programming is challenging for first-time learners.[11] But with Scratch, a simple click and drag of the mouse, learners can develop an effective foundation in programming that could form the basis for building more advanced skills in the future. Simply put, the Scratch platform lends itself to DGBL. In fact, in the early stages of the Curriculum Assessment Policy Statements (CAPS) document, Scratch was indicated in Grade 10 Information Technology — as a means of introducing programming to learners.

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[4] Lara Bertram, "Digital Learning Games for Mathematics and Computer Science Education: The Need for Preregistered RCTs, Standardized Methodology, and Advanced Technology," *Frontiers in Psychology* 11 (October 15, 2020), https://doi.org/10.3389/fpsyg.2020.02127.
[5] James A Kulik, "An Analysis of the Research on Ability Grouping: Historical and Contemporary Perspectives. Research-Based Decision Making Series.," 1992.
[6] Irene Govender, "Research Status in Computational Thinking in STEM Education," in *Advances in Research in STEM Education* (IntechOpen, 2022).
[7] Rosemary Garris, Robert Ahlers, and James E Driskell, "Games, Motivation, and Learning: A Research and Practice Model," in *Simulation in Aviation Training* (Routledge, 2017), 475–501; M P Jacob Habgood, S E Ainsworth, and Steve Benford, "Endogenous Fantasy and Learning in Digital Games," *Simulation & Gaming* 36, no. 4 (2005): 483–98; Ricardo Rosas et al., "Beyond Nintendo: Design and Assessment of Educational Video Games for First and Second Grade Students," *Computers & Education* 40, no. 1 (2003): 71–94; Nicola Whitton, "The Place of Game-based Learning in an Age of Austerity," *Electronic Journal of E-Learning* 10, no. 2 (2012): pp249-256.
[8] Whitton, "The Place of Game-based Learning in an Age of Austerity."
[9] Richard Van Eck, "Digital Game-Based Learning: It's Not Just the Digital Natives Who Are Restless," *EDUCAUSE Review* 41, no. 2 (2006): 16.
[10] Mitchel Resnick et al., "Scratch: Programming for All," *Communications of the ACM* 52, no. 11 (2009): 60–67.
[11] Irene Govender, "From Procedural to Object-Oriented Programming (OOP)-Performance in OOP: An Empirical Study," *South African Computer Journal* 46 (2010); Volkan Kukul and Recep Çakır, "Exploring the Development of Primary School Students' Computational Thinking and 21st Century Skills through Scaffolding: Voices from the Stakeholders," *International Journal of Computer Science Education in Schools* 4, no. 2 (2020): 36–57.

When one considers the exponential growth of technology over the last four decades it is fair to presume that, in the near future, not knowing how to code might well be akin to being illiterate or innumerate today.[12] While it may invite a stretch of the imagination to suggest every job in the future will require programming skills; it certainly is not too bold to advocate for the importance of preparing learners to think, and view the world, in a new digital fashion.[13]By leveraging 14.6 million job postings the International Data Corporation (IDC), according to Anderson and Gantz, was able to identify the top skills required for the positions expected to have the highest growth, and wages between 2013 and 2020.[14] Residing at the top of the skill list was 'attention to detail' and 'problem-solving ability';[15] two linchpin principles of programming.[16]

In the sections that follow, the idea that learning can be facilitated by allowing learners to be agencies of game creators rather than consumers only so that they become the developers and it becomes the process and not the product is presented.

Games in Education

DGBL offers significant potential for increasing learner motivation while enhancing the effectiveness of teaching and learning.[17] In their study, Wang and Zheng, found that students in game-based learning groups performed better in content knowledge and showed higher self-efficacy than the traditional teaching group.[18] Yet computer game development has, in the recent past, required a high proficiency level in programming skills. This is a shortcoming that has hindered the adoption and advancement of new learning technologies and is augmented by educators perceptions of the technical expertise required for game development.[19] Today, however, that limitation has been removed with the creation and availability of game creation engines such as Scratch, Unity and Kodu. Now educators and learners alike, have powerful tools with which they can create intuitive virtual environments for the incorporation of game elements into the teaching syllabus.[20] This 'gamification' of curriculum content provides schools with an opportunity to address problems involving learner motivation and engagement.[21] Moreover, educators using games to support teaching are now able to create an atmosphere that is intuitively responsive to the needs of the learner.[22] Indeed if a game is well crafted,

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[12] Dan Crow, "Why Every Child Should Learn to Code," *The Guardian* 7 (2014).
[13] Crow; Willard R Daggett, "Preparing Students for Their Technological Future," *International Center for Leadership in Education* 1 (2010): 14.
[14] Cushing Anderson and John F Gantz, "WHITE PAPER SKILLS REQUIREMENTS FOR TOMORROW'S BEST JOBS Helping Educators Provide Students with Skills and Tools They Need," *International Data Corporation*, 2013.
[15] Anderson and Gantz.
[16] Sally Fincher, "What Are We Doing When We Teach Programming?," in *FIE'99 Frontiers in Education. 29th Annual Frontiers in Education Conference. Designing the Future of Science and Engineering Education. Conference Proceedings (IEEE Cat. No. 99CH37011*, vol. 1 (IEEE, 1999), 12A4-1; Jeng-Chung Woo, "Digital Game-Based Learning Supports Student Motivation, Cognitive Success, and Performance Outcomes," *Journal of Educational Technology & Society* 17, no. 3 (2014): 291–307.
[17] Séverine Erhel and Eric Jamet, "Digital Game-Based Learning: Impact of Instructions and Feedback on Motivation and Learning Effectiveness," *Computers & Education* 67 (2013): 156–67; Wen-Hao Huang, "Evaluating Learners' Motivational and Cognitive Processing in an Online Game-Based Learning Environment," *Computers in Human Behavior* 27, no. 2 (2011): 694–704; Marina Papastergiou, "Digital Game-Based Learning in High School Computer Science Education: Impact on Educational Effectiveness and Student Motivation," *Computers & Education* 52, no. 1 (2009): 1–12.
[18] Meiqian Wang and Xudong Zheng, "Using Game-Based Learning to Support Learning Science: A Study with Middle School Students," *The Asia-Pacific Education Researcher* 30, no. 2 (April 13, 2021): 167–76, https://doi.org/10.1007/s40299-020-00523-z.
[19] Simon Egenfeldt-Nielsen, *Beyond Edutainment: Exploring the Educational Potential of Computer Games* (Lulu. com, 2011); David Michael and Sande Chen, "Serious Game: Games Thar Educate, Train and Inform M," *Canada, USA: Thomson Course Technology PTR*, 2006; Whitton, "The Place of Game-based Learning in an Age of Austerity."
[20] Van Eck, "Digital Game-Based Learning: It's Not Just the Digital Natives Who Are Restless."
[21] Joey J Lee and Jessica Hammer, "Gamification in Education: What, How, Why Bother?," *Academic Exchange Quarterly* 15, no. 2 (2011): 146.
[22] Patricia Connell McWhorter and Sally Hudson-Ross, *Student-Centered Literacy Instruction in High School: I Want To, But How?* (National Reading Research Center, 1996).

a player may well spend hours engrossed in it trying to master the, progressively harder, challenges it contains.[23]

Broadly speaking, however, using computer games in teaching and learning can in many ways be problematic, despite the many, pedagogic and motivational benefits their use may offer.[24] Another major barrier is cost, both in terms of the monetary expense of purchasing licenses and associated hardware; and also in terms of time taken for educators to develop the skills needed to be able to evaluate, or create games and the activities to support them. There are also issues concerning, the acceptability of games within formal educational contexts.[25] Moreover, practitioners need to be convinced of the potential of the medium as well as its limitations; and be confident in the use of 'new technologies', such as games.[26] Nevertheless, in the current educational setting, where there is no need for niche topics, these general issues have been easily overcome due in part to the enthusiasm of the participants. This, of course, bares testimony to either; a) the appeal of a break from the normal mode of teaching, or b) a genuine attraction toward DBGL.

CONCEPTUAL FRAMEWORK

Game-based learning (GBL), that is, learning linked to an environment that enhances knowledge and skills, and activities that involve problem-solving, contributes to a sense of achievement.[27] In this regard, GBL, or DGBL for that matter, is largely viewed from a motivational perspective, as the emphasis is placed on the ability of games to engage and motivate.[28] By providing experiences that learners enjoy and want to continually engage in, DGBL seems like an obvious fit into many modern-day classroom environments.[29] Yet, even the most flawlessly created learning modules are doomed to fail if the learners are not motivated to learn. Motivation is perhaps, the most overlooked facet of instructional strategy.[30] From an academic perspective, literature shows efforts to recognise the specific elements that contribute to making games engaging and motivational tools.[31] These elements include — incentive systems, game mechanics, visual aesthetics, game narrative and musical score.[32]

With this in mind, current motivational theories focus on answering questions that emphasise a myriad of factors that shape motivation.[33] Theoretical frameworks designed, for understanding why learners 'decide to' learn a particular thing tend to focus on the intrinsic motivation of learners, that is, on learners doing activities for the sake of the activity rather than for some external reward. However, some contemporary motivation theories, such as Deci and Ryan's self-determination theory, argue that motivation cannot simply be viewed as a dichotomy of intrinsic and extrinsic factors but rather as a device that satisfies innate psychological needs for competence, satisfaction, enjoyment, interest and

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[23] Björn Berg Marklund, "Unpacking Digital Game-Based Learning : The Complexities of Developing and Using Educational Games" (University of Skövde, 2015), http://urn.kb.se/resolve?urn=urn:nbn:se:his:diva-11805.
[24] Whitton, "The Place of Game-based Learning in an Age of Austerity."
[25] Jeroen Bourgonjon et al., "Acceptance of Game-Based Learning by Secondary School Teachers," *Computers & Education* 67 (September 2013): 21–35, https://doi.org/10.1016/j.compedu.2013.02.010.
[26] D W Govender and M Dhurup, "An Exploratory Factorial Analysis of Teachers' Perceptions of Perceived Pedagogical Benefits of Adoption of Information and Communication Technology in Teaching and Learning," *Mediterranean Journal of Social Sciences* 5, no. 20 (2014): 1214.
[27] Awuor M. Dondo, "The Cooperative Model as an Alternative Strategy for Rural Development: A Policy Analysis Case Study of Kenya and Tanzania 1960-2009" (Clark Atlanta University, 2012).
[28] Jan L Plass, Bruce D Homer, and Charles K Kinzer, "Foundations of Game-Based Learning," *Educational Psychologist* 50, no. 4 (2015): 258–83.
[29] Gee, "What Video Games Have to Teach Us about Learning and Literacy."
[30] Athanasis Karoulis and Savvas Demetriadis, "The Motivational Factor in Educational Games," *D21* 2 (2005).
[31] Anderson and Gantz, "WHITE PAPER SKILLS REQUIREMENTS FOR TOMORROW'S BEST JOBS Helping Educators Provide Students with Skills and Tools They Need"; Plass, Homer, and Kinzer, "Foundations of Game-Based Learning."
[32] Gee, "What Video Games Have to Teach Us about Learning and Literacy"; Plass, Homer, and Kinzer, "Foundations of Game-Based Learning"; Kurt Squire, *Video Games and Learning: Teaching and Participatory Culture in the Digital Age. Technology, Education--Connections (the TEC Series).* (ERIC, 2011).
[33] Plass, Homer, and Kinzer, "Foundations of Game-Based Learning."

autonomy.[34] In this study, the Intrinsic Motivation Inventory (IMI), a model of the self-determination theory, was used as part of a conceptual framework to gauge intrinsic motivation values (see Figure 1). Along with scales from the other theoretical frameworks, scales from the IMI were used in the research instrument. The paramount concern was for learners to see themselves as being in control of their own learning experiences.

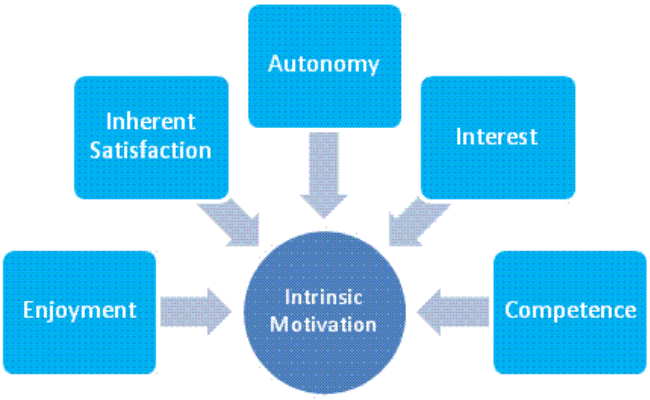

Figure 1: Conceptual framework

Constructivism in Computer Science Education

Constructivists create realities based on a myriad of, largely, experiential interactions influenced by an existing and, somewhat foundational knowledge base.[35] When applied from an educational perspective, a constructivist approach can be used to empower learners; positioning them at the epicentre of the learning process as equal and active participants in the quest for knowledge.[36] There are many learner-centered, constructivist approaches educators can use; DGBL is but one. Furthermore, the very nature of the Computer Science (CS) discipline, and by extension, the content addressed in the Information Technology (IT) syllabus, encourages the use of exciting and engaging methods of disseminating information to a tech-savvy youth — especially when one considers the nature of the internet-driven information age. But, while literature abounds detailing the many benefits of a learner-centered teaching approach; the reality at a grassroots level is that implementing DGBL correctly requires, to varying degrees, much work from the educator.[37] Additionally, educators must have a clear understanding of what it is they want their learners to internalize from each experience with the technology.[38] Both educator and learner should have a fundamental understanding of what is to be assessed and how.[39] This necessitates explicit planning from the facilitator. Moreover, the need for exemplary classroom management is crucial until learners acclimatise to the style of teaching or

[34] Richard M Ryan and Edward L Deci, "When Rewards Compete with Nature: The Undermining of Intrinsic Motivation and Self-Regulation," in *Intrinsic and Extrinsic Motivation* (Elsevier, 2000), 13–54; E L Deci and R M Ryan, "Intrinsic Motivation Inventory. Self-Determination Theory [On-Line]," 2003.
[35] Michael Orey, *Emerging Perspectives on Learning, Teaching and Technology* (CreateSpace North Charleston, 2010).
[36] Meurig Beynon, "Constructivist Computer Science Education Reconstructed," *Innovation in Teaching and Learning in Information and Computer Sciences* 8, no. 2 (June 15, 2009): 73–90, https://doi.org/10.11120/ital.2009.08020073; Peggy Cole, "Constructivism Revisited: A Search for Common Ground," *Educational Technology* 32, no. 2 (1992): 27–34.
[37] Yiasemina Karagiorgi and Loizos Symeou, "Translating Constructivism into Instructional Design: Potential and Limitations," *Journal of Educational Technology & Society* 8, no. 1 (2005): 17–27.
[38] Settachai Chaisanit, Uthairatt Phangphol, and Surachai Suksakulchai, "Game-Based Learning Technology: The Successful Implementation of Student-Centered Education," *International Journal of Digital Content Technology and Its Applications* 7, no. 8 (2013): 239.
[39] Marc Prensky, "Digital Natives, Digital Immigrants Part 2: Do They Really Think Differently?," *On the Horizon*, 2001.

see value in its implementation. Still, it must be noted that any effort to successfully prove worth in deploying a learner-centered approach is reliant on educator propensity for change.[40]

Issues concerning Scratch

Using Scratch requires equipment, where games are concerned, that is not standard such as headphones or speakers and video graphics cards. The cost implications can prove to limit many schools should they wish to deploy game development into their curriculum, even if they wish to do so using the Scratch platform. That said, Scratch games do present with a very rudimentary, if not juvenile, end-product that may not excite experienced gamers. More advanced learners may quickly become disinterested in the prospect of developing low-resolution applications that are not networkable or deployable to any mobile platform. Many children fancy themselves, as creators of the next Angry Birds or Clash of Clans — two mobile games that have seen multi-national corporations built upon their huge, worldwide success. But, developing mobile gaming apps is complex and expensive due to costs related to training, software licenses, and the deployment of apps to the mobile markets. In their defence, forward thinking developers at MIT (Massachusetts Institute of Technology) have addressed two critical flaws with the first edition of the Scratch software and version 2 is now capable of handling higher resolutions that allow for the online deployment, editing and play. Regarding the nature of this research of course these, and any other issues involving the Scratch platform, can very easily be overcome since the environment, location of the research and sample size are small. As a result, the predominant limitation in using Scratch might instead involve the choice between two divergent perspectives to using games for learning — instructionist and constructivist. What this means of course is that the issues concerning the Scratch platform are broader than simple speculation as to whether it provides the best environment for implementing DGBL. One must regard the Scratch platform for what it was designed for — a simple and easy-to-use introductory platform for learning how to code. Doing so might well prove any issues, or limitations depending on one's view, to be mute points rather than causes for concern. However, Scratch is easier to use than any other programming language in that: one does not have to memorise code, commands fit together like jigsaw puzzle pieces, they are colour coded, and error messages are rare.[41] In short, Scratch presents a viable, proven, and easy to use platform from which to test the hypothesis.

RESEARCH DESIGN AND METHODOLOGY

This research involved using a new teaching approach, DGBL, to teach IT to grade eight learners.

Study setting

The research was conducted in self-contained classroom settings at three high schools located in KwaZulu Natal, South Africa. The learners were on a five-period class schedule and the intervention adhered to the school system calendar. Curriculum content being taught during the intervention included critical concepts normally taught in the Grade 10 Information Technology (IT) syllabus — looping, branching and variable usage. The Scratch programming platform was used. Learners were observed for behaviour and engagement during regular class time for the week-long period. An online wiki was created and used as a Learning Management System (LMS) that provided a means for learners to catalogue their experience, engage with learning materials and other learners, and upload generated content. The LMS proved invaluable in providing the researcher with key insights into the learner experience. The following steps were followed in preparation for the intervention.

i. Preparing all four classes for participation, as a convenience sample, in this research.
ii. Establishing baseline Learning Outcomes (LOs) as characteristics for inclusion in all project designs for the allotted period.
iii. Incorporating DGBL into teaching and learning.

[40] Govender and Dhurup, "An Exploratory Factorial Analysis of Teachers' Perceptions of Perceived Pedagogical Benefits of Adoption of Information and Communication Technology in Teaching and Learning."
[41] Resnick et al., "Scratch: Programming for All."

iv. Observing and recording learning responses over the week-long period.
v. Gathering survey statistics (Interviews).
vi. Analysing and concluding results.

Data Collection Instruments

Using a mixed method approach, questionnaires, and focus group and individual interviews with learners and educators respectively were employed.

Participants

The participants in this study were Grade 8 learners from three Secondary Schools in KwaZulu-Natal. The classes were conveniently selected and consisted of learners with mixed abilities. Learners were taught, for a period of one week using the learner-centered DGBL method. Of the 105 learners officially invited to be a part of the research, 89 completed the questionnaire, and three groups of 6 took part in focus-group interview sessions. Three educators were involved in the study. The learners who participated had little to no prior programming knowledge using the Scratch platform. However, it was assumed that many would have been exposed to basic computer software suites, like Microsoft Office. Most of the Grade 8 learners appeared to be familiar with working with computers, before the teaching intervention commenced, as they were able to access and upload projects to the Scratch website.

Data analysis and interpretation

The data collected from the questionnaire was analysed using the statistical methods discussed below. The questionnaire was designed to determine the following information:

i. Background information detailing the experience with technology or computer skill set level for each of the participants.
ii. IT subject impression, with specific reference to coding, using scales adapted from the Intrinsic Motivation Inventory (IMI).
iii. The propensity toward GBL again using scales adapted from the IMI.
iv. Open-ended closing thoughts to elicit deeper qualitative responses concerning the learner experience.

The dataset was coded using *Google Apps* for factors associated with the research question. The analysis of the quantitative data involved breaking up complex data into manageable themes, patterns, trends, and relationships based on proven constructs. The learner participants were coded as participant1, participant2, and so on, while the educator participants were coded as ED1, 2 and 3. Analysing the qualitative data involved first producing transcripts of the interviews, after which, the data was searched for themes and categories that were associated with the conceptual framework, keeping the research question in mind.

Ensuring the trustworthiness of the study

To ensure credibility in this study, the researcher interviewed (using a digital voice recorder) the participants to gain insight into their experience with DGBL. Once the interviews were transcribed educators and learners were allowed to read the transcripts to ascertain whether they were a true reflection of their responses.

Ethical issues

During the planning and implementation of this research project due consideration was given to ethical issues in using learners as part of the data collection method. All ethical procedures were followed, which included obtaining ethical clearance from the university and the Department of Education as well as obtaining signed consent letters from the parents of the learners and the learners themselves.

FINDINGS AND DISCUSSION

Descriptive Statistics

Regarding perceived programming ability, the data showed a median score of 4.50 and a mode of 4.00. Participant responses recorded a somewhat positive view of their perceived ability (mean = 4.65; SD = 1.47) (Figure 2). This result may reflect that programming was being taught, to some degree, in some primary schools. Hence, more research needs to be done at a primary school level to investigate these claims further.

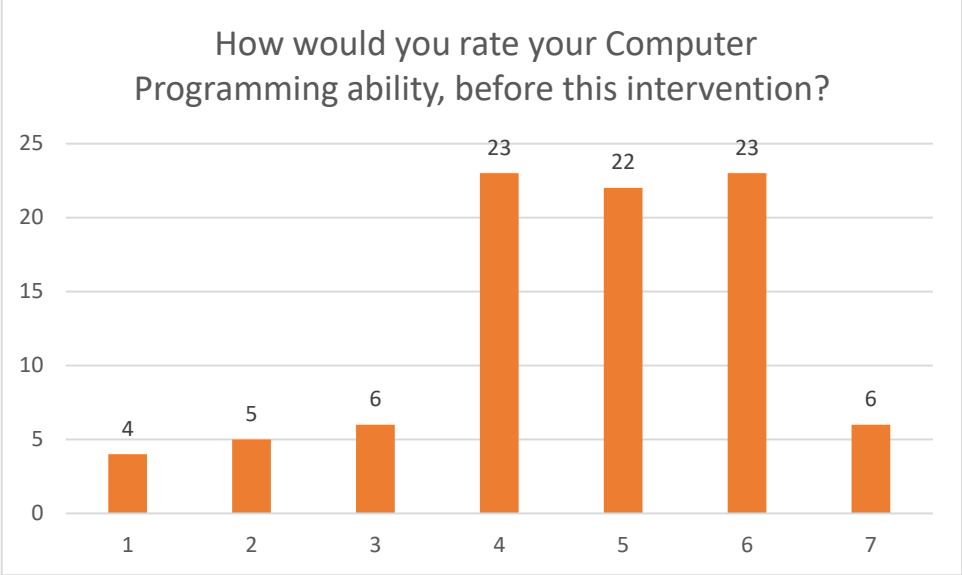

Figure 2: Background data of perceived ability prior to intervention.

The idea that children love playing digital games, was endorsed in the interviews and the entire sample associated game development with programming. Still, about 12.4% of the sample intimated that they had no idea what IT entailed prior to the intervention. However, the data also showed that a low number of participants (14) associated programming with high intellect. A possible explanation is that learners found they had been able to complete tasks with relative ease post-intervention. Also, it could mean that learners are no longer put off by the, perceived, academic exclusivity normally associated with computer programming. Interestingly, 24.7% did not envision themselves as game developers — rather, they associated the skill with '*geek-dom'* and *'nerd-ship*', two terms several participants shared during one of the focus-group interview sessions. Another interesting finding was that many believed they would have eventually developed the skills to be able to create games on their own with the "*many free courses available online*" (Participant 66). Almost a third, saw value in IT and dreamt of someday joining Google or any other giant tech company. This could, perhaps, be related to the fact that so many had prior experience with coding in primary school. But, while some saw value in learning IT even before entering high school (18% of the sample), many more indicated a disinclination towards pursuing a related career.

Before being exposed to programming using the Scratch interface, the prevalent choice selected by the participants was, “Not likely to pursue a career in IT” (1) as indicated in figure 3.

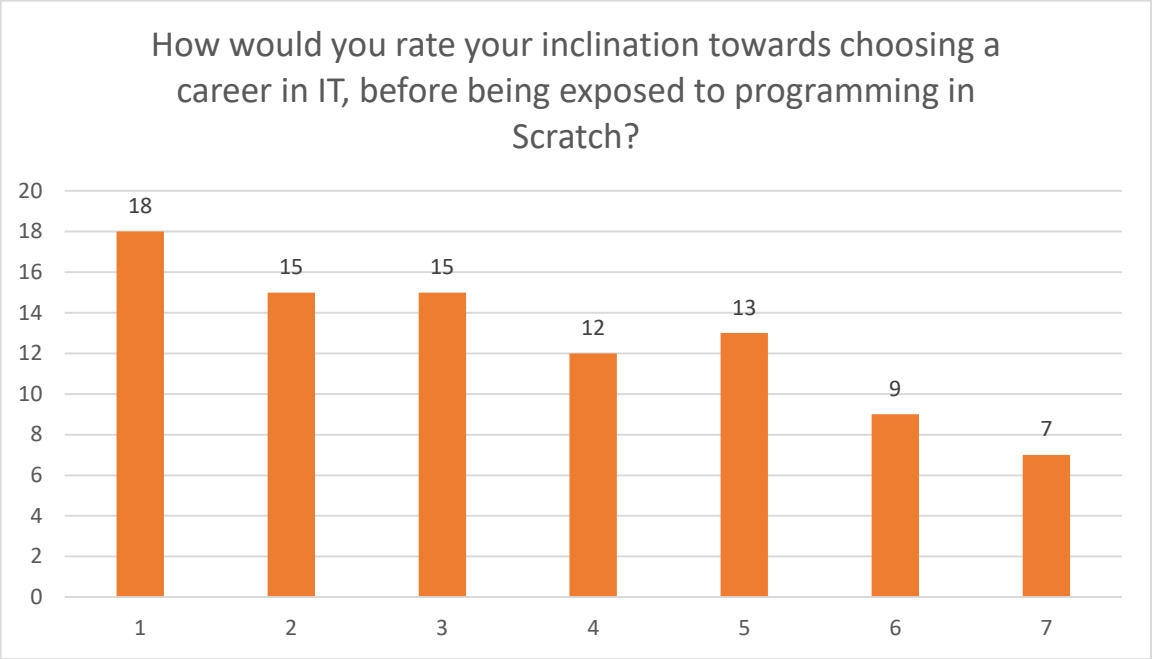

Figure 3: Learner inclination toward possible careers in IT, prior to intervention.

This view, however, did change post-intervention — where more than 23% of the sample reconsidered possible careers in IT (21 participants). Although 43.8% still thought it was interesting but remained fixed on their position of interest, 24.7% felt that they enjoyed IT more now than before. A combined 6.8% of the sample (6 participants) either still did not like IT or were simply indifferent to the prospect of it. While these results are encouraging, the reader is cautioned to regard them within the context of this study. This study involved participation from forward-thinking educators who teach in reasonably equipped computer labs. As has been shown, many learners entered high school with a reasonable level of IT ability. To be sure, research has shown this is not true of the broader population in South Africa. So, while learner perceptions of competence levels were largely positive, it must be said that without basic computer skills at their disposal it is unlikely other educators will be able to start to integrate ICTs successfully into the school curriculum.[42] Indeed, the very same logic can be applied in the instance where educators, as was the case in this study, look to do so while teaching complex CS concepts. The data certainly, does not speak to the view that all people perceive all things related to IT as being complex and exclusive. Moreover, while participants perceive a definite relationship between fun and game playing; there appears to be an unambiguous detachment from fun when the relationship with the game takes on the format of a developer rather than the player. In any event, the issues addressed in this section are discussed further in the next section. The reader is encouraged to remember that the findings, discussed thus far, reflect the participants' views on their competence level before engaging with DGBL or the Scratch platform. In the following sections, these results are juxtaposed with participant views and sentiments post-DGBL.

How can DGBL be used to enhance the teaching and learning of IT?

Throughout the intervention, participants showed tremendous aptitude and capacity in being able to self-study and work collaboratively. In addition, many displayed an eagerness to showcase their progress to both their peers and the researcher. While designing and developing original computer games can be, perhaps, beyond the expertise of some educators there exists an untold power in individual enthusiastic teaching staff.[43] Even when a good game design idea is used, only as a starting point, ill-equipped educators can do no wrong should they release their participants' creative,

[42] Govender and Dhurup, "An Exploratory Factorial Analysis of Teachers' Perceptions of Perceived Pedagogical Benefits of Adoption of Information and Communication Technology in Teaching and Learning."
[43] Whitton, "The Place of Game-based Learning in an Age of Austerity."

collaborative, and technical expertise by allowing them to translate the design into a working game. In the end, the participants reported that they did learn to create rudimentary games and that they enjoyed being able to do so. In the interviews, some reported that they had more success in understanding concepts by using the '*Hour of Code*' initiative, Code.org, at their own pace at home. Moreover, many reported that in making the games they indeed found a motivation to learn subject-related knowledge. However, this view should be seen in the context that participants were not taught said content using traditional teaching methods.

Therefore, they had no grounding from which to draw an objective comparison with being taught that content using DGBL. Nevertheless, others reported possible high-paying careers in game development and being paid to play games as being their motivation to learn how to code. Although this view may seem naive, it does somewhat speak to a wider issue that has plagued education in general. That is to say, the issue of real-world relatedness to content being taught at school. Indeed, using games to teach allows learners to learn through problem-solving or enquiry without the fear of failure or rejection. Games encourage learning through practice, repetition, mistake-making and experimentation.[44] But make no mistake, game creating can be a tediously long and complicated process that requires much ability in the educators trying to facilitate its use. Making mini-games to communicate a concept, as was done in this study, is much more manageable and appropriate for education than trying to create one of the typically large, commercial type games many are familiar with.[45] However, this can result in learners becoming bored with making, perceived, insignificant small games. But educators could address this issue and, if managed correctly, could journey together with their learners in learning how to create serious games. With the availability of commercial-grade game engines, such as Unity 3D and the Unreal Engine; and with the vast number of video tutorials available thereto related, it is not hard to imagine how the role of the educator can change in the modern world. From that of the *'fountain of all classroom-based knowledge*', to that of a '*creative classroom-based muse*'. Doing so could speak further to the ability of DGBL to merge education with the 'real world'. However, the reality of using DGBL with learners as designers, within a traditional institutional framework, might well prove less effective.

Overview of Learner Perception of DGBL

Table 1: Overall perceptions of DGBL

Scale	Composite Statement	Question Numbers	Computed Mean	Number of Items
Perceptions of initial ability	I was proficient in Computer use before coming to High School.	1 to 6 (exc.4)	4.38	5
Perceptions of the Scratch Interface	I feel comfortable and secure learning to code using Scratch.	7 to 22	4.65	16
Perceptions on using Games in T&L	I enjoyed learning this way and felt motivated.	23 to 32	4.88	10
The Role of the Teacher during class time	My teacher affirmed and supported me.	33 to 41	5.11	9
Perceptions of IT (and ability) after intervention	I now know more about the nature of IT and CS.	56 and 57	4.65	2
Overall Attitude			**4.77**	**52**

[44] Whitton, "The Place of Game-based Learning in an Age of Austerity."
[45] Van Eck, "Digital Game-Based Learning: It's Not Just the Digital Natives Who Are Restless."

The items of measurement to form categories that described participant perceptions of — their IT ability pre- and post-intervention, the Scratch interface, using games in teaching and learning, collaboration, and the role of the teacher in the classroom are reflected in table 1. About the participants' own awareness of their proficiency in basic computer skills and game development, this study endeavoured to support the notion that changes were never going to be overnight. The completion of the questionnaire, therefore, is a crucial point of departure in establishing an alignment between expectation and future success in the field of IT. In general, participants rated their IT ability higher than was expected. For those in this study, who did not have access to computer technologies; many were "*amazed by the amount they were able to learn in such a short period of time*" (Focus Group 3). This also corresponds well with the interview data, in that some felt the most challenging part of the intervention was trying to troubleshoot glitches rather than understanding content. As far as the Scratch platform was concerned, the questionnaire showed a mean score of 4.65 in its favour. It was decided to explore this issue further in the interviews. While many participants found the interface easy to engage with; others found working online with the Code.org interface to be more suitable. Moreover, interviewees felt that working in the class created a subtle atmosphere of pressure — especially if they did not complete tasks without aid or on time.

It was subsequently further emphasised that being able to work at home, and watching YouTube tutorials, certainly aided self-confidence since the biggest challenge some hi-flyers faced was "*trying to translate what's in your mind into an actual game*" (Focus Group 2). Not surprisingly, the overall impression of using games to aid teaching and learning was positive (mean = 4.88). Interestingly in the interviews, participants maintained that games *could* be used in other subjects as well due to their 'fun' characteristics. When asked in what guise they would suggest its use, some replied through the making of subject-related mini-games, others suggested the incorporation of game-like principles (by being able to re-write a test until they passed) and one suggested playing subject-related games. In response to a follow-up question, one interviewee suggested that making mini-games for other subjects "*opens up the possibility of learning coding and content*" specifically for that subject (Participant 75). This will encourage "*content-related researching ability*", he went on to add (Participant 75). Perhaps cross curricula assessment is an idea worth exploring where learners make bespoke mini-games for one subject and submit the code for assessment in IT. Though, as another interviewee pointed out, in response to this suggestion — it could very well mean double jeopardy for those who are not good at both subjects. In their response to the issue of the role of the educator during class time, participants generally felt that they were affirmed and supported during the entire process (mean = 5.11). This bodes well for the notion that the role of the educator, in a constructivist learning environment, should be that of a supporting one (mean = 4.94).

In a finding that supports the questionnaire, several interviewees said that they preferred being able to express themselves through their work without constantly being told what to do. It is thus apparent that DGBL, in the view of the participants, was successful in adding value to both the teaching and learning process. Furthermore, it was obvious that the Scratch interface was easy to pick up and that the content taught was easy to grasp; when taught in the context of the game dynamics. The overall attitude towards DGBL is reflected as having a mean score of 4.77. The analysis of the learners' responses to DGBL shows that much work still needs to be done to ensure total success. But, should practical and logistical considerations be properly addressed then DGBL, in the view of this sample, certainly does show potential as an educational innovation. The next step, as one of the participants stated, is "*to start developing mobile games; so (they) can get rich*" (Participant 1).

All the interviewees believed, DGBL using Scratch could be used to enhance both teaching and learning. One interviewee seemed acutely aware of the relationship between developing logical thinking and learning how to code; adding that Scratch can, "s*imply achieve (logical thinking development) by using blocks to assemble code, instead of text*" (ED1). Furthermore, he added, Scratch allows educators to "*keep the focus on the logic of programming rather than the syntax which normally frustrates learners*" (ED1). It is apparent that all interviewees see value in integrating technology in the teaching of IT. On that note, the interviewees indicated that technology could be used to aid content

delivery, pedagogy, and learner motivation to complete tasks. One interviewee indicated that "*learning can be supported by simulation and visual content; which helps learners to see content from a different perspective"* (ED3). Another interviewee indicated that "*learning gets better as learners get involved and take over the responsibility of learning*" (ED2). Perhaps it is this sense of direction, purpose and vision that sums up why DGBL is so successful.

While the results of this study, which was conducted in the pre-covid period, is crucial for engaged learning and increased motivation, the use of game-based learning has become even more relevant and appropriate in this post covid period. Given that the covid-19 pandemic was a catalyst for online and digital learning globally, DGBL is useable and more congruent in teaching IT post covid-19.

CONCLUSION

The present study was designed to better understand the effect of DGBL in teaching computer science or information technology to grade eight learners. Overall, it was determined that there exists a definite, almost intangible excitement factor associated with DGBL. Learners seemed particularly motivated by the fact that they could, through collaboration, be a part of the teaching and learning process. Throughout the study, learners seemed to relish the process of developing original games or providing an original idea. There is a certain appeal associated with games that give rise to a sense of achievement in realizing successful applications. All participants remained, throughout the intervention, intrinsically motivated to complete their game projects. Learning real-world skills that can equip one with the tools essential for success in a workplace, remains an undeniable and uniquely IT-related trait. Learning these skills while still at school, is a feat no other high-school subject can dare boast of. In the end, this mixed-method research mostly proved what the current literature states (that there is value in choosing to adopt or adapt new teaching innovations, that there are benefits in using DGBL and that learners want teaching and learning to be relevant).

The contribution of this study is two-fold. First, in teaching coding, computational skills were developed, which is becoming increasingly important in the digital age. Second, with the need for computational literacy growing, the question of how this skill can be effectively taught in schools is one of the key priorities in education. Hence, it has been shown that digital game-based learning promises to increase students' interest and motivation by providing affirmative and valuable learning experiences.

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COMPETING INTERESTS

The author(s) declare no competing interests.

DATA AVAILABILITY

The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

ETHICAL APPROVAL

The questionnaire and methodology for this study was approved by the Human Research Ethics committee of the University of D (Ethics approval number: HSS2083/017M).

INFORMED CONSENT

Informed consent was obtained from all participants and/or their legal guardians.

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