

The Effect of Digital Learning on the Academic Achievement and Motivation of Natural Sciences Learners: A Case Study of a South African Independent School

Sam Ramaila¹ & Nokubonga Peaceful Mpinga¹

¹ Department of Science and Technology Education, Faculty of Education, University of Johannesburg, South Africa
Correspondence: Sam Ramaila, Department of Science and Technology Education, Faculty of Education, University of Johannesburg, South Africa.

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Abstract

The South African basic education system is characterized by inadequate learner performance in science as a result of the provision of limited opportunities for learner-centred instruction. Digital resources can be used in science classrooms to enhance learner engagement and motivation. Digital resources include interactive game-based applications that can be used in online learning environments. This study examined the effect of digital learning on the academic achievement and motivation of grade 9 Natural Sciences learners in a South African independent school. The empirical investigation adopted a mixed method approach as part of a quasi-experimental design. Quantitative data was collected through the administration of questionnaires while qualitative data was collected through semi-structured interviews. A questionnaire based on the Skeletal System and a motivation questionnaire were administered as pre-tests and post-tests to establish the effectiveness of the use of digital resources as an instructional intervention on the academic achievement and motivation of grade 9 Natural Sciences learners. The empirical investigation is underpinned by the Cultural Historical Activity Theory as the underlying theoretical framework. Key findings revealed significant difference between the pre-test and post-test scores as a result of the use of digital resources as an instructional intervention. Theoretical implications for technology-enhanced teaching and learning are discussed.

Keywords: digital learning, digital resources, academic achievement, motivation

1. Introduction

Natural Sciences is a school subject in the Senior Phase as articulated in the Curriculum and Assessment Policy Statement (Department of Basic Education, 2011). South African schools still face the problem of inadequate learner performance in sciences as compared to other countries (Maree *et al.*, 2006). As a school subject, Natural Sciences provides a conceptual foundation for learners to study Physical Sciences in the Further Education and Training phase (Department of Basic Education, 2011). Innovative and evidenced-based solutions are required to overcome inadequate learner performance in science in South African schools. It is argued in this paper that innovative use of digital resources can serve as a panacea for inadequate learner performance in science. Digital resources are platforms or programs that can make it easier to perform tasks in online learning environments (Department of Health and Social Care, 2021). Digital tools can allow for flexibility in the classroom by providing a way for teachers to represent content using simulations with a view to enhance scientific literacy. Furthermore, digital resources can be used in blended classrooms where traditional and online learning are combined (Rafiola *et al.*, 2020).

The use of digital resources in teaching and learning can make the classroom more conducive for learning. Digital resources can promote learner independence by allowing learners to learn from sources other than the teacher. Digital resources also allow for flexibility, which means that learners can access learning material and information anywhere. Unfortunately, digital resources are never considered at the curriculum planning level in South Africa (Gonzales-Gomez & Canada-Canada, 2020). This predicament has significantly reduced the chances of using digital resources in the classroom. There is a positive relationship between the enactment of formative assessment and academic achievement especially if feedback is provided instantly. The use of digital resources can make it possible for teachers to administer formative assessment with a view to provide immediate feedback to learners. Enactment of formative

assessment enables teachers to identify skills that learners still lack (Elmahdi & Hattami, 2018).

2. Background

Careful selection and appropriate deployment of digital resources to achieve stipulated learning outcomes remains a key strategic imperative. The use of digital resources allows teachers to adopt learner-centred approaches. Kahoot is one of the digital tools that can be utilized to promote learning and help to improve the academic performance of learners. Kahoot is an interactive game-based application that is widely used in online learning environments. Kahoot can develop metacognitive abilities and teamwork and allows teachers to check the understanding of learners (Licorish *et al.*, 2018; Lin *et al.*, 2018; Wang & Tahir, 2020). Pedagogical affordances of the use of Kahoot have been acknowledged by Boden and Hart (2018). Edpuzzle is another type of digital tool that can be used in science classrooms. It is a free platform accessible to anyone with internet connection. Teachers can use Edpuzzle to suit their needs as it provides the flexibility to trim the video, insert a voice note and even replace the audio. Teachers can also see on the application if learners watched the whole video or if they repeated it. The Edpuzzle video can be directly assigned on google classroom and this makes monitoring easier (Wong, 2018). Edpuzzle can improve learner engagement with content (Shelby & Fralish, 2021). The use of Edpuzzle requires planning because the teacher needs to check that the video to be used is appropriate in terms of language and content (Cooke, 2018).

A considerable number of South African schools are under-resourced and this predicament makes it increasingly difficult for teachers to integrate digital resources in science teaching and learning (Hennesy *et al.*, 2015). When learners are motivated, they can process information better (Lee Chin Hin, 2011). This paper argues that coherent use of digital resources can improve academic achievement and enhance motivation of learners in science classrooms. However, there is a critical need for a formal empirical investigation examining the effectiveness of digital learning on the academic achievement and motivation of learners in science classrooms. The study is guided by the following research question.

What is the effect of digital learning on the academic achievement and motivation of Natural Sciences learners?

3. Theoretical Framework

The empirical investigation is underpinned by the Cultural Historical Activity Theory (CHAT) proposed by Engeström (1987) as the underlying theoretical framework. CHAT is essentially a socio-cultural and historical lens through which human activity systems can be holistically analysed (Engeström, 1999). As a socio-cultural and historical lens, CHAT served to provide insightful elucidation into the use of digital resources as an instructional intervention in a science classroom at a South African independent school. In terms of the structure of CHAT, the activity system consists of tools, subject, object, rules, community, and division of labor. Within the context of this empirical inquiry, the unit of analysis is essentially the use of digital resources as an instructional intervention in a science classroom.

4. Methodology

4.1 Research Design

The study adopted a mixed method approach as part of a quasi-experimental design. Quasi-experimental research is characterized by manipulation of an independent variable (Abraham & MacDonald, 2011). A quasi-experimental study is less expensive and requires fewer resources compared with individual randomized controlled trials or cluster randomized trials. A mixed method approach provides opportunities to answer research questions which require collection of qualitative and quantitative data (McMillan & Schumacher, 2014). The quantitative approach can be utilized to measure outcomes and the qualitative approach provides more information about why the specific outcomes are achieved (Li & Chu, 2021).

4.2 Sampling

The study involved 16 purposively selected grade 9 Natural Sciences learners at a South African independent school. The school is well-resourced and subscribes to the regulations of the Independent Examination Board. The participants were selected on the basis of their willingness to participate in the study.

4.3 Data Collection and Analysis

Quantitative data was collected through the administration of questionnaires while qualitative data was collected through semi-structured interviews. A questionnaire based on the Skeletal System and a motivation questionnaire were administered as pre-tests and post-tests to establish the effectiveness of the use of digital resources as an instructional intervention on the academic achievement and motivation of grade 9 Natural Sciences learners. The digital tools that were used as part of the instructional intervention are Kahoot and Edpuzzle. Kahoot is an interactive game-based application that is widely used in online learning environments. Edpuzzle is an application that involves the use of videos and voice notes. Quantitative data was analyzed using SPSS version 26. Qualitative data was specifically

collected to provide elaboration on trends that emerged from quantitative data. The interview data was transcribed and analyzed using both inductive and deductive thematic analysis (Braun & Clarke, 2012). The researchers followed the six phases of thematic analysis: familiarization with data; generation of codes; theme identification; theme consolidation; defining and analyzing the themes; and report production (Braun & Clarke, 2006).

5. Research Findings

Findings emanating from quantitative data

The pre-test and post-test results for the Skeletal System Questionnaire administered are shown in Table 1 below. There were significant differences between the pre-test and post-test scores for individual learners as a result of the use of digital resources as an instructional intervention. These significant differences between the pre-test and post-test scores strongly suggest that the use of digital resources as an instructional intervention in a science classroom appeared to be effective.

Table 1. Pre-test and post-test scores for the Skeletal System Questionnaire administered

Learner	Pre-test Score	Post-test Score	Difference in Score
1	71	86	15
2	57	93	36
3	67	80	13
4	79	93	14
5	71	79	8
6	57	87	30
7	64	71	7
8	57	86	29
9	57	86	29
10	57	86	29
11	36	86	50
12	57	79	22
13	93	100	7
14	36	93	57
15	21	57	36
16	57	64	7
Average	58.13	82.88	24.75

A paired sample t-test was performed to determine if there was a significant difference between the pre-test and post-test mean scores. The paired sample t-test results depicted in Table 2 below reflect a significant difference between the pre-test and post-test mean scores. This statistical significance underscores the need to seek innovative and evidenced-based solutions to address pervasive inadequate learner performance in science within the broader South African context. Coherent use of digital resources has pedagogic potential to provide much needed solutions. Effective and meaningful use of digital resources in science classrooms requires the enhancement of teacher professional capacity to undertake this strategic task. The onus is on the Department of Basic Education to provide meaningful platforms for progressive realization of this key strategic goal.

Table 2. Paired sample t-test results

	Pre-test	Post-test
Mean	58.13	82.88
Variance	277.58	124.78
Observations	16	16
Pearson Correlation	0.51	
df	15	
t Stat	-6.803	
t Critical two-tail	2.132	

The pre-test and post-test results for the motivation questionnaire administered are shown in Figure 1 below. The results strongly suggest that the use of digital resources as an instructional intervention can serve as a catalyst for enhancing the motivation of learners in science classrooms.

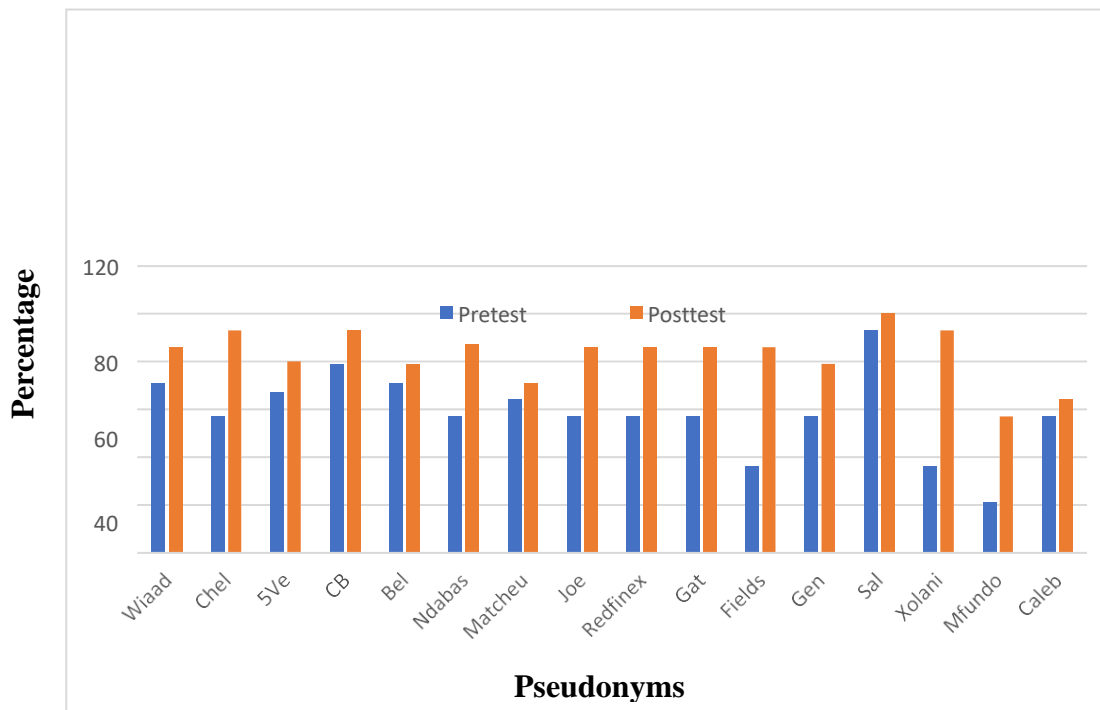


Figure 1. Pre-test and post-test scores for the Motivation Questionnaire administered

Findings emanating from qualitative data

Findings emanating from qualitative data were clustered according to the key themes that emerged during data analysis, namely: learner engagement, learner motivation, integration of digital resources in Natural Sciences teaching and learning, and challenges associated with the use of digital resources in science classrooms.

Theme 1: Learner engagement

The participants indicated that the use of digital resources promoted active engagement in classroom activities. This can be attributed to the interactive nature of the digital tools deployed. This sentiment is encapsulated in the following excerpt.

Because especially with the Kahoot ma’am because it was kind of a competition. So, you’re actually focusing on it to do better so that way you grasp the information.

In addition, the participants expressed fundamental appreciation of the learning opportunities provided by the use of

interactive game-based applications as the following excerpt indicates.

Because we the youth love games. So, it's like learning while gaming. It's a really nice learning opportunity.

The use of digital tools was perceived to provide optimal collaborative interactions between learners. Provision of instant feedback as part of the interactions was viewed as a key pedagogical advantage pertaining to the use of digital tools. This implies that the use of digital tools promotes the enactment of formative assessment which is crucial for the provision of pedagogically sound instruction in science classrooms in particular. These sentiments are captured in the following excerpt.

Because like, ma'am, even though it's like the same amount work, I prefer Kahoot because it's so interactive.

Furthermore, the use of digital tools was perceived to promote learner autonomy. Learners were able to take advantage of additional opportunities provided by the use of digital tools to revisit the content covered for purposes of consolidating their own conceptual understanding as the following excerpt illustrates.

The videos, I think watching videos is a good way of learning. Because it gives another perspective and maybe if you were not understanding what other teachers are explaining in class, you can find like a video in the YouTube channel, for example, let's find videos. And it helped me during online school when I did not understand how the concepts were explained.

Theme 2: Learner motivation

The learners were both intrinsically and extrinsically motivated when using digital resources in the classroom. The learners were particularly excited by the provision of immediate feedback when using Kahoot. The immediate feedback was a source of motivation for the learners as it enabled them to exercise control over their own learning thereby fostering meta-cognitive skills. The availability and easy access to information facilitated by the use of digital tools remained a key characteristic feature that was deeply appreciated by the learners. The learners indicated that competitive learning opportunities provided by the use of digital resources served to boost their confidence as these opportunities instilled eagerness to learn as part of a dynamic team. These sentiments are encapsulated in the following excerpt.

I think the immediate feedback we get is really important. The feedback enables us to learn. Availability and access to information is great and we learn together.

Theme 3: Integration of digital resources in Natural Sciences teaching and learning

The learners cautioned that careful selection and appropriate deployment of digital resources is of vital significance. It was pointed out that coherent use of digital resources ought to be characterized by deployment of meaningful instructional tasks and activities. These sentiments are encapsulated in the following excerpt.

I think also some teachers rely on it too much, because you just allow technology, they just think just sending a video will be enough. Sometimes the concepts must be explained in class, so they can also check you understand, is there another way I can explain that. So, like just going with autopilots, allowing technology to take over is a bit of a disadvantage for other students, including me.

This implies that meaningful use of digital resources in science classrooms requires enhanced technological pedagogical content knowledge.

Theme 4: Challenges associated with the use of digital resources in science classrooms

Access to bandwidth remains a key challenge afflicting coherent use of digital resources in science classrooms. Internet connectivity is a key requirement for effective use of digital tools in online learning environments. Prolonged use of digital resources may potentially lead to addiction on the part of learners. These sentiments are reflected in the following excerpt.

Sometimes the connectivity becomes poor and this affects the use of Kahoot. This disrupts the learning session. Otherwise, Kahoot is exciting! I feel like using Kahoot non stop!

6. Discussion

Key findings revealed significant difference between the pre-test and post-test scores as a result of the use of digital resources as an instructional intervention in a science classroom. Significant difference between the pre-test and post-test scores strongly suggests that the use of digital resources as an instructional intervention ought to be harnessed to enhance scientific literacy in science classrooms. In addition, significant difference between the pre-test and

post-test scores underscores the need to seek innovative and evidenced-based solutions to address pervasive inadequate learner performance in science within the broader South African context. Coherent use of digital resources has pedagogic potential to provide much needed solutions. The use of digital tools was perceived to provide optimal collaborative interactions between learners.

The participants indicated that the use of digital resources promoted active engagement in classroom activities. Qui and Lo (2017) explain that this engagement can be both behavioral (concentration and attention) or it can be cognitive (which is when learners make a mental effort to learn and achieve outcomes). The use of Kahoot promotes active learner engagement and enhance motivation of learners (Lin, Ganapathy & Kaur, 2017). Edpuzzle can improve student engagement with content (Shelby & Fralish, 2021). When learners are motivated and believe in their abilities, they learn and perform better (Bonney *et al.*, 2005). In addition, the learners expressed fundamental appreciation of the interactive learning opportunities provided by the use of interactive game-based applications.

Furthermore, the use of digital tools was perceived to promote learner autonomy. Digital tools can promote learner independence (Rafiola *et al.*, 2020). Learners took advantage of additional opportunities provided by the use of digital tools to revisit content covered for purposes of consolidating their own conceptual understanding. The learners were both intrinsically and extrinsically motivated when using digital resources. This is consistent with a research study conducted by Rafiola *et al.* (2020) which demonstrated that the use of digital resources can help to enhance motivation of learners and improve performance. Motivation is viewed by learners as an important factor in the learning process (Rafiola *et al.*, 2020). The learners were particularly excited by the provision of immediate feedback when using Kahoot. The immediate feedback was a source of motivation for the learners as it enabled them to exercise control over their own learning thereby developing meta-cognitive skills. According to Elmahdi *et al.* (2018), provision of immediate feedback motivates learners to perform better in assessments. In addition, learners are able to learn faster when they get a clear indication of how they are doing (Gregory, Uys & Gregory, 2014).

Coherent use of digital resources ought to be underpinned by deployment of meaningful instructional tasks and activities. Teacher professional competence on the use of digital resources is a key requirement for successful technology integration in teaching and learning (Pate, 2019). Access to bandwidth remains a key challenge afflicting coherent use of digital resources in online learning environments. Inadequate internet access has been identified as one of the major barriers to successful integration of digital resources in teaching and learning (Ghavifer, Kunjappan & Rasamany (2016).

Interpretation of key findings in terms of the adopted theoretical framework

As indicated earlier, the empirical investigation is underpinned by the Cultural Historical Activity Theory as the underlying theoretical framework. The concomitant activity system is illustrated in Figure 2 below.

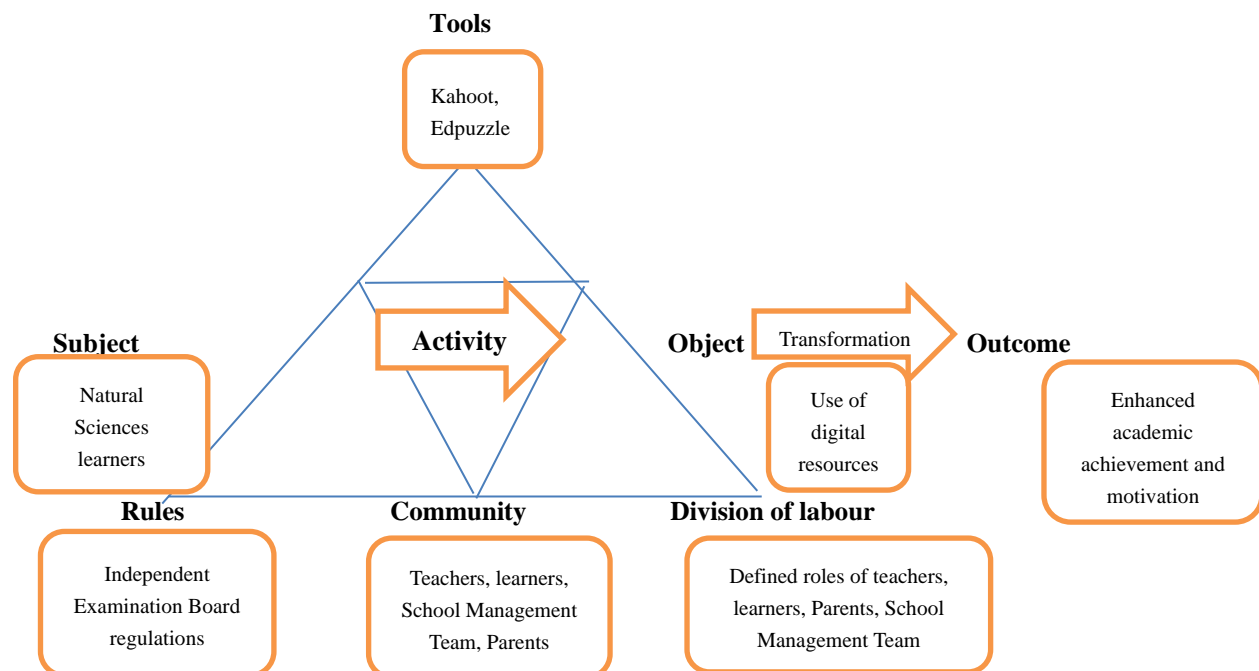


Figure 2. Activity system

The independent school that served as the research site was well-resourced. This implies that access to digital tools such as Kahoot and Edpuzzle was not a major challenge. Key findings revealed significant differences between the pre-test and post-test scores as a result of the use of digital resources as an instructional intervention in a science classroom. This observation underscores the need for the use of digital resources as an instructional intervention to enhance scientific literacy in science classrooms. The design and conceptualization of the instructional intervention as the key activity (unit of analysis) were carried out in a coherent manner before implementation. The roles of teachers, learners, School Management Team and parents were clearly defined to ensure seamless implementation of the instructional intervention. The use of digital resources brought about transformed learner experiences which culminated in enhanced academic achievement and motivation. The teaching and learning process evolved within the confines of the Independent Examination Board regulations.

7. Recommendations Arising from the Study

Effective and meaningful use of digital resources in science classrooms requires the enhancement of teacher professional capacity to undertake this strategic task. The onus is on the Department of Basic Education to provide meaningful platforms for progressive and sustainable realization of this key strategic goal. Teachers ought to be implored to harness pedagogical affordances of digital learning to enhance learner academic achievement and motivation in science classrooms by embracing pedagogic innovation. The advent of the Fourth Industrial Revolution presents meaningful opportunities for technology integration in science teaching and learning. Teachers face the key imperative to take advantage of these opportunities to foster meaningful teaching and learning through coherent deployment of digital resources in online learning environments.

8. Conclusion

The use of digital resources can be an effective catalyst for the enhancement of learner academic achievement and motivation in science classrooms. The pedagogical affordances of innovative instructional interventions ought to be harnessed to foster meaningful science teaching and learning. Coherent implementation of innovative instructional interventions can serve as a panacea for inadequate learner performance in science.

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