International Journal of Learning, Teaching and Educational Research
Vol. 24, No. 5, pp. 323-338, May 2025
https://doi.org/10.26803/ijlter.24.5.17
Received Mar 28, 2025; Revised May 11, 2025; Accepted May 17, 2025

Teachers' Understandings and Practices of Using Smartboards as Digital Tools to Teach Grade 12 Life Sciences Genetics

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Abstract. Teaching genetics makes learners understand the inheritance of characteristics and genetic disorders in organisms, as well as the impact of genetic engineering in human daily lives. Traditional methods of teaching genetics are ineffective in improving learners' understanding. The paper reports a study that investigated teachers' utilisation of smartboards as digital tools to teach genetics concepts to learners. Technological Pedagogical Content Knowledge framed the study to measure the teachers' knowledge and skills in integrating technology into the teaching of genetics concepts. Through a qualitative research approach four grade 12 life sciences teachers were purposefully selected from high schools in the West Rand District in Gauteng Province, South Africa. Each teacher was observed teaching genetics concepts to examine how they use smartboards as digital tools to teach grade 12 learners. Each teacher was also interviewed using open-ended interview schedule to explore teachers' understandings of the affordances of smart boards as digital tools to teach grade 12 genetics concepts to learners. Data was analysed thematically, and three themes emerged relating to Life Sciences teachers' use of smartboards to make genetics concepts accessible to grade 12 learners; Teachers' understanding of the affordances of smartboards as digital tools to teach genetics; and Teachers' challenges in the use of smartboards. The study highlights the potential for smartboards to enhance learner understanding of abstract concepts and ultimately improving performance in assessments.

Keywords: Genetics; grade 12 teachers; life Sciences; smartboards; technological pedagogical content knowledge

1. Introduction

Genetics is a field of life sciences that deals with studying genes, genetic variation, and heredity in living organisms (Moll & Allen, 2014). Genetics education helps learners to understand the principles of life sciences and to develop a deeper meaning of the social context using scientific lens (Ezechi, 2021). Therefore, it is imperative that learners should be developed to enable comprehension of genetics concepts and to deal with matters related to socio-scientific issues embedded in genetics which are prevalent in their communities and families (Ezechi, 2021; Machova & Ehler, 2021). According to Moll and Allen (2014), teachers and learners perceive this topic in life sciences as being difficult to learn due to the abstract nature of the concepts. Such difficult is articulated in the National Senior Certificate (2022) Life Sciences Diagnostic Report which showed how grade 12 learners perform poorly in questions on abstract genetics concepts. These difficulties emanate from learners' failure to use the correct terminologies and computing the correct genetic crosses amongst other challenges (Department of Basic Education [DBE], 2022). Previous researchers (e.g. Mussard & Reiss, 2022) found that learners tend to develop misconceptions due to lack of understanding of genetics concepts mostly because of new terminologies and failure to holistically connect and conceptualise these abstract scientific concepts.

It is therefore important for teachers to utilise teaching and learning tools that provide illustrations and visualisation to learners. The current trend is that due to influx of learning technologies, learners are being exposed to even more science visualisations to communicate ideas (Daniel et al., 2018; Trelease, 2016). One such common technology readily available in some classrooms is the smartboard, which Mata, Josef, and Hertwig (2016) acknowledged as important in improving the quality of teaching and learning. The multimedia features on the smartboard such as 3-dimensional animations, increase learner engagement and promotes learner-centred teaching approach (Ndlovu, 2015), thus improving conceptual understanding of abstract concepts such as genetics.

In the current study we argue that whilst teachers utilise the smartboards in their day-to-day teaching and learning activities, they however fail to optimally utilise it due to lack of understanding of its technological affordances and skills thereof. This argument is authenticated by a study by Korkmaz and Cakil (2024), where teachers perceived smartboards as useful tools to use in class but failed to maximise their potential due to insufficient knowledge on operating the digital tools and selecting relevant features to use in their teaching. Previous studies did not explore the basis of teachers' failure to effectively utilise smartboards but mostly focused on their attitudes and lack of technological knowledge. The current study is concerned about the basis of teachers' practices, and their understandings of the affordances of smartboard as a digital tool to enhance the teaching and learning of abstract genetics concepts.

The study therefore sought to answer two research questions: 1. How do teachers use smartboards as digital tools to make genetics concepts more accessible to grade 12 learners? 2. What are teachers' understandings of the affordances of smartboards as digital tools to make genetics concepts more accessible to grade 12 learners? Data collection involved interviewing participants and observing them teaching genetics concepts to grade 12 life sciences learners using smartboards. Through this qualitative approach, important data which provide the 'lived experiences of teachers' in terms of what they understand about smartboard use and their actual classroom practices when teaching genetics concepts, were collected. Understandably a larger sample could have yielded findings for generalisation, however the findings from the four participants provided a holistic depiction that represents what happens in similar teaching contexts locally and globally.

2. Literature review

To provide both theoretical and conceptual understanding of the topic at hand, literature was reviewed in terms of the teaching genetics concepts; use of smartboards to teach the concepts; and challenges previously identified in research on the use of smartboards.

2.1. Genetics concepts in grade 12 Life Sciences

The Curriculum and Assessment Policy Statement (CAPS) stipulates that learners should be equipped with knowledge on dominant and recessive genes and alleles; inheritance and variation; monohybrid crosses; sex chromosomes; mutations; genetic engineering; and paternity testing and DNA finger printing (DBE, 2011). The genetics taught at grade 12 level provides learners with tools to comprehend biological diversity, evolutionary principles, and hereditary patterns in organisms (Fauzi & Ramadani, 2017). Given the critical role that genetics plays in both the daily lives of organisms and basic human functioning, teachers should develop instructional tools, practices, and teaching resources that extend beyond traditional textbooks to promote effective conceptual understanding of genetics (Angraini et al., 2022). However, previous research has showed that genetics concepts are taught using traditional teaching approaches (Kazeni & Onwu, 2013), which result in learners performing badly in genetics questions in grade 12 examinations (National Senior Certificate Diagnostic Report, 2022). The abstract nature of genetics concepts contributes to instructional challenges which results in not only learners developing misconceptions but teachers as well (Moll & Allen, 2014; Biyela & Ramaila, 2021). Notably, Aivelo and Uitto (2018) attributed learners' barrier to understanding abstract biological concepts to teaching styles used by teachers, but teachers' inadequate subject matter knowledge in terms of genetics may be the cause of learner misunderstandings during lessons.

It is our contention in this paper that the use of smartboards could alleviate these challenges as using illustrations and visualisations in an interactive manner through smartboards, may lessen teachers' explanations. Vlckova Kubiatko, and Usak (2016) found that formal operational thinking is needed for learners to make connections of genetics concepts. These authors content that this can be achieved through technology integration to identify misconceptions. Computer simulations are crucial in teaching genetics as they allowed the introduction of new independent variables that are not easily accessible to learners if teachers only use explanations (Vlckova et al., 2016). Though these findings emerged from the context of Czeck, they also reflect the circumstances in similar education contexts. Notably, developing nations such as South African, have deliberately made significant technological advancements through the provisioning of smartboards in some schools, to improve teaching and learning in various subjects, life sciences included. The following section explores the use of smartboards.

2.2 Use of smartboards as digital tool in teaching genetics concepts

Smartboards, also known as interactive whiteboards, have been introduced in schools as a pedagogical intervention to ensure effective and efficient teaching and learning takes place in the classrooms (Chigamba, 2021). Globally, the efficacy of smartboards in the classroom has been the subject of national and international literature (Bayar & Kurt, 2021; Ndwandwe, Ramaligela, & Mtshali, 2024). Previous studies (e.g. Bayar & Kurt, 2021), reported that the use of smartboards improves learner achievement and engagement in science classrooms. Based on the possibilities of smartboards improving the performance of learners in South Africa, the Department of Basic Education equipped some schools with smartboards and provided initial training of teachers on the integration of ICT tools such as smartboards in schools.

Because genetics education relates to real life-contexts which requires authentic teaching and learning; thus, learners need to be active participants in an interactive lesson. According to Chigamba (2021) the smartboard enables the teacher to develop flexible lesson plan, which caters for active learner engagement with scientific concepts during a lesson. Teachers can facilitate physical interaction and autonomous learning by allowing learners to utilise Google Tabs and other smartboard features such as digital libraries to access and explore e-resources on specific genetics concepts (Ndlovu, 2015). Learners can work in pairs and share knowledge solving Mendelian genetics problems simultaneously on the smartboard, using the dual display feature, which Mohanarajah as early as 2003 noted as crucial in increasing learner participation and fostering cooperative and collaborative learning.

One of the affordances of using the smartboard as a learning tool to teach genetics concepts is that it accommodates auditory, visual, and kinaesthetic learning styles of learners thus promoting enduring learning of genetics concepts (Akar, 2020). Studies done by Giles and Shaw (2011) and Parmeter (2012) indicate that when teachers embrace the integration of smartboards in their science classrooms, they create a learning environment that enables learners to collaborate with each other in learning scientific concepts including abstract genetics concepts. This can improve learner understanding of genetics concepts and problem-solving using Punnett squares or test cross methods resulting in performance improvement (Parmeter, 2012). It is important to explore some of the challenges associated with the use of smartboards.

2.3 Challenges faced by teachers when using the smartboards to teach genetics concepts

The availability of smartboards in classrooms has not translated to optimal usage, primarily due to teachers' inadequate exploitation of this instructional digital tool. Key barriers to effective smartboard utilisation include lack of smartboard training for teachers, teachers' negative perceptions, and pervasive lack of confidence in integrating the digital tool into instructional practice (Korkmaz & Cakil, 2024). According to Korkmaz and Cakil (2024), teachers lack the enthusiasm to use smartboards to teach scientific concepts due to lack of technological knowledge to exploit the affordances provided by smartboard features. Lack of technical skills in operating the smartboard, which is caused by insufficient or no teacher training provided to the teachers (Al-Faki & Khamis, 2014) pause a huge challenge to effectively teach using this digital tool. Studies by Tefo (2020), Mihai (2020) and Mtshali (2021) revealed typical challenges in the South African context. These include insufficient teacher development in using the smartboard that hinders its integration as an instructional digital tool in the classrooms, as well as lack of internet connectivity. These authors pointed out that teachers who lack technological competency often lack confidence in using the smartboard to teach concepts and resort to the traditional ways of teaching, which defeats the purpose of digitalising the classrooms. Teachers' attitudes and beliefs about the integration of smartboard as a technological tool, also impact on how they teach biological concepts using a smartboard (Deng et al., 2014).

2.4 Theoretical Framework

The study employed Koehler and Mishra's (2009) Technological, Pedagogical and Content Knowledge (TPACK) framework as the lens to examine how grade 12 Life Sciences teachers integrate instructional technology into their lessons when teaching genetics concepts. The TPACK framework helps in examining the prerequisites in classroom practices that are essential for effective integration of technology when teaching (Young, Young, & Shaker, 2012). This framework is based on Shulman's (1986) model of Pedagogical Content Knowledge (PCK), which highlights that for effective content delivery in the learning process, teachers need to have well informed pedagogical knowledge and content knowledge of the subject matter taught. The TPACK framework, as explained by Koehler and Mishra (2009), indicates that when technological tools are used effectively, they can provide learners with a deeper understanding of the subject matter being taught. These tools (smartboard included) are endowed with specialised capabilities. The framework includes three main interconnected knowledge domains: Pedagogical Knowledge (PK), Technological Knowledge (TK), and Content Knowledge (CK) that formed the basis for the seven TPACK components, as illustrated in the figure that follows.

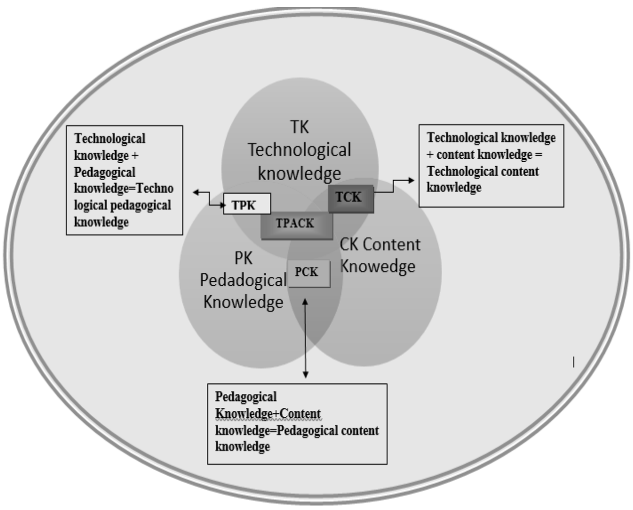

Figure 1: TPACK framework components (Mishra & Koehler, 2006)

Teachers should be proficient in the three knowledge domains and the four knowledge components to effectively teach using technological tools such as smartboards (Schmidt et al., 2009). In the current study, the TPACK framework is used to examine and evaluate teachers' knowledge and pedagogy when using the smartboard as a digital tool to teach genetics concepts to learners. Specifically, the framework will help in evaluating the teachers' CK, PK, TK, and TPACK when teaching genetics concepts using smartboards.

3. Methodology

3.1. Research design

The study adopted a qualitative case study research design (Creswell & Creswell, 2018). This qualitative approach is supported by the interpretivist paradigm and the TPACK framework. According to Creswell and Creswell (2018), qualitative approach allows the researcher to gain a deeper knowledge of the phenomenon under study by exposing the researcher to the different perspectives of participants. In this case, the researchers obtained valuable insights about teachers' TPACK when using smartboards as digital tools to teach genetics concepts to grade 12 learners.

3.2 Selection of participants

Purposeful sampling technique (Nyimbili & Nyimbili, 2024) was used to select four grade 12 life sciences teachers to participate in the study. The teachers taught grade 12 Life Sciences in four separate schools within the Gauteng West District in South Africa. Though the four schools were equipped with smartboards, they were in township communities which are disadvantaged in terms of the socio-economic backgrounds of the learners they enrolled. Hence, they were referred to as 'non-fee paying' schools. The teacher participants were presumed to be knowledgeable about the concepts of genetics and equipped to teach using smartboards as each teacher's classroom had a functional smartboard. The teachers had also taught grade 12 life sciences for more than 5 years, indicating their familiarity with the genetics concepts taught at grade 12 level.

3.3 Data collection

To collect data, each teacher was observed whilst teaching various grade 12 concepts in genetics whilst using a smartboard. As evidenced in Chigamba's (2021) study, observations create an opportunity for the researcher to observe what is being done and the behaviours of the participants. In the context of the current study aspects such as teachers' documentation of the use of smartboard in their lesson plans; smartboard features utilised; learner interactions and engagement with the smartboard or the teaching and learning materials on the smartboard; teachers' levels of knowledge of genetics concepts taught; and their abilities to utilise the smartboard for meaningful learning. Whilst each lesson lasted 45-60 minutes, the number of observed lessons for each of the four teachers were dependent on data saturation. Because the researcher was a non-participant observer during the lessons (Eldh et al., 2020), the first author managed to video-record the lessons and wrote detailed field notes for later analysis. The capturing of data from the field notes and lesson observations was done using the predetermined aspects (Tiba, 2018).

After lesson observations, each of the observed teachers was then interviewed using open-ended interview schedule to explore their understanding of the use of smartboard to teach concepts in genetics. Interviews also sought teachers' insights and experiences of using the digital tool by probing on observed episodes during the lessons. The number and duration of each teacher's interview were determined by the principle of data saturation, ensuring that sufficient depth and breadth of information were captured. Specifically, one teacher participated in two interviews, each lasting 45 minutes, as additional probing was necessary to reach saturation. In contrast, the remaining three teachers were each interviewed once for 60 minutes, as their responses provided comprehensive insights without the need for follow-up. This approach ensured that data collection was both rigorous and efficient, allowing for a thorough exploration of the research questions while avoiding unnecessary redundancy. To enhance data accuracy, the interviews were audio-recorded in conjunction with documented notes, as note taking alone (Strydom & Bezuidenhout, 2014) could be insufficient for capturing teachers' responses. In addition, both researchers observed the video recordings of the same lessons and listened to the recordings of the interviews for the four teachers, transcribed them separately, and compared their notes to ensure accurate capture.

3.4. Data analysis

Qualitative data from lesson observations and semi-structured interviews were coded after transcription of the video- and audio-recordings. The data was then analysed using Saldana's (2016) manual coding method and patterns and themes were obtained. Each teacher was treated as a case and the data was analysed separately to check for how the teacher utilised the smartboard when teaching concepts in genetics and then made connections with the responses in the interviews. Notes from the lesson observation and semi-structured interviews were used to formulate codes to identify trends and themes, which were then labelled to classify the data in line with the views of participants (Sutton & Austin, 2015). Codes obtained from each teacher's interview responses and practices in the observed lessons taught, were then analysed together. Thereafter a qualitative comparative analysis (Cooper & Glaesser, 2012) was done to check how the four teachers' practices and understandings compared, as a way of finding explanations for the similarities and differences. The three themes formed from the analysis provided responses in addressing the study's research questions.

3.5 Trustworthiness issues

To ensure the trustworthiness of the data, the participants were provided with the transcribed data and the interpretation of the findings to allow for member checking. This is in line with Birt et al. (2016) who considered member checking as a validation process to ensure credibility of the findings. In coding the data, the first author and the second author discussed and came up with a code book in accordance with Ritchie et al. (2022)'s code book development process which was then used in coding data from both lesson observations and interviews with teachers.

4. Research Findings

The study's findings are structured into three key themes that illustrate teachers' practices and understandings regarding the use of smartboards for teaching genetics concepts. To provide a clearer connection between specific findings and individual teachers, pseudonyms were assigned to the four participating teachers: Austin, Lindiwe, Melokuhle, and Gladys. This approach ensures that the analysis remains both detailed and contextually relevant while maintaining the participants' anonymity.

4.1. Theme 1: Life Sciences teachers' use of smartboards for making genetics concepts accessible to grade 12 learners

During lesson observations, the researchers requested documentation from the four teachers to review their plans for integrating smartboards into their genetics lessons. While the documents showed that teachers had planned for various genetic concepts, they lacked specific details on how smartboard features would be used to enhance learning. As a result, the smartboards were underutilised, failing to provide the interactive learning experience they are designed for. Instead, teachers primarily relied on PowerPoint presentations to illustrate genetic concepts such as monohybrid crosses, pedigree diagrams, blood groups, dihybrid crosses, sex-linked disorders, and genetic engineering.

Whilst the illustrations projected on the smartboard articulated the relevant information learners were meant to acquire, the engagement in the classrooms was limited. This shows teachers' shortfalls in PK, which made them to fail to design appropriate learning activities to engage learners. It was evident that learners struggled to comprehend concepts as they failed to make some of the pertinent connections or relationships between genetics concepts. This was depicted by the learners' failure to answer teachers' questions seeking learner confirmation of the flow of concepts from gametes formation through meiosis, identifying processes responsible for variation in offsprings, as well as how sex-linked diseases resulted. Though in interviews teachers mentioned how smartboard made concepts more accessible to their learners, it was however not translated in the actual classroom based on the observed lessons. For instance, Austin said, *"I use the smartboard to teach monohybrid crossing and the pedigree diagram, to shown inheritance of genes as well as genetic engineering."* The teacher's efforts were not realised as his learners failed to engage in discussions which were meant to show learners' understanding of the illustrations and notes provided on the smartboard.

As a way of facilitating learners' engagement, in one of the lessons, among the participants, only Lindiwe used the Power-point feature incorporating video animations to consolidate her lesson on genetics concepts. The following is what she said during interviews.

Lindiwe:

> *"When I use videos, the smartboard assists me in re-emphasising concepts that I presented with power-point slides to the learners and better their understanding of concepts since the videos also have animations of the abstract concepts like inheritance of blood groups, since we use letters to*

> *explain genotypes. The learners also learn together as they solve genetic crossing problems in pairs on the smartboard."*

There was however no evidence of learners directly engaging with smartboard features to solve genetics concepts. The teacher played the video animations and did not stop from time to time to engage the learners or explain to unpack the genetic processes unfolding in the lesson. In a way the teachers missed opportunities to engage the learners but only focused on illustrating processes, forgetting that learners may not have the capabilities to comprehend the concepts as intended in the animation. From the teacher's point of view, the video was meant to consolidate the concepts taught and not to be used to elaborate the content. This is a case of teachers' lack of both PK and TK.

In the observed lessons teachers showed knowledge of the genetics concepts taught. However, the processes which unfolded in the classrooms showed that though they possessed high levels of content knowledge as evidenced by the explanations they made and the sequencing of concepts on some notes jotted on the whiteboard, their use of smartboard showed otherwise. This shows not only teachers' limited TK but also TPACK. None of the teachers provided learners with an opportunity to interact with the material of the smartboard, instead they constantly referred to diagrams in the learners' textbooks. Though an attempt was made by some of the teachers, such as Gladys and Austin, Lindiwe's ability to operate the smartboard, insert USB drives, and use of the PowerPoint presentation features, were commendable. Additionally, video animations she showcased to teach monohybrid crossing stimulated learners' interest as evidenced by the learners' effort in asking questions. However, there were observed limitations in the teachers' TPACK, as they underutilised the smartboard features to enhance the teaching and learning of genetics concepts. As such, the observed lessons were more teacher centred with little attempt to enhance learner involvement in the teaching and learning process.

An example of underutilisation of the smartboard was observed in a lesson when Melokuhle notably projected a single slide displayed throughout the lesson. The single slide was used to explain sex-linked genetic disorders without providing even the illustrations showing the consequences of the disorder in the form of diagrams of the chromosome activities. Due to lack of technological skills, the teacher did not explore additional features of the smartboard to facilitate deeper understanding of abstract concepts by learners when teaching recessive alleles on sex-chromosomes.

4.2. Theme 2: Life Sciences teachers' understanding of the affordances of smartboards as digital tools to teach genetics concepts to grade 12 learners

The findings from the interviews conducted with the four grade 12 life sciences teachers showed a positive attitude towards using the smartboards to teach concepts in genetics. The teachers had strong advocacy for the use of smartboard as digital tools due to its audio-visual representation capabilities, which they said tend to accommodate learners' different learning styles. Findings revealed that teachers utilise smartboards to teach genetics concepts because the smartboards stimulate learner interest, boost engagement, and facilitate classroom discussions.

Though teachers acknowledged this smartboard affordance, their practices portrayed otherwise. Gladys even went further to elaborate that smartboard can be used to actively engage learners in class discussions that may assist her to identify and address learners' misconceptions. Such responses show that teachers understood how useful the smartboards are as digital tools in teaching concepts in genetics. Furthermore, Melokuhle explained that the snipping tool feature on the smartboard enables her to capture and enlarge screenshots of diagrams, allowing a more nuanced understanding of genetics concepts particularly when discussing differences between allele and gene on a chromosome.

The teachers also mentioned the role of a smartboard in assessing learners. They indicated that the smartboard can be used to conduct baseline assessments of topics and concepts that are pre-requisites to genetics concepts to be taught. Teachers pointed out that the use of a smartboard also enables collaborative learning as learners can solve a genetic cross on the smartboard in pairs though this was only observed in one class during lesson observations. One of the participants, Gladys explained her limited use of a smartboard in assessments.

Gladys:

> *"For assessment, honestly, I do not use the smartboard. I use it to drill past question papers during revision, where I display a question on blood groups for example and learners write then we discuss and do corrections and skills of how to tackle that question on genetics."*

When probed further on why teachers failed to utilise interactive features of a smartboard since they were aware of their existence, teachers mentioned many excuses and challenges that are presented in the next section.

4.3. Theme 3: Life Sciences teachers' challenges in the use of smartboards when teaching concepts in genetics

Despite the grade 12 Life Sciences teachers' enthusiasm for using the smartboard to teach genetics concepts, the findings indicated that teachers experience difficulties in implementing the integration of smartboards into their lessons. Such challenges impede teachers' continued use or willingness to explore more features and utilise this digital tool in their lessons. From the teachers' responses during interviews, one of the factors that hinders the use of the smartboard to teach genetic concepts is that the smartboard software tends to expire unexpectedly, a lesson gets disrupted, or the smartboard displays a 'no signal notification' prior to the commencement of the lesson. The teachers pointed out that when this happens, the touch sensor of the smartboard tends to malfunction or become unresponsive during a lesson which then obstructs the teaching and learning process. This was evident during an observation of Lindiwe's lesson where the smartboard upon being powered ON, it displayed a screen with a 'no signal' notification. The teacher was assisted by a learner in the grade 12 class who managed to restart the smartboard. This technical error affected ten minutes of the duration of the lesson, and the teacher had to resort to writing on whiteboard while the smartboard was rebooting.

The difficulties have a negative impact on the lesson preparations done by the teachers. Teachers clearly indicated that they become discouraged because sometimes they go to great length in preparing lessons which require the use of a smartboard, and only to abandon their plans during the lesson due to these technical issues. As a result, the teachers indicated that they resort to using the more traditional approach of teaching using the whiteboard, that is through PowerPoint presentations which do not require much preparation. The study noted that the teachers lack technical knowledge of how to explore the smartboard features and how to operate the smartboard when it malfunctions or has software problems, and this contributes negatively to teachers' confidence in utilising the smartboard to teach genetics concepts to learners. These sentiments were echoed by the following teachers' responses during interviews:

> Austin: "*The smartboard doesn't get serviced after installation, so it sometimes freezes, and software stops working and when that happens, I do not even know how to resolve it.*
>
> Lindiwe: "*…. the smartboard software sometimes expires out of the blue and needs updating and that time as a teacher I have planned to use to explain sex-linked pedigrees, for example.*
>
> Gladys: "*Sometimes you get in class and want to use, ah you see the smartboard written no signal.* "

From these teachers' responses and what was observed in certain instances in some lessons, teachers become frustrated due to lack of support in addressing the challenges they face.

In the interviews the teachers were asked about the training they received in terms of smartboard operation and use of interactive features that provide meaningful teaching and learning in their lessons. The findings revealed that teachers received smartboard training to equip them with technological skills on how to operate the smartboard. They however pointed out that the training provided was not sufficient and covered a lot of technological content in a short period of time. According to the teachers' responses, the smartboard training they received was ineffective in equipping them with the knowledge and skills to identify and utilise appropriate smartboard features for use to teach specific concepts especially the abstract ones such as concepts in genetics. Therefore, the teachers did not have confidence and technical knowledge to explore other smartboard features. One teacher indicated that she did not receive any official training on smartboard integration, and this poses a challenge when it comes to her exploring smartboard features to teach genetics concepts.

Because of this inadequacy, teachers resort to traditional methods of teaching, resulting in inadequate utilisation of smartboard features to teach genetics concepts. The teachers expressed their disappointment in that, their failure to use a digital tool which is in their classrooms, reflects badly on their skills as teachers and yet they have no control over it. On further probing, it emerged that teachers who joined the teaching profession post the installation year of smartboard did not receive any formal smartboard training. As such, teachers resort to only using the smartboard features they perceive easy to use and with less challenges when teaching such as the use of PowerPoint slides and writing on the Smart-Notebook. The following are some of the responses from teachers, which show the reasons for teachers not utilising the smartboards meaningfully.

> Lindiwe: "*Of course, because we didn't get training on dealing with technicalities but only on content integration, which was also not enough because I do not know how to operate the smartboard when it freezes while teaching.* "
>
> Melokuhle: "*For me it becomes frustrating as I did not receive any formal training on the smartboard and there is no ICT expert to consult frequently at school about the smartboard features to use when teaching genetics concepts or when I experience challenges.* "
>
> Austin: "*I only use it for basics such as the PowerPoint at the start of the lesson presentation because I do not know how to use the other nice apps it has and do not want the learners to look at me otherwise when I cannot manoeuvre the other smartboard apps.* "

The findings show that the teachers understood the affordances of smartboards as digital tools to make genetics concepts more accessible to grade 12 learners. However, the lack of training or inadequacy in the training received, militated against their efforts to use the digital tool more meaningfully to enhance learner interactions and understanding of the concepts in genetics.

5. Discussion

The teachers in this study demonstrated a sound understanding of the genetics concepts they taught and recognised the potential benefits of incorporating interactive digital tools, such as smartboards, to enhance their instruction. However, while previous research has highlighted that the abstract nature of genetics often contributes to instructional challenges, leading to misconceptions among both learners and teachers (Moll & Allen, 2014; Biyela & Ramaila, 2021), the teachers in this study did not exhibit such misconceptions. This suggests a strong conceptual grasp of the subject matter.

Despite their recognition of smartboards as valuable tools for making genetics concepts more accessible to grade 12 learners, the teachers were unable to fully leverage the affordances of this technology, showing their limitations in TK. The primary impediment was a lack of sufficient professional development in using smartboards effectively. Consequently, they were unable to implement what Chigamba (2021) describes as the potential of smartboards to facilitate flexible lesson planning and active learner engagement with scientific concepts. This finding underscores the critical gap between theoretical knowledge of digital tools and their practical application in the classroom.

The impact of inadequate teacher training on the effective use of smartboards is well documented. Al-Faki and Khamis (2014) found that teachers who lacked proper training faced significant challenges in integrating digital tools into their instruction, a finding that resonates with the experiences observed in this study.

However, unlike the teachers in Deng et al. (2014), whose attitudes and beliefs about smartboard integration directly influenced their teaching, the four teachers in this study did not exhibit resistance to using smartboard. Instead, they acknowledged the pedagogical affordances of the technology and expressed a willingness to utilise it.

The key issue, therefore, was not reluctance but limited technological proficiency, which directly impacted their instructional practices. Koehler and Mishra's (2009) TPACK framework emphasises that for technology to enhance learning effectively, teachers must develop a deep understanding of its integration into pedagogical strategies. The findings of this study align with this argument, revealing notable deficiencies in teachers' technical skills, including unfamiliarity with smartboard features, difficulties in troubleshooting malfunctions, and an overall lack of confidence in using the technology to teach abstract genetics concepts. These challenges are consistent with Matemera's (2022) findings, which highlight technical barriers as a major obstacle to the successful implementation of smartboards in science education.

Ultimately, while the teachers in this study were conceptually competent and receptive to technological integration, their limited training and technical expertise constrained their ability to maximise the smartboard's instructional benefits. This highlights an urgent need for targeted professional development programmes focused on equipping teachers with both the technical and pedagogical skills necessary to effectively integrate smartboards into genetics instruction.

6. Conclusion

Key findings from the study showed that teachers understood the affordances of smartboards in making genetics concepts more accessible to grade 12 learners. However, despite not having received adequate training in operating smartboards and utilising their interactive features, teachers persisted in using the most accessible functions to support learner understanding. This persistence highlights both the potential of smartboards in science education and the critical gap in teacher technological development. We therefore recommend targeted and continuous technological training for teachers, both at the initial teacher education level and for in-service teachers, to ensure they can fully leverage digital tools in the classroom. In conclusion, the participants in this study actively worked to complement the efforts by the Department of Basic Education to digitalise schools for improved learner performance. However, the success of these initiatives depends on more than just the availability of technology such as smartboards, teacher technological development and sustained technical support are essential in realising the goals of the curriculum and ensuring that digital resources translate into meaningful educational outcomes. The study contributes to the theoretical knowledge by providing the basis of teachers' limitations to effectively utilise smartboards. Based on the findings, a suggestion is made that future research may explore the impact of smartboard use on learners' understanding of the concepts taught and compare the use of smartboards across different science subjects.

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