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Students' Perceptions of Digital Games for Learning Chemistry in Tanzanian Higher Learning Institutions

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Abstract: *This study explored students' perceptions of digital games for learning chemistry at higher learning institutions (HLIs) in Dodoma, Tanzania. We used a descriptive research design to collect both qualitative and quantitative data from selected HLIs in Dodoma, Tanzania. The study results indicate that students hold positive attitudes toward digital games in chemistry learning, citing multimedia content, alignment with diverse learning styles, and self-paced learning, while simulation emerged as most games used, with physical chemistry identified as most topic learned through these tools. Moreover, the result shows that students' behavioral intention to use digital games was driven by personal beliefs about usefulness, including feedback, autonomy, and simplification of complex concepts. Notably, students perceived digital games as individual learning tools than collaborative platforms, with subjective norms playing little role in their adoptions. The major challenges identified were limited awareness and access to existing digital games for chemistry learning, which hindered adoption and use. This study contributes to the existing body of literature on digital pedagogy by exploring perceptions on the use of digital games for learning among higher education students, area that has not been sufficiently investigated. The findings have important implications for improving the learning of STEM subjects, which are perceived as difficult due to their complexity and abstract concepts. The study further addresses the challenge of limited access instructional resources, which persist in many schools in Africa, Tanzania in particular. The research also contributes to the existing body of knowledge regarding the use of educational technology in the Tanzanian context, which can inform future educational practices and policies.*

Keywords: *Digital Pedagogy; Digital Games; Digital Game-Based for Learning; Chemistry learning*

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1. Introduction

Digital games have emerged as effective interactive learning tools that make learning more engaging, interactive and enjoyable (Kaimara et al., 2020). Such interaction is facilitated by the combination of entertainment with educational values which foster both skills acquisition and feedback on the achievement (Cunha et al., 2019). This has potential to inspire students to tackle challenging concepts while promoting problem-solving skills and competition and motivates them to become active learners (Amzalag et al., 2024). This is consistent with Garcia & Barrientos (2023) who pointed that digital games are often integrated with scaffolding elements that promote personalized learning experience. These elements allow students to revisit and revise their understanding, viewing errors as opportunities for learning, which can be considered beneficial for learning complex concepts in chemistry.

In chemistry education, games such as Hydrocarbons Chem-Rush, Snakeleev, and Quimi-Crush help students in learning compounds, nomenclature of organic compounds and memorizing elements of the periodic table. These games were reported useful to simplifying Chemistry abstract concepts into a tangible and engaging learning (Cunha, Gonçalves, & Sarinho, 2019 ; Lutfi, Aftinia, & Eka Permani 2023). In higher learning institutions (HLIs) context across the globe, there are promising examples showcasing their potential. (Zhao et al., 2022) developed NEWTON to visualize the programming concepts in illustrative and entertaining scenarios. Similarly, (Miljanovic & Bradbury, 2020) created GidgetMT to enhance first year programing lab. In Africa, Nolwazi, the Zulu War (Randle, 2025), Usiku Game, Cowries Adventure and Kiro'o Games (African game industry, 2025), are example of digital games that are available in the market and they have shown promise in enhancing multimedia learning, indigenous language and cultural representations. In Tanzania, research of (Mtebe & Christina 2024; Manyilizu, 2023; Lee & Choi, 2020; Ongoro & Mwangoka 2019; Godfrey & Mtebe, 2018) many digital games focuses primary and secondary education. While these games demonstrate opportunities for promoting students engagement, motivation, and problem solving skills, studies have shown that they often prioritizing entertainment over cognitive process (Kaimara et al., 2021), that games often target a single set of learning outcomes preferably by designer (Kim et al., 2018; Mtebe & Christina 2024;). Therefore, to successful implementation this instructional approach necessitates a clear understanding of student's perceptions of digital games for effective chemistry learning, as these perceptions shape adoption and application of these digital tools in their studies.

1.1 Problem Statement

Numerous studies have explored students' perceptions of digital games for learning across various disciplines worldwide. The study conducted by Asniza et al. (2021) reported that pre-university students perceived Kahoot! as relevant and useful tool for fostering active participation with interaction and communication emerged as key motivators. Similarly, Sun et al. (2021) found that scaffolding in digital game enhanced students' knowledge, motivation and emotions. Moreover, Udeozor et al. (2022) and Gakime et al. (2025) found enthusiasm for digital learning games facilitated by factors such visualization and engagement while prior gaming experience correlating with performance, even though performance did not translate learning outcome. In Tanzania most of research on digital learning has focused on students perceptions of general e-learning regarding to academic performance, access to information and decision-making (Kayanda et al., 2020; Shaame & Kondo, 2024; Mohsini et al., 2024), while limited attention is given to students perceptions of using digital games for learning particularly in chemistry in HLIs, thus presenting a gap that the current study sought to address. This study investigated students' perceptions of digital games for learning chemistry. We used the Theory of Reasoned Action (TRA) as a framework to analyses student's perceptions. The TRA, posits that an individual's intention to perform a certain behavior, such as using digital games for learning, is shaped by attitude toward the behavior (i.e., belief about the potential outcomes of using digital games) and the subjective norms (perception of how important people such as peers and teachers) view their behavior (Ajzen & Fishbein, 1975). These student perceptions are essential for designing effective games in learning chemistry revealing both opportunities and barriers to its successful integration into chemistry learning within Tanzanian HLIs. Therefore, our research was guided by the following questions:

RQ1: How do students perceive the use of digital games for learning chemistry among HLIs in Tanzania?

RQ2: To what extent do students in higher learning institutions in Tanzania use digital games for learning chemistry courses?

2. Literature Review

2.1 Integration of Digital Games for Learning in Higher Learning Institution

HLIs are experiencing a substantial technological transformation though the adopting of digital solutions teaching and learning process, decision-making, access to materials, and overall practice improvement (Kayanda et al., 2020; Ndibalema, 2025). Among these innovations, digital games have gained attention for their ability to motivate and engage learners. Evidence shows that digital games enhance creative skills, critical thinking, and knowledge transfer while nurturing positive attitudes toward learning (Behnamnia et al., 2020). They guide students toward a specific goal through action and experience thus creating opportunities for experiential learning (Kucher, 2021). Their integration with supportive and low-anxiety environment promoting learner-centered learning (Cunha et al., 2019). This is consistent with, Tokarieva et al. (2019) stress that educational games promote active participation, reflection, and discussions, thereby improving conceptual understanding and memory retention. This evidence collectively suggests that digital games serve as powerful pedagogical tools that align with student centered approach and can enhance chemistry learning. Nevertheless, in Tanzania most of studies in digital games for learning targets lower education levels (Godfrey & Mtebe; 2018; Lee & Choi, 2020; Manyilizu, 2023; Mtebe & Christina, 2024). The limited use of digital games in HLIs can be attributed to the perception that these games are suitable for young learners.

2.2 Student's Perception on the Use Digital Game for Learning

Successful implementation of digital games largely depends on students' perceptions. Asniza et al. (2021) reported that pre-university students perceived Kahoot! as relevant and useful tool for fostering active participation with interaction and communication emerged as key motivators. Similarly, Sun et al. (2021) found that scaffolding in digital game enhanced students' knowledge, motivation and emotions. Gakime et al. (2025) found enthusiasm for digital learning games, with factors such visualization and engagement while prior gaming experience correlating with performance, even though performance did not translate learning outcome. Similarly, Ogunbodede et al., (2023) reported positive perceptions and high use of digital resources, however, challenges such as poor internet, weak retrieval skills and limited time persisted. Likewise, Adeozor et al. (2022) showed that fun, engagement and curriculum relevant drove adoption of digital games in engineering education though students resisted their use for assessment.

In Tanzania, on student perceptions largely focuses on mobile technology and learning management systems (LMS). For instance, Kayanda et al. (2020) reported performance expectancy and facilitating conditions influence students' intention to use academic information systems though adoption is hindered by poor functionalities, inadequate support lack and limited training. Ndibalema (2025) found that LMS support self-directed learning while identified digital illiteracy and limited cultural readiness to embrace technology. Likewise, Mohsini et al. (2024) found that perceived usefulness, ease of use, management support, and student attitude strongly affect eClass adoption. Moreover, Shaame and Kondo (2024), showed MOOCs improve performance by providing access to variety sources. These findings suggest that students are generally open to education technologies and potential to adopt digital games when they are useful, easy to use and supported.

2.3 Theoretical Framework

This study employed the Theory of Reasoned Action (TRA) (Fishbein & Ajzen,1975) as a framework to understand HLI students' perceptions of using digital games for learning chemistry. TRA is widely applied to explain human behavior across various domains, including technology adoption. It posits that an individual behavioral intention to adopt and use technology is shaped by their belief about the consequences of the behavior and their perceptions of social expectations i.e., subjective norms (Fishbein & Ajzen, 1975; Rahmayanti et al., 2021). However, actual performance depends of behavior control (Ajzen & Schmidt, 2020). This implies that for an individual to use actual use digital games depends on skills, resources and the available opportunity. In the context of this study, several factors can influence HLI students' intention and behavior toward using digital games for learning chemistry. These include the perceived benefits such as increased motivation, engagement, and relevance to chemistry content; contextual factors including autonomy, freedom, and competition; and perceived academic outcomes, like improved understanding of concepts, knowledge transfer, and better performance. Conversely, challenges like limited competence, infrastructure, mismatch with curriculum, game difficulty, and costs may play adoptions, as illustrated in Figure 1.

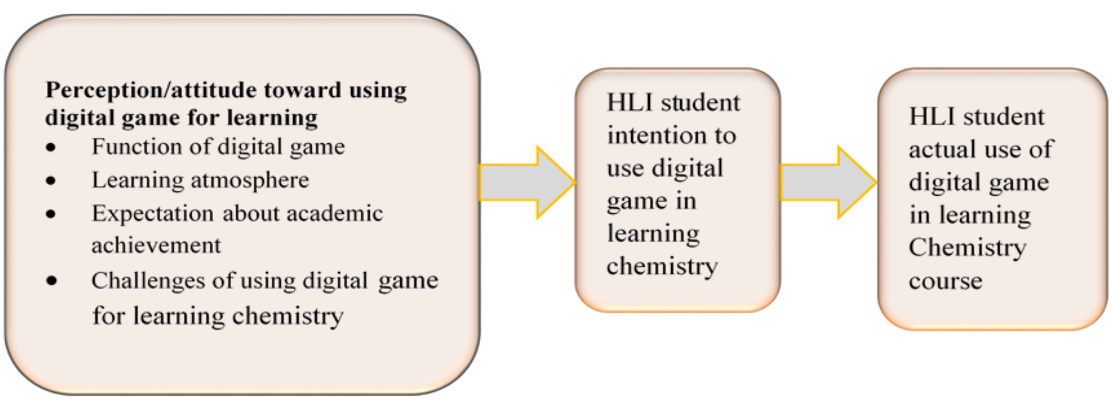

Figure 1. Conceptual framework, constructed by modifying TRA Model and Reviewing Literature

3. Methodology

3.1 Study Area

This research was carried out in HLIs located in Dodoma, Tanzania, specifically, St. John's University of Tanzania, and Mineral Resource Institute. Although Dodoma hosts numerous HLIs, but only three HLIs currently offer chemistry-related programs making the selected institutions relevant for this study. Moreover, St. John's University of Tanzania represents HLIs accredited by the Tanzania Commission for Universities (TCU) and private owned, while the Mineral Resource Institute represents HLIs operated under by the National Council for Technical and Vocational Education and Training (NACTVET) and public owned. The selection of these two HLIs was therefore strategic, ensuring representation across both regulatory bodies and ownership structures.

3.2 Research Design

This study employed a descriptive design to gather both qualitative and quantitative data on HLI students' perceptions of using digital games for learning chemistry courses. This design enables the researcher to comprehensively analyze participants' views on the topic, incorporating both qualitative insights and quantitative measurements (Creswell & Clark, 2018). Qualitative data provided rich insights into students' perspectives, experiences, knowledge, and challenges regarding the use of digital games in their chemistry learning. Quantitative data collection provided numerical insights into the extent of digital game utilization and students' perceptions of their usefulness. This method allowed generalization of findings to a broader population by indicating the prevalence of specific perceptions and behaviors.

3.3 Sampling Strategy

The study population included students from HLIs (both public and private) operating under two regulatory bodies: The Tanzania Commission for Universities (TCU) and the National Council for Technical and Vocational Education and Training (NACTVET). Multistage sampling technique was used to select HLI students from both TCU and NACTVET. Multistage sampling involves selecting samples through two or more stages of random sampling, typically based on the hierarchical structure of natural clusters within a population (Sedgwick, 2015). This approach was appropriate for our study due to the inherent clustering of HLIs by regulatory authority and ownership. In the first stage, HLIs were stratified into four categories based on their type (university and college), regulatory bodies (TCU and NACTVET), and ownership (private and public) to ensure representation and minimize selection bias with subcategories. In the second stage, institutions were randomly selected from each stratum, whereas St. John's University of Tanzania (a private university operating under TCU) and the Mineral Resource Institute (a public college operating under NACTVET) were chosen to represent the diversity of the HLIs in Dodoma, Tanzania. The sample size was determined using Yamane's (1967) formula as illustrated in equation 1.

Equation 1, formula for determining the sample size

$$n = \frac{N}{(1 + N(e)2}$$

Where: *n* stands for sample size,

N stands for the study population

e stands for margin error.

The total number of students taking Chemistry in the stated institution is 210, 98 from MRI and 112 from ST John University of Tanzania.

Therefore, the sample size of this study was;

n= 210/ (1+210 (0.05) ^{2})

n= 137

We determined the initial sample size to be 137 respondents. To maintain a balance between the two institutions, we divided the respondents equally, considering the institution with the larger student population. However, during the questionnaire collection process, some students either did not return their questionnaires or completed them inadequately and The final sample size was 129 students, 37 from Mineral Resource Institute and 92 from St. John University. Furthermore, purposive sampling was applied to identify key informants, with selection criteria such as class representatives and students with outstanding performance in chemistry in two academic semesters

3.4 Data Collection Methods

The study employed interview, the qualitative data collection tool for generating in-depth information regarding the perception and challenges regarding the applications digital games for learning chemistry (Knott et al., 2022). The researcher prepared the interview in Kiswahili language for easy communication as most students are native speakers. Likewise, quantitative data were collected using a survey with Five-Point Likert scale (ranging from *1 = strongly disagree, 2= disagree, 3 = neutral, 4= agree, to 5= strongly disagree)*. The study observed research ethics by obtaining research permit from the St. John University of Tanzania and the Mineral Resources Institute, respectively while confidentiality and participants' consent maintained in the entire research process.

3.5 Data Analysis

Qualitative data were analysed using content analysis. This analysis method enabled researchers to analyses students perceptions into meaningful patterns and categories (Juma et al., 2023). In addition, (Lyhne et al., 2025) noted that content analysis is appropriate method to explore complex social phenomena from its natural settings. The study followed Denscombe (2014) six steps for content analysis including data preparation, defining unity for analysis, generating codes, organizing code into categories and reviewing and presenting results. The study applied a multilingual review translation method to preserve meaning of original responses. On the other hand, quantitative data were descriptively analysed using the Statistical Package for Social Sciences (SPSS) software (version 25). Students' perception about digital games usage for learning chemistry were measured using Likert-scale items. The analysis involved generating frequencies and percentage to identify trends and patterns within the responses.

4. Results and Discussion

4.1 Demographic Information of Respondent

The findings in Table 1 show the majority of students approached aged between 18-27 years (91.5%). This is mainly the appropriate age for students to be enrolled in a higher learning institution in the country recently. Regarding gender, the results show that the participation of males and females was nearly equal by 65 (50.4 %) and 64 (49.6%) respectively.

Table 1: Demographic Information of Respondents

Institutions	Mineral Institute	Resource	St. John University		Total	
	37		92		129	
Gender	Male	Female	Male	Female	Male	Female
	17 20	37	48 44	92	65(50.4%)	64(49.6)
Age	18-27	28-37	18-27	28-37	18-27	28-37
	34	3	83	9	117(90.7%)	12(9.3%)

The study results demonstrated that demographic information such as gender and type of HLIs demonstrated comparable level of engagement and perceived benefit as shown in Table 1, suggesting subjective norms within this context do not shape attitude or usage pattern. Students' decisions to engage with digital games appear to driven more by personal beliefs about their usefulness that than perceived expectation from peer and institutional culture. Alongside, the study observed a clear gap in the availability of games tailored to align with the curricular and pedagogical needs in HLIs in Tanzania context, thus future research could focus on designing and developing games contextualized to this context.

4.2 Digital Games Usage for Chemistry Learning

The study sought to investigate students' utilization of digital games for studying chemistry courses. We examined the specific digital resources employed, and the motivations behind their usage, and explored specific digital games context of chemistry education. Figure 3 illustrates diverse kinds of digital games used by students for learning chemistry. It was found that 58 out of 178 students' responses use quiz or trivia games. This response is due to its ability to help students practice various types of problems, reactions, formulas, and calculations enjoyably. Moreover, 48 of students use simulations. Simulations offer a valuable tool for bridging the gap between theory and practice as they function as virtual laboratories enabling students to manipulate variables and visualize three-dimension chemical structures. This finding aligns with Manyilizu (2023) emphasized the role of simulation in fostering interactive and immersive learning experiences in chemistry education. In addition, Gakime et al., (2025) who reported positive perceptions regarding on visualization and interactive features of digital learning environment even though they identified disconnection between perceived usefulness and actual implementation. This finding suggests that realization of behavioral indentation depends on the availability of enabling infrastructure and social support to act on intentions. Conversely, 23 of students reported never having used digital games for chemistry learning. This indicates a limited awareness of the potential benefits of digital games as a learning tools

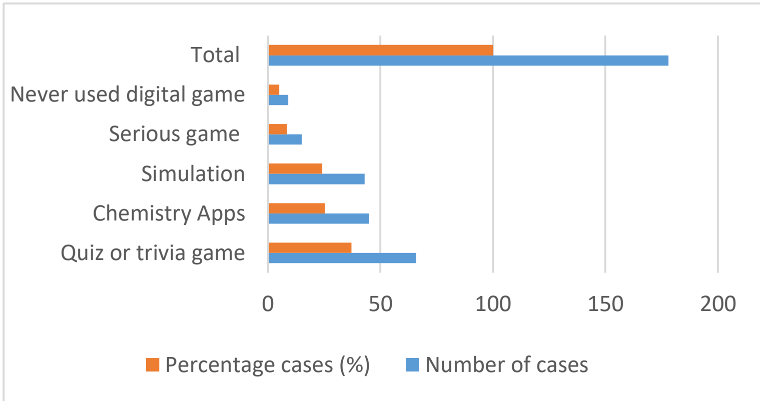

Figure 2: Kinds of Digital Games Used by Students for Learning Chemistry

4.3 Chemistry Topics Learned Using Digital Game

The study findings reveal that students are utilizing digital games to explore various chemistry topics. An analysis of 220 responses indicates that 63 (28.6%) students employ digital games for physical chemistry. The behavioral intention among students utilize these games in physical chemistry can be attributed to the topics' broad conceptual scope and the complexity of its quantitative calculations which reported challenging to many students (Manyilizu, 2023). Moreover, the study found that 52 (23.6%) use digital games for learning both inorganic and analytical chemistry, 49 (22.1%) for environmental chemistry, and 31(14.1%) for organic chemistry. These results demonstrated the potential to redefine existing norm of instructors form primary source of knowledge transmission or content delivery to facilitator of learning as emphasis by competence-based curriculum. This transition particularly relevant in Tanzania, where systemic challenges such as low teacher-student ratio, limited access to materials and insufficient teacher capacity to implement competence-based curriculum persist (Beichumila et al., 2022). Therefore, digital resources emerge not only pedagogical enhancers but as strategic to structural deficits in the education system.

4.4 Students' Perception on Using Digital Games for Learning Chemistry

Under this category, the study sought to understand students' perceptions of the opportunity and challenges of using digital games to improve academic performance and learning environment, and the challenges students experience when using digital games for learning chemistry.

4.4.1 Students' Perception of Digital Games on Learning and Academic Performance

The findings in Table 2 indicate a positive perception among students regarding the use of digital games in learning chemistry courses. A significant majority 59 (45.7%) students, agree that digital games simplify understanding of complex concepts of chemistry. This finding is supported with qualitative data where one student during interview stated that "*I think using digital game for chemistry is the best approach because it makes learning complex topics such as coordination compounds easier and fun*..." (Student U/November, 2023). These findings indicated that students view digital games as the learning effective platform to simplifying abstract concepts composed STEM subjects including chemistry into a tangible, comprehensible and engaging learning experiences (Cunha et al. 2019)

Table 2: Function of Digital Games for Learning Chemistry and Academic Performance

Perceived statements	Strongly agree		Agree		Neutral		Disagree		Strongly disagree	
	F	%	F	%	F	%	F	%	F	%
Digital game learning relates theory and practical	41	31.4	37	28.7	19	14.7	20	15.5	12	9.3
Digital games promote the retention of knowledge.	29	22.5	34	26.4	26	20.2	27	20.9	13	10.1
The digital game increases learning motivation.	32	24.9	47	36.4	22	17.1	15	11.6	13	10.1
Digital game enhances problem solving skills in chemistry learning	29	22.5	37	28.7	27	20.9	19	7.9	17	13.2
Digital games simplify understanding of complex concepts of chemistry.	47	36.4	59	45.7	12	9.3	8	6.2	3	2.3
Using digital games can lead to better grades exams and assignments.	25	19.4	29	22.5	30	23.1	24	18.6	21	16.3

Source: Field data, 2023

Moreover, 47.6 (36.4%) students agree that digital games increase motivation. The results implying students can set goals and direct students toward a specific goal by choosing an action and experiencing.

The student's motivational perceptions can be connected to game mechanics such as rewards, levels, and point as observed by Cunha et al. (2019). These features promote cognitive process for mastering intended competencies and develop problem-solving skill for real-word applications. These competencies are central to competence-based curriculum which emphasises knowledge application in real world context. However, Gakime et al. (2025) noted a persistent gap between perceived usefulness and actual classroom implementation, as actual performance depends of behaviour control shaped by skills, resources, and the available opportunity for effective applications for learning among students (Ajzen & Schmidt, 2020).

Similarly, 41 (31.8%) students strongly agree that digital game relate to theory and practise. These findings were also supported by an interview statement "understanding the mole concept became easier by visualizing the way elements combine and react in different proportions" (Student M/November, 2023). "I always look up simulation to make comparison with the practical assignment I face in class; this makes it easy to remember the procedures on how to carry my assignments (Student X/November, 2023). The findings suggest capability of digital in bridging theory and practical gap in chemistry learning. Manyilizu (2023) supported this finding pointing that games like simulation aid comprehension of topics like equilibrium and mole concepts. These findings have implications for many schools in Africa which have limited chemistry laboratories facilities and large class size. However, Kaimara et al. (2021) reported that many existing educational games are complex, narrowly focused, and lack adequate scaffolding resulting in lower score marks among students. This suggests the needs for simper, intuitive design with clear instructional guide and adaptive feedback to maximize their educational values.

4.4.2 Students' Perception Regarding the Learning Environment Offered by Digital Games for Learning Chemistry

The findings in Table 3 indicate that 53 (41.4%) students strongly agree that digital games provide immediate feedback on their learning experience. Translating that students recognize the value of digital games in providing real-time responses to their learning experience, which allows them to reflect on their understanding, monitor progress, correct mistakes, and promote self-regulated learning in real time. Timely reinforcement for correct decisions encourage repeated positive behaviors and deeper engagement with subject matter as also observed with Manyilizu (2023). Nevertheless, the challenge remains, as its difficult assess individual learning performance through games, making feedback narrow and disconnected to scaffold learning, instructional relevance and broader pedagogical goals (Adeozor et al., 2022). Integrating analytics tools to track engagement, concepts mastery, and progress overtime are essential for effective learning.

Table 3: Learning Environment Offered by Digital Game for Learning Chemistry

Perceived statements	Strongly agree		Agree		Neutral		Disagree		Strongly disagree	
	F	%	F	%	F	%	F	%	F	%
I feel I have more autonomy over the subject matter and the learning process when using digital games for chemistry	38	29.1	45	34.9	14	10.9	18	13.5	15	11.6
Using digital games provides fear free environment	38	29.5	39	30.2	24	16.6	13	10.1	15	11.6
Digital games provide immediate feedback on their learning experience	53	41.4	35	27.1	16	12.4	12	9.3	13	10.1
Using digital games in learning chemistry makes learning promotes collaboration.	26	20.2	22	17.1	25	19.4	31	24.0	25	19.4

Source: Field data, 2023

Furthermore, the findings indicate that 45(34.9%) students agree that digital games provide them full autonomy to own their learning activities. This finding was supported by interview finding as indicated "*digital game gave us control over learning and exploring topics at our own pace*" (Student F/November, 2023*).* The finding suggests that many students feel empowered by digital games, as they allow them to take ownership of their learning process, make independent decisions, and engage with content at their own pace. This finding support the paradigm shifts from teacher-centred to learner-centred approaches, which encourage active participation, confidence, and ownership of learning (Cunha et al., 2019; Kucher, 2021). However, the analysis of the result as indicated in Table 5 that 31(24.0%) students disagree that digital games promote collaboration. Interview with student shows "*collaboration means working together on assignment task or discussing concepts, which I found less delivered by these games*" (Student J/November, 2023). Another Student claimed that "*It felt like more of an individual experience rather than something where I could interact or work with others*" (Student K/November, 2023). The finding implies that students do not perceive digital games as tools for promoting teamwork rather they perceive them as suitable for individual learning. These view translates that many students consider digital games as suitable tool for individual learning. This finding contradicts with previous research emphasizing the collaboration potential of digital games (Nor-Asniza et al., 2021; Lutfi et al., 2023), suggesting the role of contextual relevance in the use game in classroom instructions through engaging end users as also advocated by Mtebe and Christina (2025).

4.4.3 Perceived Challenges in Using Digital Games for Learning Chemistry

The findings in Figure 3 indicate that the biggest challenge perceived by (33) students in using digital stems from a limited awareness of digital games in learning chemistry. This necessitates educational initiatives to sensitize and familiarize students with the educational advantages of incorporating digital games in chemistry education. When students are not familiar with digital games and don't have positive experiences with them, this can create a culture of skepticism about their effectiveness. In such environments, even the perceived subjective norms for using digital games as learning tools diminishes, reinforcing the reluctance to integrate them into classroom practices. Mtebe and Christina (2025) emphases that engage end-user in development process and aligning them with local curricular and levels of schooling to promote awareness, thus adoption and integration in learning.

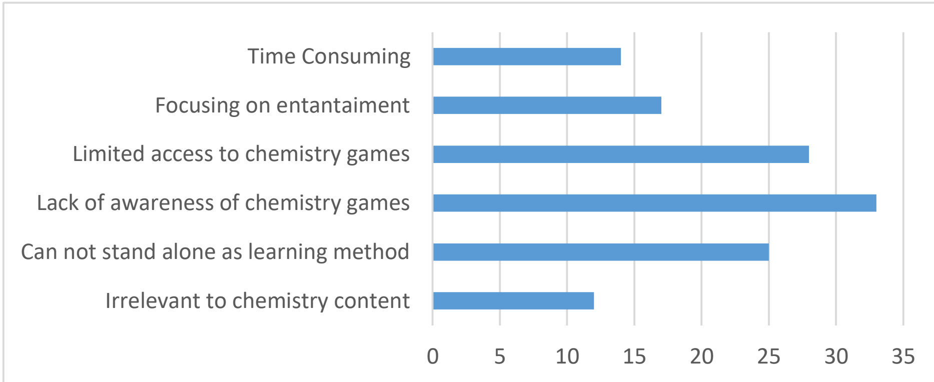

Figure 3: Challenges Using Digital Games for Learning Chemistry

Another challenge perceived by (28) students is limited access to chemistry games. This challenge can be contributed by several factors, including inadequate digital infrastructure in schools, lack of awareness about available resources, and insufficient funding to acquire appropriate games as indicated in Figure 3. As a result, students struggle to integrate educational games into their chemistry learning. These findings align with Gakime et al. (2025) which demonstrated that restricted access to ICT tools hinders both students and teachers from incorporating technology into instructional practices. The study recommends the adoption of Bring Your Own Device (BYOD) policies to reduce financial burdens on educational institutions by leveraging existing student-owned devices. Additionally, the study advocates the design and development of digital game that are specifically relevant and contextualized in Tanzanian context. Moreover, (25) students perceived that digital games cannot stand alone as a learning method. Interview findings supported this as indicated in the following statements. Student D from St. John University started *“chemistry involves difficult concepts that might not be fully covered or explained effectively in a game format alone. It might be helpful as a supplementary tool” (Student D/December 2023). A*nother student said *“it’s true that digital games are very engaging, but I'm not entirely convinced they can stand alone as the primary method for learning chemistry (Student B/December 2023).* This view implies students perceive digital games as a supplementary tool that needs to be combined with other resources such as traditional instruction, guided practice and assessment for best learning outcomes. In supporting this view Kaimara et al. (2021) caution many educational games have narrowly defined objective shaped by designers’ perspective rather than pedagogical needs.

The present study focused on two institutions, i.e., the Mineral Resource Institute and St. John University of Tanzania, as representative bodies of HLIs’ regulatory authorities in Tanzania (NACTVET and TCU). While they HLIs provided valuable insights into the use of digital games in learning chemistry, the limited sample may not fully capture the diversity of student perceptions experience, and combining University and College data may introduce disparities given their differing in curricular emphases. Differing pedagogical approaches could affect how digital games are applied and perceived in chemistry learning. Future studies should examine these contexts separately by incorporating inferential statistical analysis to enhance soundness and generalizability of the findings.

5. Conclusion and Recommendations

5.1 Conclusion

This study offers insights into students’ perceptions of digital games for learning chemistry at St. John’s University of Tanzania, and Mineral Resource Institute in Dodoma, Tanzania. The study underlines the potential of digital games to transform chemistry learning by simplifying abstract concepts through interactive and experiential methods. Positive student experiences with these games foster favourable attitudes, enhancing their engagement with complex chemistry topics can lead to improved learning outcomes. Moreover, the study indicates that interactive nature, adaptive difficulty and immediate feedback drive students to apply digital game as they able to recognize their strengths and address their weaknesses leading to improved learning experience. For effective feedback, the study suggests integrating analytics tools that track student engagement, mastery of concepts and progress overtime. Among various types of digital games, simulations were found to be especially impactful as they contextualize theoretical knowledge within real-world scenarios, bridging the gap between abstract concepts and practical applications. Importantly, digital games contribute to students' autonomy and confidence thereby encouraging proactive behavior and promoting ownership of their learning. However, demographic factors such as gender and HLIs type had minimal influences on digital games use, suggesting subjective norms or perceived social expectations play a limited role in shaping their usage. Instead, decisions to use them is based on individual belief of their usefulness, even though assessing games, digital skills, and institutional support and pedagogical alignment enhances their adoption and use for learning chemistry.

5.2 Recommendations

Based on the findings of the current study; we recommend the following:

1. The study recommends implementing Bring Your Own Device (BYOD) policies to enable students to use their mobile devices to access game-based learning content anytime and overcome infrastructure barriers
2. Integrating analytics tools to monitor student engagement, mastery, and progress regularly to ensure feedback is pedagogical meaningful and support leaning trajectories
3. Develop games that are relevant to HLIs courses and striking a balance between entertainment and educational value

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