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# Student Engagement and ICT Tools in Science Education

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**ABSTRACT**

This study is a descriptive literature review that identified effective information and communication technology (ICT) tools for science education in developing student engagement based on recent literature and studies. The different ICT tools were categorized into communication, collaborative, instructional, content development, assessment and administrative tools and the specific domains of student engagement that they developed were determined. Based on the findings, there is a wide range of ICT tools that are proven to be effective in developing student engagement and most of these tools supported the development of behavioral engagement followed by cognitive, emotional, social, and the least is agentic dimensions. This necessitates the need to investigate how ICT tools can be applied to develop students' autonomy in learning. Future research can consider contextual and demographic variations in the utilization of ICT tools. Examining how combinations of ICT tools can impact the development of all the dimensions of student engagement may also be considered along with longitudinal studies.

**Keywords:** Student engagement, Information and communication technology, Science education, Student development, Applications

## INTRODUCTION

A great deal of recent studies highlighted that student engagement has an important role in contributing to successful teaching and learning which has a significant effect on the overall academic performance of the learner. Because of this, central to any educative process or procedure is establishing student engagement. This is the reason why in planning a lesson, the classroom teacher thinks of the most effective way to spark and to sustain student engagement from the beginning until the end of every class (Al-Mutawah et al., 2021). Because of the importance of student engagement, classroom teachers are in a continuous effort to look for innovative ways to engage the students, particularly in teaching science. The science curricula are typically packed with extensive material which require students to master dense and specialized vocabulary to memorize and complex processes to understand which place too much pressure on both the learner and the teacher (Mahmoud & Taguines, 2025). The modernization and technological advancements that are rapidly being felt in this present time undeniably led to the rapid expansion of ICT tools available for the classroom teacher to utilize particularly to establish student engagement (Al-Mutawah et al, 2018 The incorporation of digital ICT tools engages students actively, hence enhancing their learning experience and achievement (Al-Mutawah et al., 2022; Mahmoud & Bawaneh, 2025). There are so many ICT tools already in existence and currently being produced in this evolving digital world (Al-Mutawah et al., 2019). However, recognizing most effective ICT tools, the effects they have on students' participation, and what specific dimensions of participation they enhance is a vital area of research.

## OBJECTIVES

### Student Engagement

Student engagement is gaining so much attention in educational research because of its significant association to student academic achievement and overall well-being (Al-Mutawah et al., 2022; Hung & Mahmoud, 2015). Student engagement is defined as a multidimensional construct that includes behavioral, emotional, cognitive, social, and agentic component and the interaction of each of these dimensions collectively contribute to the learning experience

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(Hung et al., 2015). Behavioral engagement is characterized by the academic participation of the learner which can be manifested by the learner's attendance, effort, and ability to follow classroom rules. Emotional engagement refers to the reaction of the learner on learning measured in terms of the level of interest, enjoyment, and the sense of belonging (Hung et al., 2012; Hunter et al., 2013). Cognitive engagement reflects the learner's willingness to exert the necessary effort to understand or comprehend the lesson (Mahmoud, 2009). The behavioral engagement of the learner is found to be a strong predictor of academic success (Mahmoud, 2014) and it had the strongest correlation with academic achievement compared to other dimensions. Behaviorally engaged learners adopted more effective study approaches (Smith & Lee, 2025). Behavioral engagement significantly improves the academic outcome of younger students (Mahmoud, 2015) and it has a significant benefit in improving the academic performance of at-risk students (Johnson et al., 2023). Emotional engagement is also important, and it has a significant role in the academic performance of the learner. The research findings of Rusi et al. (2024) and Liu et al. (2024) showed that a positive correlation exists between emotional engagement and academic achievement. Other than this, emotional engagement facilitates better learning outcomes and is favorable for greater accomplishment at a university level as well as special education. In the same way, cognitive engagement enhances the academic accomplishments of the learners as well and greater cognitive involvement is related to more productive academic engagement (International Journal of Indian Psychology, 2025; Mahmoud, 2023). Cognitive engagement is positively associated with academic achievement and productivity (Kahn, Gul, & Zeb, 2023) and predicts academic success. Peer relationships or social engagement inside the classroom leads to better academic outcomes and students who perceive higher levels of social support are more likely to be engaged in academic activities. The studies conducted by Bader and Mattar (2024) and Fu (2023) found that a strong positive relationship existed between social engagement and academic attainment.

## ICT Tools in Science Education

ICT tools in education refer to a wide range of digital resources and technologies that are being used to enhance the teaching, the learning, and the administration in education such as the usage of computers, mobile devices, internet flatforms and software. It encompasses hardware, software, networks, and media that are used to collect, store, process, transmit, and present information in the learning environment which support teaching strategies and learning that is student-centered (OECD, 2021). ICT tools are any technology that facilitates communication, processing, transmission, and sharing of knowledge between teachers, students, and administrators in the digital learning ecosystem. The ICT tools in education are broadly categorized into several types or classifications based on their function which include communication, instructional, collaborative, content development, assessment, and administrative tools. Communication tools function to facilitate interaction between learners and teacher and include tools like email, video conferencing (Zoom, Microsoft Teams) and any messaging applications. Instructional tools directly support the teaching and the learning process which include educational software, interactive whiteboards, and learning management systems like Moodle or Google Classroom (OECD, 2021). Content Development tools help learners and teachers in creating multimedia content in education such as Canva, Microsoft Publisher, and video editing programs (Mahmoud & Taguines, 2025). Another classification of ICT tools that are commonly used in the classroom is the assessment tools which assist in evaluating learning outcomes which include Kahoot, Quizizz, and any online testing platforms. There are many studies conducted linking the use of ICT tools with the development of different dimensions of student engagement. Effective ICT integration significantly improved student engagement (Mahmoud & Hamdi, 2009). In 2023, Liu et al., found that educational ICT resources are positively correlated with various forms of students' engagement including cognitive-motivational. It was reported that students using mobile learning platforms developed higher levels of emotional engagement and using google docs stabilized the behavioral and improved the emotional engagement of the learners. The use of ICT tools in the classroom can promote positive social interactions and coexistence among learners and it can significantly improve and promote agentic engagement (Song & Lo, 2024).

## Statement of the Problem

Most science classrooms continue being characterized by low student engagement despite increased applications of ICT tools in teaching and learning processes. Even though ICT tools such as simulations, virtual laboratories, and interactive environments have to facilitate teaching and learning processes and thus have enormous potential, it is doubtful their effective application and effectiveness in enhancing student engagement. Within science education

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where scientific ideas are abstracted and handled ICT tool deployment for facilitating active participation, motivation, and deeper comprehension is particularly significant. However, there is sparse empirical understanding of the impact of the tools on the participation of learners within different learning environments. The present study seeks to explore to what extent ICT tools enhance students' participation in scientific learning and what influences the effective deployment of the tools in the classroom. At present, the utilization of ICT tools is becoming indispensable and inevitable because of their great potential in creating a meaningful learning experience for the learners. The main goal of this review is to identify effective ICT tools proven by research to be effective tools that can be utilized in the classroom more specifically, it tries to answer the following questions: (1) What specific ICT tools are available and proven to be effective in developing student engagement in science learning? (2) How does each ICT tool impact students in terms of developing engagement in learning science? (3) What specific dimensions of student engagement are being developed by each classification of ICT tool?

## METHODS

This study employed the descriptive literature review approach to examine the relationship between student engagement and the use of Information and Communication Technology (ICT) tools in science learning. The purpose of this approach is to collect, analyze, and synthesize systematically the results of available studies in a bid to get a comprehensive overview of how the use of ICT tools influences student engagement in various science learning settings. The review focused on peer-reviewed journal articles, conference proceedings, academic textbooks, and credible online publications published in the last 10 years in order to be relevant and current. The primary search terms used were "student engagement," "ICT tools," "science education," "digital learning," and "educational technology." Google Scholar, ERIC, JSTOR, and ScienceDirect databases were used in searching for relevant literature. The inclusion criteria were that the research was on science education at the primary, secondary, or tertiary level, involved the use of ICT tools (such as simulations, virtual labs, learning management systems, interactive whiteboards), addressed aspects of student engagement (behavioral, emotional, or cognitive). It was excluded from the review were opinion articles, unpublished theses, and studies not directly addressing both ICT tools and student engagement. The data gathered were organized thematically to identify patterns, challenges, and best practices in the integration of ICT tools for promoting engagement in science classrooms. The review also highlighted research gaps and areas for further investigation. This is primarily a descriptive literature review which involved the identification, categorization, and analysis of recent literature and studies. It focuses on understanding the impact of different classifications of ICT tools such as communication, instructional, collaborative, content development, assessment, and administrative tools on student engagement as applied in different levels of education from the primary to tertiary and in different science subjects.

## RESULTS AND DISCUSSION

### ICT Tools Effective in Developing Student Engagement in Science Education

#### *Communication Tools:*

Communication ICT tools are digital platforms and devices that enable interaction between and among learners and teachers. Recent studies show that the utilization of different types of ICT communication tools significantly develops student engagement in learning science. In the study conducted by Al-Samarraie (2023), the use of digital learning platforms such as Moodle, Microsoft Teams, and Zoom significantly enhanced student engagement and learning outcomes in science education among university students. Students showed increased attendance, active participation during the discussions and submission of assignments become frequent. Students also demonstrated improved scientific inquiry, critical thinking and problem-solving skills. Another study explored another ICT communication tool particularly the use of Telegram in developing engagement among higher education science virtual classes and the researcher found out that the use of Telegram lead to frequent collaboration, peer discussion and group based scientific problem solving as well as increased interaction and participation rates (Estrada Molina, 2022). The implementation of WhatsApp among high school students for the subject Science, Technology, and Mathematics particularly in some topics in Organic Chemistry and Genetics led to significant results and the findings revealed that students demonstrated improved assignment completion, effective project collaboration and sharing of lab reports, heightened motivation and feeling more connected and with lower anxiety level. The use of Padlet developed the ability of grade 10 students studying biology in terms of scientific reasoning, formulating hypothesis,

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and analyzing data aside from the increased collaboration of the learners via the commenting and peer-feedback feature of this ICT tool. The use of Padlet also resulted in the development of active participation and deeper understanding of concepts in ecology because of the visual mapping and the ability of the students to collaborate in terms of creating contents.

***Instructional Tools:***

There are many instructional tools being employed in science instruction that developed student engagement and one of these is the PhET Interactive Simulations. A mixed-methods study by Assaf (2005) established the effectiveness of PhET simulations in learning Chemistry concepts by elderly female students on the impact of the teaching aid on the learners' confidence and learning. Yet another study illustrated that PhET simulations enhanced abstract chemistry concepts and enhanced retention in college students. It was also proven that this tool can contribute to increased participation in classroom discussions, more time-on-task during simulation-based lessons among secondary learners learning about electric circuits. Another Instructional tool, particularly Labster Virtual Laboratory was proven to be effective in developing the motivation, confidence, and the sense of autonomy of university students studying cell biology courses. This ICT tool was also used to teach genetics particularly complex and abstract topics such as gene expression and gene therapy and findings of the research revealed that it stimulates deep thinking and understanding because the abstract genetics concepts are becoming more concrete with the aid of Labster Virtual Lab (Barbeau et al., 2023). Aside from biology subjects, this ICT tool was also utilized in an experimental study in an area without physical physics laboratory and it significantly contributed to the conceptual understanding of students in the experimental group compared to the class in which the ICT tool was not used (Mosqueda, C. E. H., 2023). Moreover, in a high school biology class it significantly contributed to students' enthusiasm and participation in the face to face and in the online laboratory sessions compared to when the traditional worksheets and lectures were implemented (Labster, 2023). The Utilization of CODAP (Common Online Data Analysis Platform) in an introductory data science unit among high school learners led to the development of deeper cognitive engagement and students demonstrated competency in terms of formulating statistical questions, analyzing and interpreting data. This ICT tool was also used to teach force and motion among university education students, and they developed positive attitude towards the utilization of this ICT tool because it is easy to use, and it contributed to their mastery of the content (Zhang & DeMonte, 2021). The above positive findings were concretized by a survey supporting the effectiveness of Merge cube in developing student interaction, understanding, and enthusiasm among classrooms science teachers. Sungheetha et al. (2023) integrated Google Expeditions for science topics like ecosystem and natural disasters and found out that there was an improvement in the post-assessment scores and students exhibited increased interest and positive emotional responses as well as active exploration and participation.

***Collaborative Tools:***

Google Docs when utilized on scientific writing among college science students contributed to deeper cognitive involvement as well as positive interaction among the students and it was found out that the use of this ICT tool is linked to the improvement of the students critical thinking and the quality of their written output. These findings were validated by another study which is also applied in a high school science class where Google slide was proven to promote cognitive skill such as analytical skill as well as active class involvement (Pagutayao & Paglinawan, 2024). These findings were validated by another experimental research that showed the ability of Nearpod to develop active participation, enthusiasm, curiosity and to promote deeper understanding of difficult concepts in biology among grade 12 STEM students (Caballero, 2024). The utilization of Flip as another ICT collaborative tool contributed to the enhancement of scientific understanding, active participation, self-confidence and the reduction of anxiety related to public speaking because Flip provided an opportunity to practice oral communication among university students. A field experiments were conducted to assess the impact of Zoom among minority students in higher education science courses and researchers found out that the intervention significantly improved the grades of the student which is linked to the improved emotional connection fostering a sense of belonging. In a virtual STEM program involving not just students but parents as well, the application of Zoom led to active participation and positive collaboration between teachers, parents and students. As an instructional tool used in biology, Zoom was found useful among college students in terms of mastery of concepts. The impact of Edmodo was tested in a physics class for grade 10 learners on the topics work and energy and the usage of this ICT tool was proven to enhance the

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understanding and participation of the students. Edmodo has important contributions in developing critical thinking, motivation, and interest among grade 8 learners studying science.

***Content Development Tools:***

Another classification of ICT tools that are commonly being used in education are the content development tools that are being used by both teachers and students. There are many different tools under this category that are proven to be effective in developing student engagement in learning different science subjects in different levels of education. The use of Canva is also promising in developing student engagement. In a quasi-experimental study involving elementary learners, the utilization of Canva-based flipbook was proven to be effective in enhancing their scientific literacy in general and specifically it resulted to enhanced understanding of scientific concepts, active participation, and increased motivation and interest. The same findings were obtained from the study conducted by Sugiani in 2023. A metanalysis on the effectiveness of Canva in enhancing academic performance including science also validated the results of the studies previously presented and it was proven that Canva contributed significantly on enhanced understanding and performance in different academic subjects, active involvement, and increased motivation and attitude towards learning. Camtasia was utilized in different levels of education, and it led to consistent results. Among young learners (ages 5-6) it developed the mastery of the young learners and also led to higher level of participation, and their interest and enthusiasm about the science subject increased and this is consistent with the findings when it was used for elementary learners in their natural science class. For more difficult subject and topic such as the human respiratory system, the use of Camtasia helped students to understand difficult biological concepts and it also improved their participation, enthusiasm and curiosity of other scientific concepts. PowToon was tested on its effect on the critical thinking skills of junior high school students learning science and it was proven to enhance this cognitive process along with the development of students' participation, motivation and interest. PowToon was integrated with the 5E learning model in a quasi-experimental study focusing on elementary learners and such combination are found to be notable in improving the understanding, participation, and motivation of the students by developing positive attitude towards science. The animated videos created via PowToon also resulted to positive outcomes in terms of students' deeper understanding of STEM-Integrated Physics concepts as well as active involvement, interest and enjoyment in learning Physics. Articulate Storyline 360 was utilized to teach a complex topic particularly on cellular respiration among grade 11 senior high school students and its application led to positive results such as an enhanced understanding of the complex biological process through the interactive function of the App, improved participation in some problem-solving activities, heightened motivation and interest of learners in biology (Heliyon, 2023). Articulate Storyline 360 was also used to teach chemistry particularly phase change of matter among grade 8 students and it has a great impact on improved learning outcomes, participation and engagement of the learners. This tool was also proven to develop the critical thinking skills of senior high school students on abstract chemistry concept particularly on chemical bonding topic.

***Assessment Tools:***

An important aspect of teaching and learning is assessment and there are many ICT assessment tools that are proven to be effective in developing student engagement and one of these is Kahoot. As supported by a comprehensive meta-analysis done by Özdemir (2024), the analysis of 43 studies revealed that students in the experimental group where Kahoot was integrated, showed improved understanding and retention of scientific concepts, increased participation, as well as enhanced motivation and reduced anxiety (Özdemir, 2024). This ICT tool has the potential to improve the self-efficacy, interest, and enjoyment of the learners. These findings were also consistent in terms of making students to stay focused and interactive during discussions, it also fosters a sense of community among learners not to mention its contribution in improving their comprehension of science concepts in an online course (Smith, 2025). A study conducted about Quizizz among secondary education students specializing in science proved the effectiveness of this tool in improving understanding of physics concepts, increasing participation and completion of assessments, and heightening interest and enthusiasm. The effect of Quizizz in grade 6 science led to better academic performance, increased students 'enthusiasm and attention, as well as heightened enjoyment and participation (Ramadhan & Arifin, 2024). It also contributed to developing students' interest in science for grade 5 learners. (Rahmawati et al., 2023). Quizalize was also employed to support formative assessment in teaching work, energy, and power in grade 10 physics and the study found out that incorporating Quizalize led to improved academic performance, increased participation, interest and motivation. It also contributed to the improvement of understanding among grade 8 science students because when Quizalize was employed, they process information and apply it at the same time and

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the assessments given in the form of games, increased the interest and motivation of the learners. A research examined online homework with Socrative by grade 10 students studying kinematics and dynamics in physics class and deployment of such ICT tool improved performance of the examined students, stimulated and boosted their confidence, and raised participation and interactions within the class. This was aided by a second study whereby Socrative was used to institute formative assessment for simulation of chemistry lesson and lab activities among high school and university chemistry students and identified that the system works effectively to provide real-time misconception correction, students were more engaged and motivated, and involvement in quizzes and discussion increased. Another ICT assessment tool is Plickers and the use of this among elementary school science learners when used formative assessments led to greater student progress compared to the traditional method in terms of improved understanding of scientific concepts through interactive quizzes, increased motivation and interest, and higher participation rates in different classroom activities (Shana & Al Baki, 2020). Another study confirmed the effectiveness of Plickers among chemistry educators and students indicating that it positively contributed to improving comprehension of chemical concepts and influenced higher motivation and interest in the subject. In primary science, quasi-experimental design with pre-test and post-test demonstrated that when Edpuzzle was utilized, student engagement, interest and motivation, and comprehension and achievement were significantly improved. These findings aligned with the result of a study in which researchers integrated Edpuzzle videos as pre-lab activities among undergraduate students enrolled in a first-year intro biochemistry lab course and established that it allowed students to learn at their own pace and resulted in higher preparation and motivation, reduced anxiety during experimentation, and better understanding of lab procedures and principles.

**Table 1.** Effective ICT Tools in Science Education: Impacts and Dimensions of Student Engagement

| ICT Tools | Description of the Impact on Student Engagement | Dimension of Student Development |
|---|---|---|
| | Communication Tools | |
| Moodle, Microsoft Teams, and Zoom | Increased attendance, participation, and assignment Submission/ Development of scientific inquiry, critical thinking, and problem-solving skills (Al-Samarraie, 2023) | Behavioral Cognitive |
| Telegram | Frequent collaboration, peer discussion and group based scientific problem solving as well as increased interaction and participation rates (Estrada Molina, 2022). | Behavioral Social |
| WhatsApp | Improved assignment completion, effective project collaboration and sharing of lab reports, heightened motivation and feeling more connected and with lower anxiety level. | Behavioral Emotional Social |
| Padlet | Improvement in scientific reasoning, hypothesis formulation, and data analysis and increased collaboration. Developed active participation, deeper understanding of ecological concepts through visual mapping and collaborative content creation. | Behavioral Cognitive Social |
| Google Jamboard | Developed student collaboration and increased student motivation and sense of classroom community. | Social Emotional |
| | Instructional Tools | |
| PhET Interactive Simulations | Improved academic achievement and motivation Improved self-confidence and learning experience (Assaf,2025) Enhanced understanding and better retention. Increased participation and time-on-task. Promote problem solving and analytical thinking and boosted pupil's enthusiasm. | Behavioral Cognitive Emotional |

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| Labster Virtual Labs | Developed students' interest, enjoyment, confidence and students taking an active role in their learning.<br>Encouraged deep thinking and deeper conceptual understanding (Barbeau et al., 2023).<br>Increased investment in learning, employing strategic thinking and deep processing (Mosqueda, C. E. H., 2023)<br>Improved enthusiasm, participation, and behavior (Labster, 2023). | Agentic<br>Behavioral<br>Cognitive<br>Emotional |
| CODAP (Common Online Data Analysis Platform) | Increased investment in learning applying strategic thinking and deep processing.<br>Developed active participation and sustained effort and persistence | Behavioral<br>Cognitive |
| Merge EDU with Merge Cube | Increased learners' participation, understanding, excitement and curiosity.<br>Enhanced content knowledge and positive attitude (Zhang & DeMonte, 2021)<br>Enhanced problem-solving skills, increased active participation, increased interest.<br>Enhanced student interaction, understanding, and enthusiasm. | Behavioral<br>Cognitive<br>Emotional |
| Google Expeditions | Increased concentration and positive affective responses towards content, better understanding of difficult concepts by means of interactive visualization, and genuine exploration and engagement with virtual content.<br>Improved knowledge, active engagement, enhanced interest and autonomy.<br>Improved understanding of STEM material, active participation, and increased motivation and interest. | Agentic<br>Behavioral<br>Cognitive<br>Emotional |
| | Collaborative Tools | |
| Google Workspace for Education (Docs, Meet, Slides) | Improved quality of critical thinking and writing.<br>Improved active participation, timely submission of assignments, and responsibility for group work.<br>Improved analytical thinking and active involvement (Pagutayao & Paglinawan, 2024).<br>Improved social interaction of students fostering feelings of belongingness and community. | Behavioral<br>Cognitive<br>Social |
| Nearpod | Increased motivation and positive attitude towards science, and more favorable participation.<br>Improved capacity for critical thinking and skill processing.<br>Increased understanding, active participation, and increased enthusiasm and interest (Caballero, 2024). | Behavioral<br>Cognitive<br>Emotional |
| Flip (formerly Flipgrid) | Increased familiarity with scientific issues, increased self-confidence and lower anxiety while speaking, more effective participation.<br>Enhanced capacity of students to articulate their learning, enhanced active participation in discussion and feedback, and enhanced peer interaction and collaborative learning. | Behavioral<br>Cognitive<br>Emotional<br>Social |
| Zoom | Increased academic performance due to increased emotional involvement that fosters a sense of belongingness. | Behavioral<br>Cognitive<br>Emotional |

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| | Active participation and collaborative interactions between parents, children, and teachers.<br>Enhanced understanding of biology concepts. | Social |
| Edmodo | Enhanced understanding and increased participation in an interactive online activity.<br>Developed the critical thinking skills and increased motivation and interest.<br>Demonstrated higher levels of peer collaboration and interaction, improved motivation and interest as well as critical thinking. | Behavioral<br>Cognitive<br>Emotional<br>Social |
| Content Development Tools | | |
| Microsoft PowerPoint / Prezi | Increased participation in class activities, enjoyment in the lesson, and deeper understanding of scientific concepts (SEAQIS, 2024).<br>Increased interaction during lectures, facilitated concept retention, reduced boredom and confusion.<br>Enhanced comprehension of scientific concepts, increased attention and classroom participation and developed positive attitude towards learning science.<br>Self-directed exploration of the content, positive response to Prezi, and enhanced understanding. | Agentic<br>Behavioral<br>Cognitive<br>Emotional |
| Canva for Education | Enhanced understanding of scientific concepts, active participation, and increased motivation and interest.<br>Improved the comprehension, increased the participation, and enhanced the motivation and interest of the students (Sugiani, 2023).<br>Enhanced understanding and performance, active involvement, and increased motivation and attitude. | Behavioral<br>Cognitive<br>Emotional |
| Camtasia | Improved understanding of scientific, active participation, and increased enthusiasm and interest.<br>Enhanced comprehension, greater participation in class discussions and activities, positive attitude toward learning and increased motivation.<br>Improved grasp of complex biological processes, increased participation, and enhanced curiosity and enthusiasm. | Behavioral<br>Cognitive<br>Emotional |
| PowToon | Enhanced critical thinking, active participation, and increased motivation and interest in science topics.<br>Improved understanding, increased participation, and enhanced motivation and positive attitude.<br>Deepened comprehension of STEM concepts, active involvement in learning activities and increased interest and enjoyment in physics learning. | Behavioral<br>Cognitive<br>Emotional |
| Articulate Storyline 360 | Enhanced understanding, active participation, and increased motivation and interest (Heliyon, 2023).<br>Improved learning outcomes, higher level of participation and engagement.<br>Enhanced students' critical thinking skills. | Behavioral<br>Cognitive<br>Emotional |
| Assessment Tools | | |

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| Kahoot! | Improved understanding and retention of scientific concepts, increased participation, as well as enhanced motivation and reduced anxiety (Özdemir, 2024).<br>Improvement in understanding of scientific content, self-efficacy, interest, and enjoyment.<br>Improved focus and understanding, active participation, promoting interactive participation and fostering a sense of community among learners (Smith, 2025). | Agentic<br>Behavioral<br>Cognitive<br>Emotional<br>Social |
| Quizizz | Improved understanding, increased participation and completion of assessments, and heightened interest and enthusiasm.<br>Better academic performance, increased students 'enthusiasm and attention, as well as heightened enjoyment and participation (Ramadhan & Arifin, 2024).<br>More enthusiasm, enjoyment, and interest in science lessons (Rahmawati et al., 2023). | Behavioral<br>Cognitive<br>Emotional |
| Quizalize | Improved academic performance, increased participation, interest and motivation.<br>Improved conceptual understanding because students actively process information and applied concepts during interactive quizzes and increased interest and motivation due to the gamified nature of assessment. | Behavioral<br>Cognitive<br>Emotional |
| Socrative | Improved examination performance, increased motivation and confidence, and higher participation and class interactions.<br>Beneficial in providing real-time correction of misconceptions, students felt more interested and motivated, and participation in quizzes and discussions increased. | Behavioral<br>Cognitive<br>Emotional<br>Social |
| Plickers/ Edpuzzle | Improved understanding, increased motivation and interest, and higher participation rates (Shana & Al Baki, 2020).<br>improving comprehension and influenced higher motivation and interest in the subject.<br>Significant improvement in students' participation, interest and motivation, as well as understanding and achievement.<br>Allowed students to learn at their own pace and resulted in enhanced preparation and participation, reduced anxiety in performing experiements, and better comprehension of laboratory techniques and concepts. | Agentic<br>Behavioral<br>Cognitive<br>Emotional |

## CONCLUSION

Since agentic engagement is the least developed dimension, future research should investigate on how ICT tools can be redesigned or repurposed to foster learner autonomy, self-direction, and sense of ownership over learning which are all essential in developing lifelong learning which is the goal of every educator and educational institution. Future research can also focus of the effectiveness of different ICT tools considering contextual and demographic variations such as cultural, socio-economic, geographical factors, primary vs. secondary vs. tertiary level of education, gender and accessibility dimensions. Longitudinal studies on engagement development can also be done along with examining how combinations of ICT tools can influence multidimensional engagement. Selecting ICT tools that can be utilized in the classroom is crucial. It is imperative that educators consider the nature of the learners considering their needs and interests as well as the expected learning outcomes. This understanding is vital to be able to choose

the most appropriate ICT tool that can yield the most fruitful results which support the holistic development of every learner in every science class.

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