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Utilization of Dynamic Visualization Tools: Enhancing Students' Motivation and Engagement in Biology Education

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ABSTRACT

The recent ranking of the Philippines in the international assessments only reflects the shortcomings concerning the lack of scientific interest, instructional support, mastery of essential competencies, and the ongoing issue with the extensive use of gadgets among students. Furthermore, motivation is often overlooked, which propels engagement and influences academic performance. Thus, this research utilized Dynamic Visualization Tools (DVTs) to enhance the motivation and engagement of 30 academically low-performing Grade 9 students in biology education at Banga National High School (BNHS) academic year 2023–2024. A quasi-experimental design was used and the participants rated their motivation and engagement levels through a pre- and post-self-reported survey with a 4-point Likert scale. Results showed that utilizing DVTs improved student motivation and engagement in biology, and a strong association was found between these two variables, demonstrating how these resources enhance students' overall learning experiences and academic success in the subject. In conclusion, DVTs are beneficial instructional tools that make students motivated and actively engaged, even with the least mastered concepts, intrinsically and effectively. All these significantly contribute to the existing body of knowledge on technology-integrated teaching strategies and therefore recommend that educational stakeholders should further apply and examine other implications of DVTs in the field of education.

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1. INTRODUCTION

Because of the rapid improvements in technology, the education sector is always changing and this necessitates flexibility on the part of educators to suit the demands of learners. EdTech or educational technology is widely employed in today's world (Rolfes *et al*., 2020), it includes interactive visual aids like animations, simulations, and three-dimensional models that can change the way how they are displayed visually while being taught. These tools are often used in classrooms and have been shown to improve students' learning, indicating the importance of incorporating them into teaching practices (Raposo *et al*., 2020). Moreover, research consistently underscores the crucial role of student motivation and engagement in education. It is emphasized that motivation propels students' action, with engagement being the observable evidence of that motivation, illustrating their reciprocal relationship. Furthermore, some researchers (Fuertes *et al*., 2023) identified the primary predictor of high school academic success, which is self-efficacy. Academic motivation and cognitive engagement also predict better academic performance, making them an important aspect of learning.

Globally, Asian countries, notably Singapore and Hong Kong, are known for their performance in mathematics and science as evidenced by international assessments such as TIMSS and PISA. The 2022 PISA results ranked Singapore first while Hong Kong was fourth. These nations stand out for their advancements in technology in pursuit of educational improvements through learning initiatives and innovative practices. Essentially, Singapore focuses on cooperative learning while personal motivation is for Hong Kong, which is the leading factor to their academic success. On the other side, the Philippines faces challenges as evidenced by its consistently low rankings in the same assessments. This shows a significant learning gap underscoring the imperative for urgent educational reforms. This outcome was analyzed and research suggested that one of the reasons for the Philippines' poor performance was attributed to the prolonged absenteeism of students, predominantly influenced by the lack of motivation caused by a prevalent reason of boredom.

Aside from that, in Philippine biology education, challenges still arise with science teachers identifying competencies like "Patterns of Non-Mendelian inheritance" and "Photosynthesis and Respiration" as least learned by Grade 9 students (Eviota & Boyles, 2022). With the same findings (Santos *et al*., 2021), students' low mastery is linked to their lack of interest in these topics. Moreover, dating back to DepEd Order No. 25, s. 2002, factors are also cited such as students' lack of scientific interest, teaching deficiencies, and resource constraints, resulting in low science performance. Despite two decades having passed, these challenges remained while science teachers grapple with addressing the low academic performance of students and their extensive use of gadgets in the classroom setting today (Morales *et al*., 2022).

To address these challenges, it's essential to embrace student-centered approaches in science education that prioritize motivation and active involvement among learners (Arrieta *et al*., 2020). Enhanced motivation and engagement are important components of overall achievement among students, as they have a direct correlation to academic performance and conceptual understanding. With that, modern technology integration will help students understand concepts even better, turning science education into an interesting and engaging experience that emphasizes the interplay between academic success, motivation, and engagement (Miyamoto *et al*., 2019; Salame & Makki, 2021; Morales *et al*., 2022). Therefore, in this study, the researchers focused solely on the importance of motivation and engagement in science education. This was carried out because a large body of research on educational materials—static or dynamic visual aids—frequently prioritizes cognitive aspects while

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overlooking the importance of motivation and engagement in students' overall learning experience. By acknowledging the influence of technology, this study aimed to develop a new instructional approach for students in the twenty-first century.

This study was conducted to investigate the enhancement of students' motivation and engagement in the context of biology education by utilizing Dynamic Visualization tools. Specifically, the study sought to answer the following questions:

(i) What is the degree of motivation of students in learning biology before and after the integration of dynamic visualization tools, in terms of: Internal motivation; External motivation; Personal relevance; Responsibility; Self-efficacy; and Anxiety
(ii) What is the degree of engagement of students in learning biology before and after the integration of dynamic visualization tools, in terms of: Cognitive engagement; Behavioral Engagement; and Affective engagement?
(iii) Is there a significant difference in the degree of motivation of students before and after integrating dynamic visualization tools?
(iv) Is there a significant difference in the degree of engagement of students before and after integrating dynamic visualization tools?
(v) Is there a significant relationship between the motivation and engagement of students in learning biology?.

2. METHODS

A quasi-experimental design was used in this study and researchers have adopted a one-group pre-survey and post-survey questionnaire for gathering data. A quasi-experimental research design was the most applicable, chosen for investigating the impact of dynamic visualization tools on students' motivation and engagement in biology class. A non-random method or criteria was used in this study to assign respondents to the treatment group, which did not have any control group. To ensure systematicity and minimize bias, the researchers utilized a random sample selection within the treatment group, enhancing internal validity.

The conceptual framework (see **Figure 1**) of this study illustrates how students' motivation and engagement (dependent variables) in biology education are affected by dynamic visualization tools (independent variable). Motivation encompasses various elements, including internal and external motivation, personal relevance, responsibility, self-efficacy, and anxiety, generally defined as the innate drive students display during their learning process. On the other hand, engagement measures how interested and involved students are in the learning process. It takes into account affective, behavioral, and cognitive engagement. Using immersive and interactive technologies such as dynamic visualization tools can change the way traditional teaching methods are taught and influence students' motivation and engagement. Procedurally, pre-surveys are first used to gauge baseline motivation and engagement along with their designated dimensions. Then, the independent variable that follows is the implementation of dynamic visualization tools, which are meant to improve students' educational experiences. Finally, a post-survey measures the same dimensions of motivation and engagement, allowing for a comparative analysis of pre-and post-intervention data. This framework evaluates the dynamic visualization tools' effectiveness in improving the motivation and engagement of students in the context of biology education.

This study utilized the Mean and Standard Deviation for SOPs 1 and 2 to measure and compare pre- and post-motivation and engagement levels of students before and after the

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integration of DVTs in biology class. A paired sample t-test was used for SOPs 3 and 4 to compare the degree of students' motivation and engagement before and after the integration of DVTs in biology class. A simple linear regression was employed for SOP 5 to analyze the linear relationship between motivation and engagement, aiming to determine if these variables correlate with each other in the context of biology education.

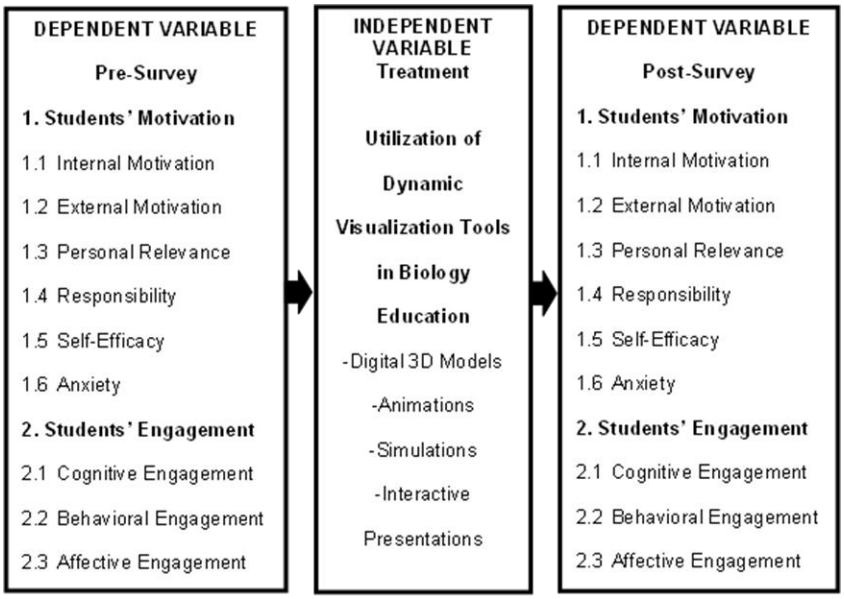

Figure 1. Schematic Diagram of Conceptual Framework

3. RESULTS AND DISCUSSION

This part presents the analysis and interpretations of findings about the respondents' degree of motivation as well as their engagement in biology education. It also focuses on presenting the results from before and after the integration of dynamic visualization tools, the significant differences, and the significant relationship between motivation and engagement variables.

3.1. Degree of Students' Motivation in Learning Biology Before and After the Integration of Dynamic Visualization Tools

This presents the findings of the study in terms of motivation and its dimensions. The discussions feature the motivation levels of students in learning biology, comparing before and after the integration of dynamic visualization tools, and examining its determined implications.

Table 1 shows the degree of internal motivation of students in learning biology before and after the integration of DVTs. The pre-survey has an overall mean of 2.87 (SD = 0.43) and was interpreted as a "Moderately High Degree of Motivation." Specifically, Item 3, "I find learning biology interesting," obtained the highest mean of 3.20 (SD = 0.55) and was interpreted as a "Moderately High Degree of Motivation." This suggests that most students are already internally motivated to learn biology concepts driven by their interests, even before the researchers introduced them the DVTs. In contrast, Item 5, "Understanding biology makes me feel accomplished," obtained the lowest mean of 2.67 (SD = 0.66) and was interpreted as a "Moderately High Degree of Motivation." This result shows that students might have a low sense of achievement when learning biology although their motivation level is found to be

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moderately high. Perhaps, students find biological concepts not fulfilling considering how some of them are too complex and difficult to grasp.

Table 1. Degree of Motivation of Students in Learning Biology Before and After the Integration of Dynamic Visualization Tools in terms of Internal Motivation (*n* = 30).

Survey	Internal Motivation	Mean	SD	Interpretation
Pre-Survey	1. I enjoy learning Biology	3.03	0.49	MHDM
	2.What I learned in Biology is more important to me than the grades I receive.	2.70	0.53	MHDM
	3. I find learning Biology interesting.	3.20	0.55	MHDM
	4. I like learning challenging Biology concepts	2.77	0.73	MHDM
	5. Understanding Biology makes me feel accomplished	2.67	0.66	MHDM
	6. I feel proud learning and understanding Biology	2.83	0.65	MHDM
	Average Mean	2.87	0.43	MHDM
Post-Survey	1. I enjoy learning Biology	3.43	0.50	HDM
	2.What I learned in Biology is more important to me than the grades I receive.	3.13	0.43	MHDM
	3. I find learning Biology interesting.	3.17	0.59	MHDM
	4. I like learning challenging Biology concepts	3.13	0.51	MHDM
	5. Understanding Biology makes me feel accomplished	3.13	0.51	MHDM
	6. I feel proud learning and understanding Biology	3.27	0.58	HDM
	Average Mean	3.21	0.37	MHDM

Note: LDM = Low degree of motivation, MLDM = Moderately Low degree of motivation, MHDM = Moderately high degree of motivation, and HDM = High degree of motivation.

On the other hand, after the integration of DVTs in biology classes, the post-survey gained an overall mean of 3.21 (SD = 0.37) and was interpreted as a "Moderately High Degree of Motivation." In particular, the item that got the highest mean of 3.45 (SD = 0.50) and was interpreted as a "High Degree of Motivation" is Item 1 which says "I enjoy learning biology." It clearly shows from this result how DVTs can enhance the students' motivation as well as their enjoyment of learning biology concepts. Contrastingly, the item that gained the lowest mean of 3.13 (SD = 0.43) and was interpreted as a "Moderately High Degree of Motivation" is Item 2, "What I learn in biology is more important to me than the grades I receive." This shows that most of the students prioritize their grades over their learning of biology concepts. This preference for grades over learning means that students might highly prioritize their performance in tests and assignments as a way to measure success rather than truly enjoying and engaging with the material in biology. They might be more concerned with achieving external markers of success (like grades) than having more interest in learning and acquiring knowledge in biology.

Table 2 shows the degree of motivation of students in learning biology before and after the integration of DVTs in terms of external motivation. The pre-survey got an overall mean of 2.91 (SD = 0.31) and was interpreted as a "Moderately High Degree of Engagement." Particularly, Item 2, "Getting an 'outstanding' grade in biology is important for me," obtained the highest mean of 3.27 (SD = 0.64) and was interpreted as a "High Degree of Motivation." This implies that a majority of respondents share a strong motivation towards excelling in biology and view achieving an exceptional grade as a significant and desirable

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accomplishment. On the other hand, Item 1, "I want to do better than my classmates in biology assessment," gained the lowest mean of 2.43 (SD = 0.57), interpreted as a "Moderately Low Degree of Motivation." This indicates that students do not prioritize outperforming their classmates academically. Possibly, because they do not feel rewarding to compete for it.

Table 2. Degree of Motivation of Students in Learning Biology Before and After the Integration of Dynamic Visualization Tools in Terms of External Motivation (n = 30).

Survey	External Motivation	Mean	SD	Interpretation
Pre-Survey	1. I want to do better than my classmates in Biology assessments	2.43	0.57	MLDM
	2. Getting an 'outstanding' grade in Biology is important for me.	3.27	0.64	HDM
	3. I consider how Biology will affect my overall subjects.	2.53	0.63	MHDM
	4. I think learning Biology can help my future career.	3.10	0.55	MHDM
	5. I think learning Biology can help me get a good job.	3.20	0.48	MHDM
	Average Mean	2.91	0.31	MHDM
Post-Survey	1. I want to do better than my classmates in Biology assessments	2.60	0.56	MHDM
	2. Getting an 'outstanding' grade in Biology is important for me.	3.13	0.63	MHDM
	3. I consider how Biology will affect my overall subjects.	2.97	0.49	MHDM
	4. I think learning Biology can help my future career.	3.17	0.65	MHDM
	5. I think learning Biology can help me get a good job.	3.20	0.41	MHDM
	Average Mean	3.01	0.33	MHDM

After the integration of DVTs, the post-survey garnered an overall mean of 3.01 (SD = 0.33) and was interpreted as a "Moderately High Degree of Motivation." Specifically, Item 5, "I think learning biology can help me get a good job," gained the highest mean of 3.20 (SD = 0.41) and was interpreted as a "Moderately High Degree of Motivation." This suggests that DVTs contributed to building a strong belief among students that learning biology can lead to good job opportunities, this means that students became more future-oriented and focused on their careers. This motivation can drive them to engage more actively in their studies and strive for academic success in biology. Moreover, the lowest mean of 2.60 (SD = 0.56) and interpreted as a "Moderately High Degree of Motivation" is Item 1, "I want to do better than my classmates in biology assessments." Although there is an increased mean from the pre-survey, it remained the lowest among surveyed items. It shows that DVTs may enhance overall motivation levels but certain aspects of motivation such as competitiveness in academic assessments still require further emphasis as it could stimulate positive learning outcomes.

Table 3 shows the students' degree of motivation in learning biology before and after using DVTs for personal relevance. The pre-survey gained an overall mean of 2.91 (SD = 0.21) and was interpreted as a "Moderately High Degree of Motivation" while the post-survey gained an overall mean of 3.15 (SD = 0.31) and was interpreted as a "Moderately High Degree of Motivation." In particular, Item 4 from the pre-survey, "What I learned in biology will be helpful to me," obtained the highest mean of 3.10 (SD = 0.40), interpreted as a "Moderately High Degree of Motivation." After the integration of the DVTs, Item 4 in the post-survey still got the highest mean with the calculated value of 3.33 (SD = 0.48). Surprisingly, the interpretation of this result has changed which became "High Degree of Motivation." This finding strongly shows that students are motivated when they perceive a direct connection

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and relevance between what they learn in biology and in their lives as well as when maximizing the use of DVTs in learning the concept. However, on the other hand, the pre-survey revealed that Item 1 "What I learned in biology relates to my personal goals" got the lowest mean of 2.73 (SD = 0.52) and was interpreted as a "Moderately High Degree of Motivation." Similarly, Item 1 in the post-survey remained at the lowest mean of 3.03 (SD = 0.49) and is still interpreted as a "Moderately High Degree of Motivation." This shows that while students manipulate DVTs in their learning and likely see some connection between the biology subject with their personal goals, it may not be as strong as they perceive the usefulness of the subject to their relevant interests.

Table 3. Degree of Motivation of Students in Learning Biology Before and After the Integration of Dynamic Visualization Tools in Terms of Personal Relevance (n = 30).

Survey	Personal Relevance	Mean	SD	Interpretation
Pre-Survey	1. What I learned in Biology relates to my personal goals.	2.73	0.52	MHDM
	2. What I learned in Biology is relevant to my life.	2.87	0.43	MHDM
	3. What I learned in Biology has practical value for me.	2.97	0.18	MHDM
	4. What I learned in Biology will be helpful to me.	3.10	0.40	MHDM
	5. I consider how I'll apply the concepts I learned in Biology.	2.90	0.48	MHDM
	Average Mean	2.91	0.21	MHDM
Post-Survey	1. What I learned in Biology relates to my personal goals.	3.03	0.49	MHDM
	2. What I learned in Biology is relevant to my life.	3.10	0.40	MHDM
	3. What I learned in Biology has practical value for me.	3.20	0.55	MHDM
	4. What I learned in Biology will be helpful to me.	3.33	0.48	HDM
	5. I consider how I'll apply the concepts I learned in Biology.	3.10	0.55	MHDM
	Average Mean	3.15	0.31	MHDM

Table 4 shows the degree of students' motivation in learning biology before and after using DVTs in terms of responsibility. Before the integration, the overall mean motivation was calculated as 2.95 (SD = 0.30) and was interpreted as a "Moderately High Degree of Motivation." Item 1, "I try to figure out why I'm having trouble learning," obtained a mean of 3.17 (SD = 0.53), interpreted as a "Moderately High Degree of Motivation." This shows that students are motivated to figure out why they have difficulties when it comes to their learning. They are proactive in finding solutions to their learning difficulties, which reflects a sense of responsibility towards their learning process. Contrastingly, Item 3 "I ensure that I learn biology well by using strategies" got the lowest mean of 2.60 (SD = 0.56) and it was interpreted as a "Moderately High Degree of Motivation." This result explains that even though students are motivated, learning biology using strategies is quite uncommon for them. With this, educators should promote various learning styles that could elevate students' level of motivation.

After the utilization of DVTs in biology classes, **Table 4** revealed the overall mean score of post-survey which is 3.00 (SD = 0.33). This score was interpreted as a "Moderately High Degree of Motivation." Specifically, Item 4 which says that "It is my fault if I do not understand the biology ideas" got the highest calculated mean of 3.10 (SD = 0.66). This was also interpreted as a "Moderately High Degree of Motivation." Based on this result, utilizing DVTs in biology classes can motivate the students and help them be accountable for their learning gains. Additionally, this sense of ownership, combined with the integration of DVTs, fosters a conducive learning environment and contributes to students' personal growth. In contrast,

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Item 2, "I put enough effort into learning biology" obtained the lowest calculated mean of 2.87 (SD = 0.57) and is still interpreted as a "Moderately High Degree of Motivation." This shows that while students maximize DVTs and acknowledge their role in exerting effort toward learning biology, their motivation in this aspect may not be as strong as their sense of accountability in understanding the subject matter. This highlights the significance of fostering a sense of responsibility and a commitment to learning among students.

Table 4. Degree of Motivation of Students in Learning Biology Before and After the Integration of Dynamic Visualization Tools in Terms of Responsibility (n = 30).

Survey	Responsibility	Mean	SD	Interpretation
Pre-Survey	1. I try to figure out why I'm having trouble in learning Biology.	3.17	0.53	MHDM
	2. I put enough effort into learning Biology.	3.10	0.48	MHDM
	3. I ensure that I learn Biology well by using strategies.	2.60	0.56	MHDM
	4. It is my fault if I do not understand the Biology ideas.	2.93	0.78	MHDM
	5. I prepare well for the Biology assessments.	2.93	0.58	MHDM
	Average Mean	2.95	0.30	MHDM
Post-Survey	1. I try to figure out why I'm having trouble in learning Biology.	3.07	0.64	MHDM
	2. I put enough effort into learning Biology.	2.87	0.57	MHDM
	3. I ensure that I learn Biology well by using strategies.	3.00	0.45	MHDM
	4. It is my fault if I do not understand the Biology ideas.	3.10	0.66	MHDM
	5. I prepare well for the Biology assessments.	2.97	0.56	MHDM
	Average Mean	3.00	0.33	MHDM

Table 5 shows the degree of motivation of students in learning biology before and after the integration of DVTs in terms of self-efficacy. Before the integration, the pre-survey of students accumulated an average mean of 2.26 (SD = 0.49) and was interpreted as a "Moderately Low Degree of Motivation." In particular, Item 3 in this category says, "I believe I can master the knowledge and skills in the biology class" which gained the highest mean of 2.47 (SD = 0.51) but is interpreted as a "Moderately Low Degree of Motivation." This implies that, while students' confidence was not drastically low, the majority of them were not highly confident about their ability to master biology concepts and their competencies. As the student population lacks a strong belief in their capability to excel in biology through acquiring knowledge and skills, this might impact their actual performance, as confidence levels can significantly influence academic performance. On the contrary, Item 5 which says, "I believe I can earn 'outstanding' grades in biology" got the lowest mean of 1.87 (SD = 0.73) and was interpreted as a "Moderately Low Degree of Motivation." This indicates that students are not self-efficaciously driven by their eagerness to acquire high grades in their biology subject, suggesting a concerning lack of confidence among students and a potential barrier to high academic performance in biology, leading to self-limiting beliefs.

Following the integration of DVTs, the garnered overall mean of students' motivation from post-survey is 2.85 (SD = 0.37) and interpreted as a "Moderately High Degree of Motivation." In particular, Item 2 which says that "I am confident I'll do well on the written biology assessments" obtained the highest mean of 2.93 (SD = 0.52). This result was interpreted as a "Moderately High Degree of Motivation." An inference from this finding is that utilizing DVTs in biology classes can boost students' motivation level as well as their confidence level in taking biology assessments. It has also revealed that even though there are students who feel confident and ready to take biology assessments, there are still some students who experience self-doubt and or anxiety. On the other hand, "Moderately High Degree of

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Motivation" was interpreted for Item 1 "I expect to do well or better than other students in biology class," which gained the lowest mean of 2.67 (SD = 0.55). The findings suggest that while students are optimistic about their performance due to improved teaching methods using DVTs, they became more realistic or cautious of outperforming their peers. This indicates that technological tools aid in understanding the material and stimulate students' awareness of the competitive academic environment leading them to excel collaboratively.

Table 5. Degree of Motivation of Students in Learning Biology Before and After the Integration of Dynamic Visualization Tools in Terms of Self-Efficacy (n = 30).

Survey	Self-Efficacy	Mean	SD	Interpretation
Pre-Survey	1. I expect to do well or better than other students in Biology class.	2.37	0.72	MLDM
	2. I am confident I'll do well on the written Biology assessments.	2.47	0.63	MLDM
	3. I believe I can master the knowledge and skills in the Biology class.	2.47	0.51	MLDM
	4. I am confident I'll do well on the practical Biology assessments.	2.13	0.82	MLDM
	5. I believe I can earn 'outstanding' grades in Biology.	1.87	0.73	MLDM
	Average Mean	2.26	0.49	MLDM
Post-Survey	1. I expect to do well or better than other students in Biology class.	2.67	0.55	MHDM
	2. I am confident I'll do well on the written Biology assessments.	2.93	0.52	MHDM
	3. I believe I can master the knowledge and skills in the Biology class.	2.90	0.40	MHDM
	4. I am confident I'll do well on the practical Biology assessments.	2.90	0.48	MHDM
	5. I believe I can earn 'outstanding' grades in Biology.	2.83	0.65	MHDM
	Average Mean	2.85	0.37	MHDM

Table 6 shows the degree of motivation of students in learning biology before and after the integration of dynamic visualization tools in terms of anxiety. Before the integration, the pre-survey of students gained an overall mean of 2.48 (SD = 0.36), interpreted as a "Moderately Low Degree of Motivation," indicating a high anxiety level. Wherein, Item 2 which says, "I am determined to succeed in biology assessments" gained the highest mean of 2.73 (SD = 0.64) and was interpreted as a "Moderately High Degree of Motivation," indicating a moderately low anxiety level. This suggests that despite an overall moderate level of motivation and anxiety among low-performing students before the integration of DVTs, they still exhibited a notably high level of motivation to succeed in assessments with low anxiety levels. In contrast, Item 3 which says "I acknowledge that I have unique strengths in biology" got the lowest mean of 2.20 (SD = 0.55) and it was interpreted as a "Moderately Low Degree of Motivation" with a moderately high anxiety level. It suggests that students get anxious and often experience self-doubt about their abilities in learning biology. These findings emphasize that addressing anxiety needs immediate action and self-perception of strengths in fostering a conducive learning environment should be promoted.

Following the integration of DVTs, the post-survey garnered an overall mean of 2.90 (SD = 0.40) which was interpreted as a "Moderately High Degree of Motivation." Notably, Item 2,

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"I am determined to succeed in biology assessments" gained the highest mean of 3.13 (SD = 0.51), interpreted as a "Moderately High Degree of Motivation" with a moderately low anxiety level. This result shows how utilizing DVTs in biology education can enhance students' motivation while reducing their anxiety levels. This result can be attributed to DVTs considering their accessibility and engaging nature. On the contrary, item 3, which says, "I acknowledge that I have unique strengths in biology" also gained the lowest mean of 2.67 (SD = 0.48), interpreted as a "Moderately High Degree of Motivation" with a moderately low anxiety level. This implies that even though the integration of DVTs generally boosts student motivation, there is some hesitation among students to recognize their unique strengths in biology. The relatively lower score for this item suggests that while the tools have helped increase overall confidence and reduced anxiety, they may not have fully addressed students' self-perception regarding individual capabilities within the subject.

Table 6. Degree of Motivation of Students in Learning Biology Before and After the Integration of Dynamic Visualization Tools in Terms of Anxiety (n = 30).

Survey	Anxiety*	Mean	SD	Interpretation
Pre-Survey	1. I feel calm and well-prepared when it is time to sit for a Biology assessment.	2.30	0.60	MLDM
	2. I am determined to succeed in Biology assessments.	2.73	0.64	MHDM
	3. I acknowledge that I have unique strengths in Biology.	2.20	0.55	MLDM
	4. I approach Biology assessments with a positive attitude.	2.67	0.71	MHDM
	Average Mean	2.48	0.36	MLDM
Post-Survey	1. I feel calm and well-prepared when it is time to sit for a Biology assessment.	2.70	0.53	MHDM
	2. I am determined to succeed in Biology assessments.	3.13	0.51	MHDM
	3. I acknowledge that I have unique strengths in Biology.	2.67	0.48	MHDM
	4. I approach Biology assessments with a positive attitude.	3.10	0.61	MHDM
	Average Mean	2.90	0.40	MHDM

Note: LDM = Low degree of motivation, MLDM = Moderately Low degree of motivation, MHDM = Moderately high degree of motivation, and HDM = High degree of motivation.

To examine students' motivation, a survey was conducted to measure six factors that contribute to motivation, including internal motivation, external motivation, personal relevance, responsibility, self-efficacy, and anxiety. **Table 7** shows the result that participants had a "Moderately High Degree of Motivation" before utilizing DVTs in biology class, with a grand mean of 2.73 (SD = 0.21). Among the surveyed variables, "responsibility" obtained the highest mean of 2.95 (SD = 0.30), indicating a "Moderately High Degree of Motivation.” It only suggests that focusing on enhancing the sense of responsibility among students, which is already relatively high, could further improve overall motivation. In contrast, "self-efficacy" got the lowest mean of 2.26 (SD = 0.49) and was interpreted as a "Moderately Low Degree of Motivation.” This suggests that students may lack confidence in their ability to succeed in academic tasks, potentially impacting their motivation levels and overall engagement in learning activities.

After the integration of DVTs, the participants' motivation levels showed significant improvement. The grand mean score increased to 3.05 (SD = 0.29), interpreted as a "Moderately High Degree of Motivation.” Among the surveyed variables, "internal motivation" scored the highest mean of 3.21 (SD = 0.37), indicating a "Moderately High Degree of Motivation.” This could be attributed to various factors, including personal interest in lessons, personal goals, or a sense of autonomy in learning. In contrast, "self-efficacy," with an average mean of 2.85 (SD = 0.37) remained the lowest among various parameters,

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indicating a "Moderately High Degree of Motivation." Despite being identified as the weakest aspect, there is still an evident improvement from its pre-survey result after using DVTs in biology classes. Various factors can be attributed to this result, such as deep-rooted beliefs about one's abilities, past experiences, or the perceived difficulty of academic tasks. Additionally, it highlights the persistent need for targeted interventions and support mechanisms to hone students' confidence in their academic abilities.

Table 7. Summary Table of the Degree of Motivation of Students in Learning Biology Before and After the Integration of Dynamic Visualization Tools.

Survey		Mean	SD	Interpretation
Pre-Survey	Internal Motivation	2.87	0.43	MHDM
	External Motivation	2.91	0.31	MHDM
	Personal Relevance	2.91	0.21	MHDM
	Responsibility	2.95	0.30	MHDM
	Self-Efficacy	2.26	0.49	MLDM
	Anxiety	2.48	0.36	MLDM
	Grand Mean in Motivation	2.73	0.21	MHDM
Post-Survey	Internal Motivation	3.21	0.37	MHDM
	External Motivation	3.01	0.33	MHDM
	Personal Relevance	3.15	0.31	MHDM
	Responsibility	3.00	0.33	MHDM
	Self-Efficacy	2.85	0.37	MHDM
	Anxiety	2.90	0.40	MHDM
	Grand Mean in Motivation	3.05	0.29	MHDM

3.2. Degree of Students' Engagement in Learning Biology Before and After the Integration of Dynamic Visualization Tools

This presents the result of the study in terms of engagement and its dimensions. The discussion revolves around the engagement levels of students in learning biology, comparing before and after the integration of dynamic visualization tools, and examining their determined impact and implications.

Table 8 shows a detailed analysis of the degree of student engagement in learning biology before and after the integration of DVTs in terms of cognitive engagement. The pre-survey gained an overall mean of 2.68 *(SD = 0.26)*, which was interpreted as a "Moderately High Degree of Engagement." Among the surveyed items, Item 1 "I am looking forward to learning more about biology" and Item 10 "I am trying to learn as much as I can in our biology class" both received the highest mean of 2.97 *(SD = 0.56)* which was interpreted as a "Moderately High Degree of Engagement." This result shows that students might be actively thinking of new biological concepts and open-mindedly try to grasp these concepts as much as they can. However, the lowest mean of 2.20 *(SD = 0.48)* in pre-survey is Item 3 which says "I devote my time to practice solving biology problems after school" and is interpreted as "Moderately Low Degree of Engagement." This result in engagement in biology education indicates that students do not allocate enough time to practice problem-solving in their biology class after school, as a result, it can negatively affect their mastery of the subject matter.

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Table 8. Degree of Engagement of Students in Learning Biology Before and After the Integration of Dynamic Visualization Tools in terms of Cognitive Engagement *(n = 30)*

Survey	Cognitive Engagement	Mean	SD	Interpretation
Pre-Survey	1. I am looking forward to learning more about Biology.	2.97	0.56	MHDE
	2. I read my Biology book in advance to be ready in our class.	2.27	0.58	MLDE
	3. I devote my time to practice solving Biology problems after school.	2.20	0.48	MLDE
	4. I am intellectually stimulated during Biology class.	2.60	0.56	MHDE
	5. In my free time, I spend time looking for more information on topics discussed in Biology class.	2.80	0.55	MHDE
	6. Whenever I am absent in class, I ask my classmates to help me understand my missed Biology lesson.	2.97	0.72	MHDE
	7. I recognize the value of learning in our Biology class.	2.93	0.37	MHDE
	8. I am investing time and effort to learn a lot in our Biology lessons.	2.77	0.50	MHDE
	9. I have to stay late at night to study our lessons in Biology.	2.30	0.53	MLDE
	10. I am trying to learn as much as I can in our Biology class.	2.97	0.56	MHDE
	Average Mean	2.68	0.26	MHDE
Post-Survey	1. I am looking forward to learning more about Biology.	3.13	0.57	MHDE
	2. I read my Biology book in advance to be ready in our class.	2.60	0.62	MHDE
	3. I devote my time to practice solving Biology problems after school.	2.73	0.45	MHDE
	4. I am intellectually stimulated during Biology class.	2.97	0.61	MHDE
	5. In my free time, I spend time looking for more information on topics discussed in Biology class.	2.80	0.55	MHDE
	6. Whenever I am absent in class, I ask my classmates to help me understand my missed Biology lesson.	3.27	0.58	HDE
	7. I recognize the value of learning in our Biology class.	3.20	0.61	MHDE
	8. I am investing time and effort to learn a lot in our Biology lessons.	2.93	0.58	MHDE
	9. I have to stay late at night to study our lessons in Biology.	2.67	0.61	MHDE
	10. I am trying to learn as much as I can in our Biology class.	3.23	0.50	MHDE
	Average Mean	2.95	0.32	MHDE

Note: LDE = Low degree of engagement, MLDE = Moderately Low degree of engagement, MHDE = Moderately high degree of engagement, and HDE = High degree of engagement

In contrast, the post-survey result garnered an overall mean of 2.95 *(SD = 0.32)* and was interpreted as a "Moderately High Degree of Engagement." Despite variations in individual responses, the collective engagement level within the group remained notably above average. Furthermore, Item 6, "Whenever I am absent in class, I ask my classmates to help me understand my missed biology lesson" received the highest mean of 3.27 *(SD = 0.58)*. This result suggests a consistent and proactive approach to learning and reflecting a "High Degree of Engagement" among students. It highlights the students' inclination towards collaborative learning and their willingness to take initiative in ensuring their comprehension of the subject matter. Meanwhile, Item 2, "I read my biology book in advance to be ready for our class" obtained the lowest mean of 2.60 *(SD = 0.62)* and was interpreted as a "Moderately High Degree of Engagement." This suggests that there is a lesser degree of engagement in independent preparatory activities among students. Moreover, it highlights an area where students could benefit from additional support or encouragement to enhance their proactive learning strategies and maximize their readiness for classroom learning experiences.

Table 9 provides a detailed analysis of student engagement in learning biology before and after the integration of dynamic visualization tools, specifically in terms of behavioral

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engagement. The pre-survey result showed an overall mean of 2.91 *(SD = 0.35)*, indicating a "Moderately High Degree of Engagement." Among the survey items, Item 2, "I am doing the seatwork given by the biology teachers in class," got the highest mean of 3.27 *(SD = 0.45)*, signifying a "High Degree of Engagement." This suggests that teachers have made classroom activities more engaging, as students were highly motivated to do the assigned seatwork. On the other hand, the item with the lowest mean of 2.43 *(SD = 0.57)* and was interpreted as a "Moderately Low Degree of Engagement" is Item 3. This item states, “I am standing and answering my teacher's questions when called in the biology class.” This result explains why students seemed to be less behaviorally engaged in class discussions or responding to teacher questions. Additionally, this finding could also be due to various factors such as the shyness of students, lack of interest in the topic, or feeling unprepared to answer questions being asked.

After the integration of DVTs, the post-survey gained an overall mean of 3.04 *(SD = 0.34)* and was interpreted as a "Moderately High Degree of Engagement.” Among the items surveyed, Item 1, "I am listening to the teacher's discussion during biology class," achieved the highest mean of 3.37 *(SD = 0.56)*, indicating a "High Degree of Engagement.” The increased students' engagement in biology class, particularly in actively listening to the teacher's discussion signifies the effectiveness of DVTs. Also, the high mean score implies that when DTVs are used compared to traditional teaching methods, students become more engaged in biology class. In contrast, Item 4, "I raise my hands whenever I know the answer in biology class," obtained the lowest mean of 2.73 *(SD = 0.52)* and was interpreted as a "Moderately High Degree of Engagement.” This suggests that while students are generally engaged in biology class, their willingness to actively participate by raising their hands to answer questions is not as strong as their engagement with other aspects of the learning process. Moreover, although students may be invested in the subject matter or actively participate in collaborative learning activities, they may also feel less confident or inclined to contribute verbally in the classroom setting. Possible reasons for this reluctance could be due to low communication skills, shyness, fear of being wrong, or cultural norms discouraging students who want to speak out in class.

Table 10 provides a detailed analysis of student engagement in learning biology before and after the integration of DVTs in terms of affective engagement. The table shows an overall mean of 2.85 *(SD = 0.29)*, interpreted as a "Moderately High Degree of Engagement." Among the surveyed items, Item 4 which says "I am trying my best not to be absent in biology class" had the highest mean of 3.37 *(SD = 0.56)*, indicating a "High Degree of Engagement." It means that students are highly motivated to attend biology classes. Despite the overall moderately high engagement, the particularly high score for Item 4 suggests that students place great importance on attending biology class and participating actively. On the other hand, Item 10, "I am not bored in our biology class," had the lowest mean of 2.53 *(SD = 0.68)* and was interpreted as a "Moderately Low Degree of Engagement." This suggests that students may experience boredom during biology class, indicating a lack of interest or stimulation. The moderately low level of engagement in this aspect implies that students may not be fully invested or actively engaged in the material or class activities. This stresses the importance of addressing the factors contributing to boredom in the classroom and reassessing teaching methods, instructional materials, or classroom dynamics to enhance student engagement.

After the integration of DVTs, the post-survey yielded an overall mean of 3.19 *(SD = 0.40)* and was interpreted as a "Moderately High Degree of Engagement." Specifically, Item 9 which

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says "I enjoyed the activities in our biology class" obtained the highest mean of 3.37 *(SD = 0.61)*, indicating a "High Degree of Engagement." It suggests that students highly value collaborative learning experiences, which can enhance their engagement and learning outcomes. In contrast, Item 3 which says "I am sharing my ideas and notes with my classmates in biology," had the lowest mean of 2.97 *(SD = 0.67)* and was interpreted as a "Moderately High Degree of Engagement." It means that students are somewhat engaged in sharing their ideas and notes with classmates, but not as strongly as in other activities measured.

Table 9. Degree of Engagement of Students in Learning Biology Before and After the Integration of Dynamic Visualization Tools in terms of Behavioral Engagement *(n = 30)*

Survey	Behavioral Engagement	Mean	SD	Interpretation
Pre-Survey	1. I am listening to the teacher's discussion during Biology class.	3.10	0.48	MHDE
	2. I am doing the seat-work given by the Biology teachers in class.	3.27	0.45	HDE
	3. I am standing and answering my teacher's questions when called in Biology class.	2.43	0.57	MLDE
	4. I raise my hands whenever I know the answer in Biology class.	2.63	0.61	MHDE
	5. I am doing my assignment in Biology.	3.13	0.51	MHDE
	6. I raise my hands and ask questions whenever I have queries about the lesson presented in our Biology class.	2.77	0.68	MHDE
	7. I am actively participating in the different activities in our Biology class.	3.07	0.52	MHDE
	8. I study my lessons at home whenever there are Biology tests.	2.70	0.53	MHDE
	9. I am writing down notes in my Biology class.	2.93	0.87	MHDE
	10. I am doing my Biology projects creatively and submitting them on time.	3.10	0.71	MHDE
	Average Mean	2.91	0.35	MHDE
Post-Survey	1. I am listening to the teacher's discussion during Biology class.	3.37	0.56	HDE
	2. I am doing the seat-work given by the Biology teachers in class.	3.10	0.55	MHDE
	3. I am standing and answering my teacher's questions when called in Biology class.	3.03	0.56	MHDE
	4. I raise my hands whenever I know the answer in Biology class.	2.73	0.52	MHDE
	5. I am doing my assignment in Biology.	3.17	0.46	MHDE
	6. I raise my hands and ask questions whenever I have queries about the lesson presented in our Biology class.	2.90	0.55	MHDE
	7. I am actively participating in the different activities in our Biology class.	3.13	0.63	MHDE
	8. I study my lessons at home whenever there are Biology tests.	2.90	0.48	MHDE
	9. I am writing down notes in my Biology class.	3.07	0.52	MHDE
	10. I am doing my Biology projects creatively and submitting them on time.	3.00	0.53	MHDE
	Average Mean	3.04	0.34	MHDE

Note: LDE = Low degree of engagement, MLDE = Moderately Low degree of engagement, MHDE = Moderately high degree of engagement, and HDE = High degree of engagement

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Table 10. Degree of Engagement of Students in Learning Biology Before and After the Integration of Dynamic Visualization Tools in terms of Affective Engagement (n = 30)

Survey	Affective Engagement	Mean	SD	Interpretation
Pre-Survey	1. I like the feeling when I am solving problems in Biology class.	2.60	0.67	MHDE
	2. I help my classmates solve Biology problems whenever they have difficulties.	2.70	0.70	MHDE
	3. I am sharing my ideas and notes with my classmates in Biology.	2.90	0.61	MHDE
	4. I am trying my best not to be absent in Biology class.	3.37	0.56	HDE
	5. I am happy that my teacher in Biology encourages me to be involved in class.	2.57	0.57	MHDE
	6. I am glad that my classmates are willing to help me answer Biology problems.	3.17	0.65	MHDE
	7. I like the way my Biology teacher delivers the lesson in class.	2.77	0.63	MHDE
	8. My Biology teacher tries his best for me to learn.	2.97	0.76	MHDE
	9. I enjoyed the activities in our Biology class.	2.90	0.48	MHDE
	10. I am not bored in our Biology class.	2.53	0.68	MHDE
	Average Mean	2.85	0.29	MHDE
Post-Survey	1. I like the feeling when I am solving problems in Biology class.	3.03	0.61	MHDE
	2. I help my classmates solve Biology problems whenever they have difficulties.	3.07	0.45	MHDE
	3. I am sharing my ideas and notes with my classmates in Biology.	2.97	0.67	MHDE
	4. I am trying my best not to be absent in Biology class.	3.23	0.68	MHDE
	5. I am happy that my teacher in Biology encourages me to be involved in class.	3.30	0.65	HDE
	6. I am glad that my classmates are willing to help me answer Biology problems.	3.33	0.61	HDE
	7. I like the way my Biology teacher delivers the lesson in class.	3.17	0.59	MHDE
	8. My Biology teacher tries his best for me to learn.	3.30	0.60	HDE
	9. I enjoyed the activities in our Biology class.	3.37	0.61	HDE
	10. I am not bored in our Biology class.	3.10	0.66	MHDE
	Average Mean	3.19	0.40	MHDE

Note: LDE = Low degree of engagement, MLDE = Moderately Low degree of engagement, MHDE = Moderately high degree of engagement, and HDE = High degree of engagement

To examine students' engagement, a survey was conducted to measure three factors that contribute to engagement which are cognitive engagement, behavioral engagement, and affective engagement. **Table 11** shows the results revealing that the participants had a “Moderately High Degree of Engagement” before the intervention, with a grand mean of 2.81 *(SD = 0.12)*. Among the surveyed variables, “behavioral engagement” showed the highest mean of 2.91 *(SD = 0.35)*, indicating a "Moderately High Degree of Engagement." It only suggests that focusing on enhancing behavioral engagement among students could further improve overall engagement. However, "cognitive engagement" got the lowest mean of 2.68 *(SD = 0.26)*, which can be interpreted as a "Moderately High Degree of Engagement.” This suggests that students might have low initiative to learn biology concepts after class and they

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might not put enough time into voluntarily learning biology concepts through problem-solving, critical thinking, and the like.

After the integration of dynamic visualization tools, the participants' engagement levels showed significant improvement. The grand mean score increased to 3.06 *(SD = 0.12)*, interpreted as a "Moderately High Degree of Engagement." Among the surveyed variables, "affective engagement" scored the highest mean of 3.19 *(SD = 0.40)*, suggesting a "Moderately High Degree of Engagement." This suggests that students became happier and liked the feeling of learning biology with the integration of DVTS. In contrast, "cognitive engagement," with an average mean of 2.95 *(SD = 0.32)* indicating a "Moderately High Degree of Engagement," remained the lowest among various parameters. Despite being identified as the weakest aspect, there are still evident improvements compared to its pre-survey results, which should not be understated. Therefore, these findings can be attributed to factors such as not investing time in practicing learning biology through DVTs, and or not trying to remember their prior knowledge about the subject matter.

Table 11. Summary Table of the Degree of Engagement of Students in Learning Biology Before and After the Integration of Dynamic Visualization Tools

Survey		Mean	SD	Interpretation
Pre- Survey	Cognitive Engagement	2.68	0.26	MHDE
	Behavioral Engagement	2.91	0.35	MHDE
	Affective Engagement	2.85	0.29	MHDE
	Grand Mean in Engagement	2.81	0.12	MHDE
Post-Survey	Cognitive Engagement	2.95	0.32	MHDE
	Behavioral Engagement	3.04	0.34	MHDE
	Affective Engagement	3.19	0.40	MHDE
	Grand Mean in Engagement	3.06	0.12	MHDE

Note: LDE = Low degree of engagement, MLDE = Moderately Low degree of engagement, MHDE = Moderately high degree of engagement, and HDE = High degree of engagement

3.3. Difference in the Degree of Motivation of Students Before and After Integrating Dynamic Visualization Tools

This presents the integration of dynamic visualization tools in biology education, focusing on the change in students' motivation levels before and after the adoption of these technologies. By analyzing this data, the researchers aim to determine how such tools influence student motivation in educational settings.

Table 12 shows the result of the paired sample t-test in the attempt to determine whether there is a significant mean increase in the test scores of students on the degree of motivation after integrating DVTs into their subject. Based on the results, there is a significant difference, t (29) = -6.113, p = 0.000, noting that the degree of motivation after integrating dynamic visualization tools ($\bar{x}$ = 3.05, *SD = 0.29)* is 0.32 points higher than the degree of motivation before integrating dynamic visualization tools ($\bar{x}$ = 2.73, *SD = 0.21)*. This rejects the null hypothesis of no significant mean difference.

Table 12. Difference in The Degree of Motivation of Students Before and After Integrating Dynamic Visualization Tools.

	Survey	N	Mean	SD	t	df	p	Interpretation
Motivation	Pre-Survey	30	2.73	0.21	-6.113	29	0.000	Significant
	Post-Survey	30	3.05	0.29				

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The t-value of -6.113 and the associated p-value of 0.000 suggest that the observed difference in mean motivation scores is unlikely to have occurred by random chance alone, which indicates a strong statistical significance. The mean motivation score after integrating DVTs ($\bar{x}$ = 3.05) is significantly higher than the mean motivation score before integration ($\bar{x}$ = 2.73). This implies that the resulting 0.32 difference is considered to be meaningful in an educational context where even a slight increase in student motivation can lead to positive learning outcomes.

The resulting standard deviations (SD) for before *(0.29)* and after *(0.21)* integrating DVTs in biology classes show a change in motivation scores within the sample. The decrease in SD after the integration indicates that students' responses are consistent. This consistency suggests that there's a more uniform impact of DVTs on students' overall motivation.

By rejecting the null hypothesis of no significant mean difference, the alternative hypothesis that integrating DVTs leads to a significant increase in student motivation will be accepted. Consequently, as the findings indicate that DVTs can positively impact student motivation, then educators should consider incorporating such tools into their teaching practices to capture students' interest, facilitate a better understanding of complex concepts, and promote active learning.

3.4. Difference in the Degree of Engagement of Students Before and After Integrating Dynamic Visualization Tools

This presents the integration of dynamic visualization tools in biology education, focusing on the change in students' engagement levels before and after the integration of these educational technologies. By analyzing the data, the researchers aim to determine how such tools influence student engagement in educational settings.

Table 13 shows the result of the paired sample t-test in the attempt to determine whether there is a significant mean increase in the test scores of students on the degree of engagement after integrating dynamic visualization tools into their subject. Based on the results, there is a significant difference, t(29) = -4.330, p = 0.000, noting that the degree of engagement after integrating dynamic visualization tools ($\bar{x}$ = 3.06, *SD = 0.32*) is 0.25 points higher than the degree of engagement before integrating dynamic visualization tools ($\bar{x}$ = 2.81, *SD = 0.26*). This rejects the null hypothesis of no significant mean difference. The t-value of -4.330 and the associated p-value of 0.000 indicate a highly significant difference in mean engagement scores before and after integrating dynamic visualization tools.

Table 13. Difference in the Degree of Engagement of Students Before and After Integrating Dynamic Visualization Tools.

	Survey	N	Mean	SD	t	df	p	Interpretation
Engagement	Pre-Survey	30	2.81	0.26	-4.33	29	0	Significant
	Post-Survey	30	3.06	0.32				

The results of this study indicate that the mean engagement score of ($\bar{x}$ = 3.06) for post-integration is significantly higher than the mean engagement score of ($\bar{x}$ = 2.81) for pre-integration. A value of 0.25 difference also suggests that there is a meaningful improvement in students' engagement. Furthermore, results indicated that standard deviations (SD) for

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pre-integration and post-integration are *(0.32)* and *(0.26)*, respectively. These results are important for understanding the variation in engagement scores within the samples. Also, the decrease in SD of post-integration from pre-integration suggests a more consistent response from the students and a more consistent overall impact of DVTs on student engagement. Since the study rejected the null hypothesis of no significant mean difference, an alternative hypothesis can be accepted that integrating DVTs into biology classes will increase student engagement. These findings imply that interactive and dynamic visual elements are necessary to engage students if student engagement is a priority for educators in education. These findings emphasize a need to create an education experience that provides students with opportunities to be involved with technology-enhanced learning environments that may capture their interest and foster active participation in learning biology.

3.5. Relationship Between Motivation and Engagement of Students in Learning Biology

This presents the relationship between motivation and engagement, essential for improving educational outcomes in biology. This discussion focuses on how motivation influences student engagement and promotes deeper learning in biology, aiming to identify enhancements in both elements and improve the overall educational experience in this complex subject through dynamic visualization tools.

Table 14 shows the result of the simple linear regression analysis that aims to determine the significant direct effect of students' motivation and engagement in learning Biology. Findings revealed that there is a causal or linear relationship between the variables, F (1,58) = 83.478, p = 0.000. Also, students' motivation is found to have a significant direct effect on students' engagement (B = 0.815, t = 9.137, p = 0.000). The analysis proves that there is a significant linear relationship between students' motivation and their engagement in learning Biology. This finding is supported by the calculated F-statistic (F (1,58) = 83.478) and its associated p-value (p = 0.000), suggesting that the relationship is unlikely to be due to random chance.

The regression analysis revealed that students' motivation has a significant direct effect on their engagement in learning Biology. This is indicated by the coefficient (B) of 0.815, which represents the strength and direction of the relationship, as well as the associated t-value (t = 9.137) and p-value (p = 0.000). These values signify that higher levels of motivation are associated with greater engagement in learning Biology. Thus, the coefficient of 0.815 indicates that for every one-unit increase in students' motivation, there is an expected increase of 0.815 units in their engagement in learning Biology. This suggests a substantial positive impact of motivation on engagement in this context.

These findings have valuable insights for both educators and policymakers involved in designing and implementing Biology education. Educators and policymakers can use this information to understand the important role of motivation in influencing engagement levels among students and therefore design techniques and strategies that can promote engagement and heighten students' motivations.

Table 14. Relationship Between Motivation and Engagement of Students in Learning Biology (*n* = 30).

		B	S.E	β	t	p-value
1	(Constant)	0.579	0.259		2.230	0.030
	Motivation	0.815	0.089	0.768	9.137	0.000**

Note: F (1,58) = 83.478, p = 0.000, R = 0.768, R2 = 0.590, ΔR2 = 0.583

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4. CONCLUSION

The utilization of dynamic visualization tools (DVTs) in biology education has shown variations in students' motivation levels. Based on the pre-survey results, it was found that students have moderately high levels of motivation across dimensions. Challenges were also highlighted particularly in the aspect of self-efficacy and anxiety. On the other hand, after the utilization of DVTs in biology classes, post-survey results showed an enhancement in students' motivation, especially in the enjoyment of learning, recognition of biology's career prospects, and a sense of responsibility for comprehending complex biological concepts. Despite these positive outcomes, issues in grade emphasis, peer competitiveness, and low self-efficacy are evident and areas for future research were highlighted.

In addition, students' overall engagement levels were found to have variations. Before the utilization of DVTs in biology classes, pre-survey results showed a moderately high level of engagement but low engagement in certain activities like practicing biology problems at home or even outside the class. However, the post-survey revealed an enhancement in students' overall engagement levels, specifically, there's an improvement in the aspect of affective engagement such as feeling happy when learning biology through DVTs. Although an enhancement of students' engagement was found, barriers to cognitive engagement have persisted, indicating the need to maximize the potential of DVTs in enhancing students' engagement. Nonetheless, DVTs are effective in capturing students' attention as well as facilitating them in learning biology more actively.

In elaboration, the enhanced students' motivation in biology education brought by the utilization of DVTs proves how such tools cannot merely capture students' interest but can also promote active learning that could lead to conceptual understanding. Similarly, the enhanced students' engagement in biology education after the utilization of DVTs emphasizes how instructional materials with dynamic visual elements can help promote interactive learning opportunities. This implies that leveraging the available resources in a technology-driven world and digital space can foster a conducive learning environment for learners. Moreover, the decrease of variability in motivation and engagement scores highlights a consistent positive effect across student populations. Therefore, educators can integrate DVTs into biology education to support learners achieve their academic success.

To sum it up, as using DVTs in biology education has revealed a causal relationship between motivation and engagement, educators must emphasize these two aspects considering how it can positively affect the academic performance of every learner in biology education. Thus, this study highlights the importance of incorporating DVTs in biology education and it also suggests new avenues for future researchers to explore other ways in which such tools can be used to optimize student learning outcomes. By effectively incorporating DVTs in biology education, learners can be supported to have motivating and engaging learning experiences that will scaffold them to achieve their fullest potential in biology and beyond.

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6. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. Authors confirmed that the paper was free of plagiarism.

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