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Transforming an Online Advanced Diploma Molecular Biology Module: A student engagement case study

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Abstract. This case study explored the transformation of the online Advanced Diploma Molecular Biology Module to enhance student engagement. Student engagement refers to the active participation of students in their learning process, which is influenced by their activities and a conducive environment established by educational institutions. The study aimed to determine various strategies and interventions for improving student engagement in online learning of molecular biology through an engagement framework. A literature review and document analysis were conducted to address the research questions guiding this study. The analysis of Learning Units 1 and 2 of the Molecular Biology modules revealed that there are limited student engagement activities, teacher/student relations, and peer interactions. The findings indicate the need for interactive content, regular feedback, active learning components, and community-building efforts to contribute to a supportive and motivating learning experience. The findings also suggest that a multifaceted approach, leveraging both technological tools and innovative pedagogical strategies, can effectively boost student engagement and academic performance in online courses. This case study highlights the potential of innovative educational methods to improve online learning environments and promote a more engaging and successful learning experience. Future research ought to investigate the impacts of these strategies on student achievement and retention.

Keywords: Transform; Student engagement; collaboration; online engagement framework; social constructivism theory

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1. Introduction

The utilisation of online platforms for teaching and learning has experienced a significant rise globally and in the South African higher education system. (Hollister et al., 2022; Moonasamy & Naidoo, 2022; Wang et al., 2025). The sudden shift to online learning was triggered by the COVID-19 pandemic, resulting in a 97% increase in the number of undergraduate students involved in online learning compared to the previous year, 2019 (Mate & Weidenhofer, 2021). Online education frequently demands greater autonomy and self-regulation from students, while instructors must actively engage students in the online environment (Zhou & Wang, 2023).

Research has shown that students' engagement and enthusiasm in their education significantly affect their learning (Fang & Tse, 2023; Ferri et al., 2020; Rowan & Jin, 2022; Sibanda & Josua, 2022). Higher academic achievement, persistence, task completion, and physical or psychological well-being are generally associated with more engaged students (Redmond et al., 2018).

Student engagement in teaching and learning also involves attention, effort, participation, curiosity, enthusiasm, and passion (Chiu, 2021). Learning can be maximised when it involves students' cognitive, emotional, and behavioral responses to teaching and learning within and beyond the classroom. While students are more likely to engage in face-to-face classes, it has become more difficult to actively involve students in online classes (Ferri et al., 2020). It is, therefore, imperative to ascertain student engagement strategies in online teaching and establish a suitable framework for executing these tactics.

This higher education study was driven by the following main research question: How can student engagement improve in an online molecular biology module? To address this question, this study aimed to determine various strategies and interventions for improving student engagement in an online molecular biology classroom through an online engagement framework. The related subsidiary questions and objectives are as presented in Table 1.

Table 1: Subsidiary questions and objectives

Subsidiary question	Objectives
What are the present viewpoints about student engagement in online molecular biology classrooms?	Determine the current viewpoint on student engagement in online molecular biology classes through a literature review.
What factors influence online student engagement in the Advanced Diploma Molecular Biology module?	Carry out a reflective document analysis to identify factors influencing student engagement in online Advanced Diploma Molecular Biology module classes.
Which proposed strategies and interventions (or guidelines) can be used to improve student engagement in online Molecular Biology classes?	Recommend student engagement strategies and interventions (or guidelines) to improve student engagement in an online Molecular Biology class.

1.1 Online engagement theoretical framework

Redmond et al. (2018) online engagement framework consists of five communication points that must be addressed to facilitate student adaptation to a new online learning environment. They include social engagement, cognitive engagement, behavioral engagement, collaborative engagement, and emotional engagement. Student social engagement should be fostered by implementing activities that promote active student involvement in constructing their learning community. Teacher-directed active learning practices promote cognitive engagement, but students must also understand the need to develop transdisciplinary metacognitive abilities such as critical thinking and inquiry.

Providing students with opportunities to connect topic knowledge and learning tasks to their own lives and effectively articulating this connection to their classmates, can enhance their behavioral engagement. As a result, learners are more inclined to seek assistance or help their peers when necessary. This dedication to broader social and behavioral interaction contributes to the cultivation of students' emotional involvement and the formation of favourable attitudes towards learning and the online learning environment.

2. Literature review

Student engagement, as defined by various researchers (Wingfield et al., 2015; Skinner, 2016; Cent-Boonstra et al., 2021; Donham et al., 2022; Lasekan et al., 2024; Aldowah et al., 2025), is a multifaceted construct that includes aspects such as active involvement, contextual influence, institutional role, and behaviour indicators. This comprehensive perspective is indispensable for creating strategies that effectively increase engagement in online learning environments. Student engagement is essential for effective and deep learning (Skinner, 2016). Moreover, it has been shown that there is a correlation between student involvement and two other variables: students' enthusiasm to learn and their persistence to finish school. Additionally, long-term career prospects are more significant for students who are actively involved in their education (Cents-Boonstra et al., 2021).

The online learning of Molecular Biology is entirely synchronous and presents a diverse array of pedagogical, technological, and social challenges and opportunities, all of which have an impact on student engagement. Student engagement in online classes is a crucial factor that predicts the sustainability of virtual education, as it significantly influences learning outcomes and overall effectiveness. Research has demonstrated the significance of student engagement in achieving positive outcomes in multiple aspects (Lasekan et al., 2024).

Additionally, student engagement is significant as it improves student understanding and retention, critical thinking and problem-solving, motivation and interest, and collaboration and communication. Active engagement helps students process information more effectively, leading to better understanding and long-term retention. Interactive and participatory learning experiences are more memorable than passive learning experiences. A study of schools that had undergone organisational changes showed a direct link between greater

psychological engagement, higher grades, and better performance (Abla & Fraumeni, 2019).

According to Vincent-Lancrin (2023), engaged students are more likely to engage in higher-order thinking, such as analysing, evaluating, and synthesising information. They develop problem-solving skills by applying concepts to real-world scenarios. Instructors should therefore develop learning activities that are specifically designed to encourage critical thinking. Additionally, integrating critical thinking into all subjects of the curriculum ensures that students are consistently allowed to cultivate this skill, even in the subjects they most enjoy. Engaging teaching methods can also increase a student's interest and motivation, making them more devoted to the subject matter. A motivated student is more likely to strive to succeed. Motivation is an essential requirement and a vital component for fostering student participation in the learning process. Student involvement in learning serves as both a goal and a method for students to achieve strong academic results. This is significant because genuine involvement might result in enhanced academic performance throughout a student's educational journey.

For educators to understand and address the concerns of students and create stimulating learning environments, it is imperative that they actively listen to the feedback provided by students (Saeed & Zyngier, 2012). Also, Oxford and Jocyrk (2020) highlighted that student engagement often involves collaborative activities, improving student communication skills, and their ability to work in teams. These skills are essential in scientific research and professional development. For example, graduate students can support undergraduate students as they "teach by example". Graduate students can present and lead the discussion early in the semester. Undergraduate students can observe high-quality presentations and understand the process and expectations before they make their presentations. Considering the significance of student engagement for students' success both now and in the future, it is necessary to foster student participation. Various engagement strategies can be used to promote a deeper understanding and retention of molecular biology concepts. The following strategies will be discussed:

2.1 Interactive lectures and discussions

In molecular biology, a demonstration can be used during lectures to show how abstract or complex concepts work in practical applications. Interactive lecture demonstrations can incorporate student participation in the demonstration using the active learning techniques PODS (Predict, Observe, Discuss, and Synthesize). Overall, interactive demonstrations using PODS increase student understanding of the concepts when compared to passive demonstrations (Mazzolini et al., 2011). Questions and prompts can be used to encourage students to think critically and participate in discussions. Think-pair-share activities, where students discuss concepts with peers before sharing with the larger group, can also be incorporated. Ruado and Cortez (2024) showed that the use of Interactive Slide Presentations significantly enhanced the students' achievement in Biology, wherein there was an increase in the students' scores from pre-test to post-test.

2.2 Hands-on Laboratory Experiments

Biology laboratory courses are often designed to be hands-on and student-centered, using active learning methods to teach students laboratory skills, science literacy, and scientific knowledge that they will use in their scientific careers. Active learning is a very effective teaching method, as experiments in Advanced molecular biology allow students to apply theoretical knowledge in practical settings. The cookie-cutter laboratories, where every student conducts the same exercises, are often replaced by inquiry-based laboratories where students formulate hypotheses, design experiments, and analyze results (Sarvary et al., 2022).

2.3 Problem-Based Learning (PBL)

Molecular biology problems requiring students to research, collaborate, and propose solutions are used. This approach fosters deep learning and helps students see the relevance of studies. Students are provided with the chance to engage in collaborative problem-solving, develop mental frameworks for learning, and cultivate self-directed learning habits through repeated practice and reflection (Yew & Goh, 2016). The concept involves implementing problem-based learning alongside a range of practical laboratory activities to promote experiential learning, wherein students acquire knowledge via active engagement (Agyeman et al., 2020).

2.4 Flipped classroom

Flipped learning has garnered substantial attention as a potential means to enhance student engagement, improve learning outcomes, and adapt to the evolving educational landscape. Students are encouraged to review lecture materials and readings at home, freeing up class time for active learning activities such as discussions, problem-solving, and group work. This method encourages students to take responsibility for their learning (Baig & Yadegaridehkordi, 2023). For example, students can be asked to create a lesson plan and mini video to teach a simple molecular mechanism of disease with learning objectives, a brief activity, and appropriate assessment mechanisms (Kanapeckas Métris, 2020).

2.5 Case studies and scenarios

Use case studies to illustrate how molecular biology concepts are applied in real-life situations, such as genetic engineering or disease treatment. Analyzing case studies can help students understand the practical implications of theoretical knowledge. For example, students can be assigned a project to create a scientific news release and a short podcast describing a recent advancement in understanding the molecular basis of a disease (Kanapeckas Métris, 2020).

2.6 Technology-enhanced learning

According to D'Angelo (2018), technology directly influences students' behaviour by increasing their level of engagement in learning activities, emotionally by favourably affecting their attitudes and inclinations towards learning, and cognitively by requiring mental effort to absorb the content. In Advanced Molecular Biology, digital tools like molecular visualization software, online simulations, and interactive tutorials can be utilized. These tools can help students visualize complex structures and processes, making abstract concepts more

concrete. Interactive multimedia, simulations, and gamified learning platforms have been demonstrated to captivate learners' attention and encourage active participation (Bhat, 2023).

2.7 Collaborative projects

Students can collaborate using technology both in the classroom and remotely. Students may collaborate on projects, exchange ideas, and pick up tips from their peers via online resources, discussion forums, and virtual classrooms (Bhat, 2023). For the Advanced Molecular Biology group, projects can be assigned where students investigate a molecular biology topic, conduct research, and present their findings. Collaboration encourages peer learning and the development of teamwork skills.

2.8 Frequent Assessments and Feedback

Digital tools facilitate the provision of immediate feedback on assessments, exams, and assignments. This enables instructors to modify their teaching strategies and help students identify areas for improvement, thus reinforcing learning (Bhat, 2023). Online formative assessments, such as quizzes, concept maps, and one-minute papers, to gauge understanding and provide timely feedback, may be implemented. By incorporating these active engagement strategies, educators can create a dynamic and interactive learning environment that promotes a more profound understanding and retention of molecular biology concepts. Engaged students are likely to be enthusiastic learners who can effectively apply their knowledge to solve complex biological problems.

3. Methodology

Exploratory research is conducted to evaluate phenomena from a fresh perspective, acquire novel insights, and uncover the nature of the occurrences (Makri & Neely, 2021). A qualitative approach rooted in the social constructivism paradigm was employed to examine how student engagement can be enhanced in an online molecular biology module using an online engagement framework. Through qualitative research methodology, focus on a more profound comprehension of student engagement in online education and instruction could be obtained. Additionally, Moonasamy and Naidoo (2022) state that Vygotsky's (1978) social constructivism theory posits that learning is not exclusively an internal or passive process; instead, it asserts that cultural contexts play a critical role in shaping comprehension and initiating profound learning.

Consequently, social constructivism is a collaborative learning approach that emphasizes student engagement, dialogue, and knowledge exchange. This learning theory prioritizes active interaction among students, the instructor, and other components of the teaching-learning process over teacher monotony in the classroom, through active student engagement. Furthermore, it teaches students to retain information that they independently discover and construct, as opposed to that which is provided by the instructor (Saleem et al., 2022). This exploratory nature and "an interpretative, naturalistic approach to the world" are fundamental attributes that define qualitative research methods (Werang & Radja Leba, 2022), which are relevant to this study. The study population consists of all students

studying online for post-diploma modules at the University of Technology. The total number of postgraduate students studying online is 71. However, the sample of this study consists of 53 students in an Advanced Diploma in Molecular Biology Module.

3.1 Case Study Research Design

A case study is an analysis of the uniqueness and complexity of a particular case to comprehend its activities and specific circumstances (Tomaszewski et al., 2000). The case study method allows a researcher to thoroughly analyze the data within a particular context. Typically, the case study method involves choosing a small geographic area or a highly restricted group of persons as the focus of an investigation. Case studies, at their core, involve the examination and investigation of current real-world occurrences using meticulous analyses of specific events or circumstances, along with their interconnections (Zainal, 2007).

However, establishing a cause-and-effect connection and drawing conclusions can be challenging, especially when considering a small number of case studies. Generalising findings can also be problematic (Queirós et al., 2017). By employing a case study design in this study, we can "develop a comprehensive and nuanced comprehension of the various aspects" (Crowe et al., 2011) of student engagement in the molecular biology module. The comprehensive nature of the investigation and the research allow the investigator the flexibility to employ any data acquisition method that aligns with their objectives, on the condition that the method is both practical and ethically sound.

Various data collection methods are typically employed to ensure a rigorous and impartial examination of the phenomenon being studied. These methods include participant/non-participant observation, surveys, questionnaires, in-depth interviews, and the analysis of documents (including audio-visual records, archival manuscripts, books, and natural settings), etc. (Priya, 2021). In this study, the focus is on document analysis.

3.2 Document Analysis (Data collection and analysis)

The qualitative content analysis (QCA) method was used to analyse and interpret the content of textual data using the systematic coding process to identify strategies that can help foster engagement in an Advanced Diploma molecular biology module. Content analysis processes involve three main phases: preparation, organisation, and reporting of results (Elo, 2014). The final product of data analysis is the identification of categories, themes, and patterns (Assarroudi et al., 2018). In this study, learning Units One and Two in the Molecular Biology Learner Guide were examined. The rationale for analysing these specific learning Units was that they would provide insightful information regarding strategies for student engagement in online learning.

3.3 Trustworthiness and Credibility

The key to the trustworthiness of a qualitative study is transparency; therefore, theory and research methods were outlined. The choice of methodology enabled the detection of findings/phenomena in the appropriate context for the research

to be valid (Elo et al., 2014). To enhance reliability, data was extracted from sources in the document analysis (Lueng, 2015).

3.4 Ethical considerations

It is essential to consider ethical concerns at every level of a qualitative study to weigh the possible risks and advantages of the research (Arifin, 2018). Approval from the UFS Ethics Committee was obtained (UFS-HSD2017/1215/21/3). Proper citation of sources was done to prevent plagiarism. Approval to utilise the module was acquired from the Head of the Department (state in full)-name of dept and University.

4. Results

This study sought to transform teaching and learning through student engagement in an online Molecular biology module. An analysis of the factors that contribute to student engagement in this module was examined (See Appendix 1 & Table 1). The module design and delivery of content are the major factors that contribute to student engagement. The Molecular Biology Module examined in this study has six learning units that are taught online on Blackboard Ultra (Ref). This study focused on Learning Units 1 and 2. Learning Unit 1 comprises DNA structure and function, and learning Unit 2 is on RNA structure and function. The main objective of Learning Unit 1 is to support students in comprehending the structure of DNA and some of the techniques used in molecular genetics, while Learning Unit 2 explores the contemporary structure of RNA and its role in controlling cellular mechanisms.

The lectures of this module are presented in PowerPoint mode and are supplemented with YouTube videos. The subject matter's inherent complexity is one of the primary challenges. The lack of practical components makes it challenging to comprehend the complex concepts and detailed processes that are inherent in molecular biology. The module also lacks the integration of multimedia resources, including animations and interactive simulations, that can enhance the accessibility and engagement of intricate molecular biology concepts (D'Angelo, 2018; Bhat, 2023). Assessment tasks in these two learning units include tests and quizzes.

These include structured questions, fill-in-the-gaps, matching, labelling of diagrams, and multiple-choice questions. Another crucial determinant is the degree of engagement demonstrated by students and educators. In a conventional educational environment, direct interpersonal exchanges facilitate the development of a feeling of community and inclusion, which might be difficult to reproduce in an online learning environment. Molecular biology is a fully online module. There is minimal interaction between the students and the lecturer, as well as among students. Although the classes are delivered as live online sessions and prompt feedback is given to students, the module lacks discussion forums and has low student participation. Higher levels of student involvement are likely to occur when students are integrated into a learning community. Ensuring a feeling of belonging is crucial for sustaining motivation and interest in the course content (Bedenlier et al., 2019).

Furthermore, given that the module is fully online, technological accessibility is crucial in fostering student involvement. It has been noted that there are differences in students' technology availability and competence. Not every student possesses dependable internet connections or the requisite technical equipment to actively engage in online courses. Furthermore, certain students may encounter difficulties in using digital tools and platforms, impeding their capacity to actively participate in the course content. Disparities in learning experiences and outcomes might arise from technical impediments, which can hinder the maintenance of consistent engagement throughout the class (Farrell & Bruton, 2020; Das, 2022). Both personal motivation and self-discipline play an equally significant role in modulating student engagement.

Effective online learning necessitates a greater level of self-regulation compared to conventional classroom environments. Intrinsic motivation and effective time management skills are key factors that contribute to the sustained engagement of students. Conversely, individuals who do not possess these abilities may encounter difficulties in concentrating and managing their tasks within the designated timeframe. Instructional staff can assist students by furnishing explicit instructions, establishing attainable timeframes, and providing consistent feedback to ensure their adherence to the established plan.

Engagement in an online Molecular Biology course is also influenced by the social environment. The encouragement required to maintain commitment to online learning appears to be provided by the support of family, friends, and colleagues. Furthermore, the implementation of social interaction opportunities within the course, such as peer review activities or group tasks, can enhance students' sense of engagement and connection (Wang et al., 2023). Most students in the molecular biology course are employed, while a small number are pursuing internships.

Consequently, students' engagement levels can be substantially influenced by the relevance of the course content to their personal and professional objectives. Students are more inclined to dedicate time and energy to their academic pursuits when they perceive the information as valuable and relevant to their professional pursuits. By emphasising the practical applications of molecular biology concepts and engaging in discussions regarding current research, students can better understand the significance of the material they are studying, thereby enhancing their engagement (Saaed & Zyngier, 2012).

A combination of instructional design, interaction levels, technological accessibility, personal motivation, social environment, and content relevance influences student engagement in an online Molecular Biology class. Addressing these factors holistically can help create a more engaging and effective online learning experience, ultimately leading to better student learning outcomes (See Table 2).

Table 2: Summary of an analysis of engagement in the Molecular Biology Module

Factors that influence student engagement online	Current Scenario of Molecular Biology Module	Comments to improve the module
The design and delivery of content	Learning Units 1 and 2: DNA structure and function & RNA structure and function Diagrams are only used to illustrate the DNA and RNA structure; there is no building of the model •There is no practical activity for DNA isolation and quantification, as well as gel electrophoresis •Techniques for gene analysis and gene transcript are presented theoretically.	•Use the free online lab simulator https://amino.bio/pages/ To introduce DNA structure, an electrophoresis simulation should be adopted. •Lecture delivery can be improved by incorporating interactive tools such as Mentimeter and Kahoot. •Interactive diagrams where students can click on different sections to get more information or see an animation of the process should be incorporated.
Teacher/ student relationship	Student-teacher interaction is very limited as the module is offered fully online.	Allow for videos during the lecture. Arrange for face-to-face consultations.
Peer relationships	Limited interactions as classes are fully online. There are no face-to-face activities which further limits the interaction.	Incorporate group work and collaborations in the learner guide. Students can simulate the process of RNA transcription using colored paper strips to represent different nucleotides. They can work in groups to transcribe a DNA sequence into mRNA, reinforcing the concept of complementary base pairing. This can be done outside class time and videos can be on during the group sessions.
Digital literacy	Most students seem to be able to navigate Blackboard.	Students are encouraged to attend Blackboard training sessions at the beginning of the semester.
Socioeconomic and cultural factors	Most students come from disadvantaged backgrounds and depend on NSFAS funding for their educational needs.	Make students aware of the support services that the institution offers.
Time management	Low class attendance, as some students are full-time employees. They listen to class recordings in their own time.	Guide students on time planning. Due dates for assessments are clearly outlined in the learner guide for students to plan and prepare in advance.

5. Discussion

In the online Molecular Biology Module, the learning experience is collectively shaped by various factors influencing student engagement (Table 1). The quality of instructional design is one of the most critical factors (Lasekan et al., 2024). A well-organised course with interactive elements and distinct objectives can

captivate students' attention and maintain their interest. Table 3 shows a reflection on the research questions.

Table 3: Reflecting on specific research questions

MAIN RESEARCH QUESTION
How can student engagement improve in the online molecular biology module? Student engagement is an essential determinant of the efficacy of online learning environments. In the molecular biology module under consideration, augmenting engagement can result in improved learning outcomes and a more fulfilling educational experience. Integrating interactive content, peer facilitation, consistent feedback, practical applications, and modern technologies may enhance the engagement and efficacy of online learning experiences. Confronting obstacles and consistently adjusting to students' requirements will enhance the module's success.
SUBSIDIARY QUESTIONS
What are the present viewpoints about student engagement in online molecular biology classrooms? The transition to online learning during COVID-19 has been met with obstacles, including a lack of interaction and a sense of belonging. Nevertheless, these challenges can be alleviated by implementing strategies such as active learning and small-group activities.
What factors influence online student engagement in the Advanced Diploma Molecular Biology module? Instructional design, interaction levels, technological accessibility, personal motivation, social environment, and content relevance influence student engagement in an online Molecular Biology course. A more engaging and effective online learning experience can be achieved by addressing the factors holistically, resulting in improved student learning outcomes.
Which proposed strategies and interventions (or guidelines) can be used to improve student engagement in online Molecular Biology classes? Incorporation of interactive content. Implementation of active learning techniques (group discussions, case studies, and problem-based learning). Live sessions and virtual office hours are crucial to fostering a sense of community and facilitating real-time engagement. Emphasizing the practical applications of molecular biology concepts.

Drawing from the reflection on Table 3, improving student engagement in an online Molecular Biology class requires a multifaceted approach that addresses digital learning environments' unique challenges and opportunities. A document analysis of Learning Units 1 and 2 (see Table 2) highlighted the factors that point to the strategies for improving student engagement in Molecular Biology class (See Appendix 1). These student engagement strategies can be effectively approached by integrating the five key elements of the Online engagement framework by Redmond et al. (2018). Each component is crucial in creating a holistic and engaging learning environment.

Cognitive engagement involves stimulating students' intellectual curiosity and encouraging deep learning. Therefore, one of the most effective strategies is to incorporate interactive content. By utilising multimedia elements such as videos, animations, and interactive simulations, instructors can bring complex biological

processes to life. These tools not only make the material more accessible but also cater to different learning styles, thereby enhancing overall engagement. For instance, virtual labs allow students to conduct experiments in a simulated environment, providing a hands-on experience often missing in online learning (Getenet & Tualaulelei, 2023).

A study by García et al. (2025) to improve the learning of Natural Sciences with interactive resources involved creating within the Moodle virtual learning environment a module that incorporated PowToon, Phet Interactive Simulations, and H5p Interactive with selected topics based on their pedagogical relevance and the capacity of concepts to be exploited with interactive simulators. The results showed that content became more interactive, visual, and accessible, and enhanced the understanding of complex concepts by offering visual and hands-on experiences.

The significance of peer learning and collaboration is underscored by collaborative engagement. The implementation of active learning techniques is an essential element. Students should be encouraged to apply their knowledge to real-world scenarios through problem-based learning, group discussions, and case studies. This method encourages critical thinking and collaboration and cultivates a more profound comprehension of the subject matter. Regular feedback and assessments are essential for sustaining student engagement.

Students can identify areas where they require additional support by receiving immediate feedback on their comprehension through frequent quizzes, surveys, and formative assessments. This ongoing feedback cycle keeps students motivated and, on the course, (Bhat, 2023). Research by Seery et al. (2021) demonstrated that peer mentoring fosters collaborative learning in Higher education. Although the study is not exclusive to molecular biology, the principle applies to this subject.

Active participation in social activities is essential for cultivating community among students. Live sessions and virtual office hours are crucial for fostering a sense of community and facilitating real-time engagement. These sessions allow students to interact directly with the instructor and their classmates, seek clarification on difficult subjects, and ask questions. The interaction alleviates the sense of isolation sometimes linked to online learning. Moreover, using discussion forums and peer interaction can greatly augment participation.

Establishing environments that facilitate collaboration, idea sharing, and course material discussion among students cultivates a collaborative learning atmosphere and offers diverse viewpoints on the subject matter (Hutton & Robson, 2019). A study on student satisfaction and interaction in higher education revealed that the transition to online learning during the COVID-19 pandemic diminished contentment, heightened stress, and decreased engagement owing to the absence of social interaction (Wong & Chapman, 2022). This emphasizes the need for collaborative and community-building initiatives in online learning.

The concept of behavioral engagement centers on the active engagement and participation of students in learning. Gamification is a novel approach to enhance engagement. Educators can enhance the enjoyment and competitiveness of the learning process through the integration of features such as badges, leaderboards, and incentives for task completion or high exam scores. This methodology has the potential to inspire pupils to engage actively and pursue excellence.

The implementation of personalised learning routes is essential in enhancing engagement. Including student-selected subjects or projects within the course scope synchronises the content with their individual and vocational aspirations, enhancing motivation and commitment to the learning process (Singh et al., 2022). Maintaining students' motivation and interest necessitates emotional engagement. According to Trowler et al. 2021 behavioral engagement, including showing up, taking part, and putting in effort, is very important for academic performance and retention.

Additionally, engagement can be substantially improved by emphasising the practical applications of molecular biology concepts. Students can comprehend the significance of the material they are learning by discussing current research, investigating case studies, or inviting guest speakers from the field. This connection to real-world applications enhances the material's fascination and significance. In an online learning environment, it is essential to maintain consistent and transparent communication. Students can remain engaged and organised by receiving consistent updates and reminders regarding course expectations, deadlines, and available resources. Resources such as tutorials, study manuals, and reading materials can also assist students in their educational endeavours (Saaed & Zyngier, 2012).

These strategies to increase student engagement in online learning can have a significant impact on the larger learning community. As lecturers innovate through strategies such as interactive content, real-time feedback, and gamification, these methods would spill over into face-to-face instruction, boosting pedagogical standards across departments. Diverse learners, including those with disabilities or from remote environments, can benefit from online interaction tools that are adapted to their needs. This promotes a more inclusive academic atmosphere, which benefits the entire learning community. Online platforms offer comprehensive analytics on student behavior and performance.

This information can help institutions improve courses, identify at-risk pupils, and allocate resources more effectively. Engaging online settings frequently attract non-traditional learners, such as working professionals. This broadens the learning community beyond regular pupils and promotes a culture of lifelong learning. Discussion forums, peer cooperation, and virtual study groups help students feel connected, creating a supportive learning atmosphere. This sense of belonging can lower dropout rates and boost general morale throughout the institutions.

6. Conclusion

In summary, improving student engagement in an online Molecular Biology module requires integrating interactive content, active learning strategies, regular assessments, live interactions, real-world connections, and effective communication. Incorporation of interactive content such as lab simulators, Mentimeter, and Kahoot tools would help students grasp complex molecular processes such as DNA replication and improve retention through visual and kinaesthetic learning. Presenting real-life biological problems or research scenarios would foster problem-based learning, encouraging critical thinking and knowledge application. Use of gamification and quizzing tools would increase engagement and motivation, thereby encouraging collaboration.

By incorporating these student engagement strategies, educators can create a more engaging and effective online learning experience, accommodating diverse learning styles, thereby addressing the complexity of the subject while utilising digital tools. Although this qualitative study sheds valuable light on improving student engagement in Molecular Biology online learning, it involved a small group of learners, which may be a challenge when drawing conclusions that apply across different contexts or institutions. Future research ought to investigate the impacts of these strategies on student achievement and retention. Furthermore, examining the scalability of these methodologies across many disciplines and educational levels may yield significant insights for wider applications. The findings from this case study underscore the potential of innovative educational practices to transform online learning environments and foster a more engaging and effective educational experience.

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APPENDIX 1: SUMMARY OF THEMES ON STRATEGIES THAT CAN IMPROVE STUDENT ENGAGEMENT IN THE MOLECULAR BIOLOGY MODULE

Overarching theme: Transforming an online Advanced Diploma Molecular Biology Module

Theme: Student engagement		
Condensations	Codes	Categories
Active participation and institutional influence	Active participation and institutional role	Defining student engagement Defining student engagement
Basic behaviour and contextual approach Understood and operationalized in various ways	Behaviour indicators and context	Defining student engagement
Viewed in three primary domains	Multifaceted construct Multifaceted construct	Defining student engagement
Theme: Factors that influence student engagement		
Condensations	Codes	Categories
Aligning course content with students' interests	Course content	Design and delivery of course content
Motivation is seen as a prerequisite to learning	Motivation	
Good relationships between students	Peer relations	Learning communities
Collaborate actively in group space	Collaboration	Learning communities
Theme: Challenges and opportunities for student engagement in online learning		
Condensations	Codes	Categories
Learners very often lose hope	Lack of motivation	Challenges in online learning
New online students struggle with online learning environments	Limited digital literacy	Challenges in online learning
	Internet connection and	Challenges in online learning
Students may not have a well-equipped facility	technical issues	Challenges in online learning
	Student isolation	
some students can feel more distant from the instructor and to each other		Challenges in online learning
students face difficulties in adhering to a consistent study routine	Time management	Challenges in online learning
Theme: Opportunities for student engagement	Interactive tools	Opportunities for student engagement
technologies they encounter in their daily lives	Collaborative tools	Opportunities for student engagement

student-student interactions in online classes	Immediate feedback	Opportunities for student engagement
Interaction between students and teachers	Learning communities	Opportunities for student engagement
Interpersonal contact	Skills development	Opportunities for student engagement
Training on protocols and guidelines before enrolling in an online class		
Theme: Online Engagement Framework (Redmond et al., 2018)		
Condensations		
Five key communications points	Social engagement	Online engagement Framework
	Cognitive engagement	Online Engagement Framework
	Behavioural engagement	Online Engagement Framework
	Collaborative engagement	Online Engagement Framework
	Emotional engagement	Online Engagement Framework