Embracing the Collaborative Elements in STEM Classroom- Based Assessment: A Qualitative Case Study of the Ekosistem Module

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Abstract

The Ekosistem Module (STEM Educator Student Exploration) is a comprehensive learning module designed to support classroom-based STEM assessment through collaboration among educational management, field experts, school teachers, and teacher trainees. This study employed a case study design to examine the modules implementation in reducing teachers' workload stigma and addressing challenges in STEM teaching and learning. Face-to-face and online collaboration were used to establish a supportive ecosystem that enhances teaching, learning, and assessment practices. The participants were three science teachers from a rural school. The module integrates content learning, pedagogical strategies, classroom implementation, and continuous assessment. Initial findings showed that most Year 5 students were at proficiency levels 2 to 4, with only 6.25% achieving levels 5 and 6. After implementation, more students reached higher proficiency levels. Teachers also reported improved access to subject matter experts during the assessment process. The module's effectiveness was supported by administrative collaboration, expert input via webinars, professional learning community engagement, project-based learning, and structured challenges. These findings indicate that the Ekosistem Module has strong potential to enhance classroom-based assessment in STEM and support effective teaching practices.

Keywords: STEM education, classroom-based assessment, collaboration, project-based learning, teacher development

Introduction

STEM education and the role of collaboration

In the 21st century, the global education landscape is undergoing a paradigm shift, driven by the urgent need to prepare learners for an increasingly unpredictable and complex future. Traditional pedagogical models are proving inadequate to address the demands of a rapidly evolving world characterised by volatility, ambiguity, and disruption. This environment has been conceptualised by futurologists as the BANI world, a reality that is Brittle, Anxious, Nonlinear, and Incomprehensible, where change is not only constant but often chaotic and uncontrollable.

In response to these conditions, STEM (Science, Technology, Engineering, and Mathematics) education emerges as a powerful framework to equip students with the skills needed to navigate such uncertainties. STEM education fosters critical thinking, creativity, problem-solving, collaboration, and technological fluency, all of which are essential in preparing learners to thrive in a BANI world. Beyond content mastery, it emphasises adaptability, resilience, and the capacity for innovation.

Collaboration has emerged as a key pillar of effective STEM learning. Collaborative learning in STEM classrooms encourages students to engage in shared inquiry, peer dialogue, group problem-solving, and knowledge construction. All of which mirror the interdisciplinary and team-based nature of real-world STEM work environments. Research shows that collaboration not only deepens understanding of content but also enhances communication skills, empathy, and the capacity to manage complexity, which is essential for navigating the uncertainty of a BANI world.

Moreover, collaborative elements in STEM classroom tasks allow learners to experience collective resilience, in which mistakes and ambiguities become opportunities for mutual learning rather than individual failure. This approach aligns with the shift from traditional teacher-centred methods to learner-centred, inquiry-based, and socially constructed models of teaching and learning. It empowers students to take ownership of their learning, support one another, and develop the capacity to thrive in unfamiliar, nonlinear scenarios.

This study examines the role and implementation of collaborative elements in STEM education, particularly how they can be systematically embedded into CBA and integrated through modules such as Ekosistem. The discussion cites collaborative pedagogy as a strategic educational response to the challenges of the BANI world, and a foundation for cultivating a resilient, future-ready generation.

Significance of Classroom-Based Assessment in Malaysia's Education System

The benefit of the Ekosistem Module is closely aligned with the collaborative elements embedded within its structure and the evolving needs of the science curriculum, which emphasises inquiry-based learning, higher-order thinking skills, continuous classroom-based assessment, and integrated STEM approaches. In response to the demands of the curriculum, which require teachers to balance content mastery, effective pedagogy, and systematic assessment, the module establishes a supportive, interconnected ecosystem that strengthens both instructional quality and assessment practices through collaboration among key stakeholders.

Overview of the Ekosistem Module

The main objectives of this module are to provide guidelines for STEM educators to conduct STEM teaching and learning with confidence and effectiveness. Secondly, this module assists the teacher in choosing a suitable T&L approach that meets the needs of CBA in STEM subjects.

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module establishes a supportive, interconnected ecosystem that strengthens both instructional quality and assessment practices through collaboration among key stakeholders.

The benefits of the Ekosistem Module were demonstrated through:

1. Strong collaboration and support from school administrators.
2. The provision of digital knowledge input from STEM experts via webinars.
3. Professional Learning Community (PLC) engagements involving teachers, lecturers, and teacher trainees to identify and refine appropriate teaching and learning (T&L) strategies.
4. The implementation of project-based learning approaches.
5. Structured ecosystem challenge activities that reinforced students' mastery and application of STEM concepts.

Statement of the problem

Collaboration is an essential skill for students across all levels of education. In STEM education, the Ministry of Education explicitly requires promoting collaboration through classroom-based assessment practices. Collaboration is assessed within the curriculum across various domains, including the ability to function in multidisciplinary teams and the ability to communicate effectively. Employers also seek graduates who can work collaboratively; however, they report that students are often not adequately prepared in this area (Jaschik, 2015). In addition, insufficient assessment support for collaborative elements contributes to less effective teaching and learning practices that promote student collaboration. Assessment approaches frequently emphasise individual knowledge rather than group processes or collaborative outcomes, which makes it challenging to evaluate and enhance collaborative skills (Le et al., 2018).

Traditional STEM education is often siloed by discipline, with little integration across subjects or collaborative planning among teachers, which limits students' ability to see connections and work effectively in teams (Havice et al., 2018). This disciplinary segregation hinders the development of critical interdisciplinary skills necessary to address complex, real-world problems that inherently transcend traditional academic boundaries (Park & Cho, 2022). This fragmentation impedes students development of a holistic understanding of how scientific, technological, engineering, and mathematical concepts interrelate and apply to practical scenarios (Thibaut et al., 2018).

Studies by Tapilouw et al. (2017) and Poobalan et al. (2021) support professional development programs for STEM teachers and emphasise the importance of continuous training to improve teaching quality and classroom-based assessment. Rahman et al. (2022) further suggest that STEM teachers should be equipped with the necessary knowledge to deliver instruction confidently in school settings. Therefore, this study implements the Ekosistem Module (STEM Student Educator Exploration) to foster an interdependent learning environment that promotes collaboration and supports classroom-based STEM assessment. The module adopts student-centred approaches, including project-based learning and Project-Oriented Problem-Based Learning. In STEM education, project-based learning encourages students to work collaboratively in groups to investigate authentic problems or meaningful questions over an extended period. This approach is grounded in constructivist learning theory, which emphasises student-centred inquiry and the application of integrated knowledge to complex challenges. As a result, it supports deeper understanding and the development of essential skills (Havice et al., 2018).

Research objectives and research questions

1. To study the impact of the Ekosistem Module on improving collaborative elements.
2. To identify the teaching and learning strategy in the Ekosistem Module that enhances the collaborative elements

Scope and limitations

One limitation of this study was that participants were primary school pupils. The teacher and pupils were identified before this study based on their performance in the previous years CBA. The low achievers were selected to see the impact of the Ekosistem Module.

Literature Review

Collaborative Learning in STEM Education (MMI)

Collaborative learning has gained increasing attention in STEM (Science, Technology, Engineering, and Mathematics) education as educators seek more effective methods to enhance student outcomes. The approach aligns with the interdisciplinary and problem-based nature of STEM, promoting deeper engagement and the development of 21st century skills.

Collaborative learning is an instructional approach in which students work together in small groups to achieve shared learning goals. According to Laal and Ghodsi (2012), collaborative learning involves learners engaging in a coordinated effort to solve a problem, complete a task, or create a product. In STEM education, this method is particularly valuable because it mirrors real-world scientific inquiry and engineering practices, which are often team-based.

Collaborative learning in STEM education would increase student engagement by making the learning process more interactive and student-centred. According to Johnson and Johnson (2009), when students work collaboratively, they become more responsible for their learning and that of their peers. This increased accountability encourages participation and persistence, particularly in challenging STEM topics.

At the same time, STEM collaboration provides authentic opportunities for students to practice and refine their communication skills. Through discussion, negotiation, and peer teaching, students learn to articulate their thoughts clearly and listen to others. Vygotsky's (1978) sociocultural theory supports this, emphasising the importance of social interaction in cognitive development. Clear communication is essential in STEM fields where precise data interpretation and presentation are critical.

Furthermore, collaborative learning enhances problem-solving abilities by exposing students to diverse perspectives and requiring them to work together to find solutions. In STEM, where problems are often complex and open-ended, group collaboration fosters analytical thinking and creativity. According to Hmelo-Silver (2004), collaboration supports the development of a deeper understanding through discussion and shared cognitive efforts.

One of the main challenges is unequal participation. Some students may dominate discussions, while others may remain passive (Gillies, 2004). This imbalance can limit the benefits of collaboration and lead to frustration within the group. Conflicts may arise due to differences in personalities, work ethics, or academic ability. Poor group dynamics can hinder communication and reduce overall effectiveness (Cohen, 1994). Teachers need to carefully structure groups and monitor interactions to minimise this issue.

Collaborative activities often require more time than traditional instruction, which can be a barrier in content-heavy STEM curricula. Teachers may struggle to balance collaborative tasks with the need to cover extensive syllabi (Slavin, 1995). Assessing individual contributions in group work can be challenging. Without clear rubrics or peer evaluations, students may feel that their efforts are not fairly recognised (Oakley et al., 2004).

Classroom-Based Assessment

Principles and purpose of CBA. The Malaysian education system has undergone significant reforms, particularly with the introduction of Classroom-Based Assessment, also known as Pentaksiran Bilik Darjah, as a core c omponent of its pedagogical framework (Mannogaran & Shaid, 2023). This shift, aligned with the Malaysian Education Blueprint 2013–2025, emphasises a holistic evaluation of student learning, moving beyond traditional summative examinations to formative assessments integrated into daily teaching and learning processes (Razak et al., 2023).

Integration of collaborative tasks in assessment

Collaborative learning, in which students work together to achieve a common goal, is increasingly recognised as a vital element of PBD. This approach fosters a dynamic learning environment where students actively engage with the material, share ideas, and learn from one another. Collaborative activities in PBD can take various forms, including group projects, peer assessments, and cooperative problem-solving tasks. Collaborative elements such as peer accountability, leadership, and strong communication skills are required to handle tasks assigned by teachers. The teacher and the school’s environment also created a comfortable learning environment that supports the pupils in learning effectively. These may also increase their desire to engage in or initiate collaborative learning (Priddie, 2024).

Professional and Faculty Learning Communities (FLCs) / PLCs

PLCs are typically rooted in K–12 education and comprise teams of educators who collaborate to improve student outcomes through collective inquiry and data-driven decision-making (DuFour & Fullan, 2013). FLCs, increasingly common in higher education, involve faculty from various departments in ongoing discussions and experiments with teaching methods, frequently aligned with institutional objectives for student achievement and educational reform (Cox, 2013; Furco & Moely, 2012). Regardless of their contextual differences, both models emphasise continuous communication, shared responsibility, and evidence-based practices.

A key characteristic of PLCs and FLCs is the importance of peer support. When teachers engage in organised, collaborative settings, they tend to reflect critically, adopt new methods, and sustain modifications in their teaching practices over time (Trust & Horrocks, 2017). Stoll et al. (2006) state that cultivating trust and common values in professional communities promotes a culture of collective accountability that enhances both innovation and sustainability. Likewise, Laursen and Austin (2014) found that FLCs in STEM fields fostered sustained engagement in active learning and inclusive teaching through social support and opportunities for repeated experimentation.

Recent research highlights the emotional and cognitive aspects of peer involvement in learning communities. Members of FLCs report heightened professional fulfilment, a sense of community, and diminished isolation. These elements are crucial to sustaining pedagogical experimentation and innovation, especially in higher education, where teaching is often underappreciated (Kezar & Gehrke, 2017). Collaboration among peers enables faculty to refine new approaches through collective feedback, normalise setbacks as part of professional development, and align innovations with disciplinary standards (Czajka & McConnell, 2016).

Moreover, PLCs and FLCs serve as frameworks for integrating equity-centred teaching practices. Research indicates that professors participating in these communities tend to adopt inclusive teaching methods, especially when diversity and social justice are key objectives of the community (Ginsberg & Bernstein, 2011; Buch & Barron, 2018). Ongoing peer support in these situations aids faculty in addressing biases, revising the curriculum, and fostering confidence in handling sensitive subjects. However, sustaining these communities presents structural and cultural challenges. Time constraints, lack of institutional recognition, and inconsistent leadership support can impede lasting impact (Kezar, Gehrke, & Elrod, 2015). Successful communities need purposeful design, guidance, and alignment with organisational goals. Guidance from leaders and dedication to the organisation are crucial for integrating these models into institutional frameworks and guaranteeing their effects continue beyond personal involvement (Spillane et al., 2019).

The Ekosistem Module as a Pedagogical Tool

The Ekosistem Module (STEM Student-Educator Exploration) is a comprehensive, dynamic learning module designed to foster an interdependent environment that enhances the implementation of CBA in STEM through collaboration among education administrators, subject-matter experts, school teachers, and student teachers. Through this module, challenges such as teacher workload and the perceived difficulty of STEM subjects can be addressed through both face-to-face and online collaboration, fostering a positive ecosystem that supports effective teaching and learning (T&L). Project-Based Learning, integrated with Problem-Based Learning approaches, was used as a T&L strategy to promote collaborative elements as an important aspect of completing the given task, creativity in problem-solving, and critical thinking in decision-making.

Theoretical foundation

Discovery Learning Model

A review of the Discovery Learning Model shows significant effectiveness in enhancing conceptual understanding, critical thinking skills, and student motivation across various educational levels. Studies by Ng et al. (2019), Ariza and Syamsuddin (2020) reported substantial improvement in students' comprehension and academic performance in science and mathematics subjects at the secondary level through discovery learning. Gunawan et al. (2021) observed increased critical and creative thinking skills among university students in information technology courses, while Putra et al. (2019) demonstrated improved problem-solving abilities and creativity among primary students in science subjects.

However, research by Kurniawati et al. (2023), Hidayati and Widodo (2020) also highlighted challenges in implementing this model, including the need for sufficient resources and additional guidance for less experienced students. Overall, discovery learning has proven to offer considerable educational benefits, provided its implementation is supported with adequate resources and training.

Project-Based Learning

Project-Based Learning (PBL) has shown positive effects in strengthening conceptual understanding, collaboration skills, and student motivation. Capraro et al. (2020) reported that PBL enhances problem-solving and teamwork skills among secondary school students in science subjects. Meanwhile, Jones and Li (2023) found that PBL in engineering education positively impacts students understanding of technical concepts and practical applications at the university level. A study by Tan et al. (2024) found that PBL in mathematics improves critical thinking skills and motivation to learn.

Overall, these studies demonstrate that PBL is an effective approach for fostering active learning and comprehension across various STEM fields. In implementing PBL, teachers serve as facilitators. They must shift their roles from knowledge transmitters to learning facilitators, a shift that requires adequate training and support (Powell et al., 2021).

Project-oriented Problem-Based Learning

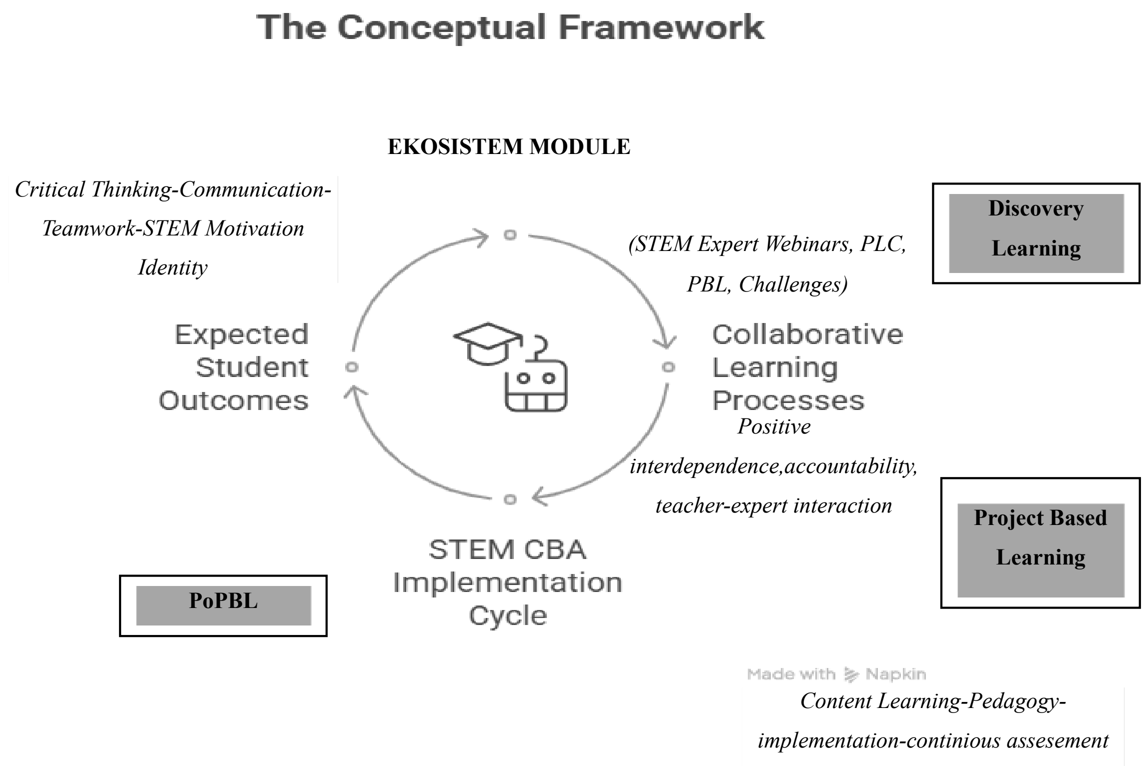
Project-oriented problem-based learning is grounded in student-centred, constructivist, and experiential learning theories. It emphasises learning through engagement with real-world problems in collaborative projects, helping students develop both deep understanding and essential 21st-century skills such as communication, collaboration, and interpersonal skills (Alali, 2024; Rizki et al., 2024; A. Kalmos et al., 2014; W. Husin et al., 2014).

Conceptual Framework

Figure 1 shows the conceptual framework for this study. The framework is grounded in constructivist theory and cooperative learning models that emphasise the role of social interaction, shared knowledge-building, and continuous formative assessment in enhancing learning experiences and outcomes (Johnson & Johnson, 2009; Vygotsky, 1978).

Figure 1

Ekosistem Module: The Conceptual Framework



Ekosistem Module

At the core of the framework is the Ekosistem Module, a structured and dynamic model that fosters active collaboration between educational administrators, STEM field experts, teacher educators, and pre-service teachers. The module integrates various strategies, including expert-led webinars, Professional Learning Communities (PLCs), project-based learning, and real-world problem-solving tasks, to provide meaningful input and practical engagement for teachers. It serves as the foundational platform that activates collaboration across institutional and professional boundaries.

Collaborative Learning

The module operationalises collaborative learning as the primary mechanism for pedagogical transformation. Collaborative learning, as described by Dillenbourg (1999) and further supported by the cooperative learning model of Johnson and Johnson (2009), emphasises positive interdependence, individual accountability, and promotive interaction.

These elements are present in the module's structure through shared decision-making, co-planning, and peer discussions within PLCs and during engagement with STEM content experts. This collaborative environment supports teacher development and reduces the perceived isolation and workload stress often associated with STEM teaching.

STEM Classroom-Based Assessment

Collaborative engagement through the module naturally leads to enhanced implementation of STEM CBA. STEM CBA is structured around a cyclical process involving content knowledge acquisition, pedagogical planning, classroom enactment, and ongoing formative assessment (Heritage, 2010). Teachers involved in the ecosystem are better equipped to assess students authentically and align learning goals with real-world competencies. The alignment of instructional practices and assessment strategies supports the development of higher-order thinking skills among students (Morrison et al., 2020).

Expected student outcomes

The ultimate aim of the framework is to develop key 21st-century competencies among students. The module, through its collaborative and inquiry-based approach, fosters:

- Critical Thinking: through STEM problem-solving and project-based Learning.
- Communication: via presentations, teamwork, and student-led discussions.
- Teamwork: through structured group tasks and shared responsibilities.

Studies have shown that collaborative, inquiry-driven environments increase student motivation and self-efficacy, particularly in STEM education (Honey et al., 2014; Stroupe et al., 2020). The increase in the percentage of students achieving higher performance levels (TP 5 and 6) in this study supports the modules i mpact on student outcomes.

Methodology

Research Design

Qualitative data collection, including semi-structured interviews and classroom observations, was used to gather rich evidence about the process each participant has undergone and continues to undergo to sustain the pedagogical change using the ekosistem Module. For this study, we wanted to study cases that demonstrated extraordinary sustainment in pedagogy that is often abandoned in teaching practice, i.e., collaborative elements, due to common challenges of time constraints or lack of understanding about the concept of T&L strategies.

Participants

This study took place at the beginning of the school semester at a rural primary school in Kedah. The sample was selected through convenience sampling, as the researchers had easy access to the school during the practicum training by STEM field preservice teachers. Three teachers are participating in this study.

Data Collection

There were several steps of data collection during this study. Classroom observations using a checklist (Table 1) were conducted to survey the T&L strategies used by the teachers during the lesson, and the extent to which pupils were involved in the activity. The checklist was adapted from the collaborative elements needed by the Science Dokumen Standard Kurikulum Persekolahan (DSKP). After the observations, we conducted brief interviews with the teacher to ask further questions about the observations following the application of the Ekosistem Module. The interview was open-ended and lasted 10 minutes. The main objective of the interview was to ask the teachers to reflect on the previous T&L process, and on the process after applying the Ekosistem Module.

Procedure

To effectively implement collaborative learning in the Ekosistem Module, specific instructional procedures and structural supports are embedded throughout the T&L process. These procedures are intentionally designed to promote active participation, shared responsibility, and knowledge construction among students. The collaborative framework is integrated in the following key stages of the module. The phases of the module are:

1. Investigations on students' performance to study the needs of the students
2. Plan a suitable webinar for teachers according to the topic related to STEM
Classroom. Webinar to enhance teachers' confidence in applying a meaningful approach in STEM T&L.
3. Plan the Lesson Plan for the STEM Classroom, mapping with CBA
4. T&L sessions with the students
5. STEM Challenges – (students)
6. Reflections on the Ekosistem Module – (teachers)

Group Formation and Norm Setting

At the start of the module, students are strategically grouped into heterogeneous teams based on their learning styles, academic abilities, and interpersonal skills. This diversity encourages peer learning and exposure to varied perspectives. Clear group norms and expectations are established collaboratively with the students to promote accountability, respect, and effective communication.

Collaborative Task Design

STEM activities within the module are designed to require interdependence, where each team member has a specific role or task contributing to the completion of a larger group objective. The activities involved:

1. Identify Problems and Local Issues
2. Scientific inquiry experiments
3. Data analysis tasks
4. Problem-solving scenarios using real-world STEM issues
5. Decision-Making, Product Inventions, New Ideas.
6. Presentations

Tasks are designed so that no single student can complete the activity alone, ensuring the need for shared effort. In this module, we examine how assessments are designed and conducted through collaborative learning in STEM education. In a collaborative STEM learning environment, assessment practices are intentionally structured to evaluate both individual understanding and group performance. The assessment process is summative, focusing on students scientific thinking, participation, communication, and ability to solve problems as a team through structured group tasks and shared responsibilities. Communication is assessed through presentations, teamwork, and student-led discussions.

Data Analysis

Checklists were used to collect data from classroom observations, thematic analysis of qualitative interview data, and reflective feedback. Descriptive statistics for assessment results are also used to present the frequencies. Participants in the study completed this Ekosistem Module during their instruction. The Practicum teacher trainee observed how they handled the T&L sessions, filled out the checklist, and asked questions. Feedback on the Ekosistem Module was collected via a Google Form.

Findings

Teachers' Experience Using the Ekosistem Module

Three teachers: Teachers are involved in T&L and STEM Lessons; they deliver the lessons and ask students to complete reflections. Here are the reflections by the teachers:

> Teacher 1: *I always use textbooks, workbooks, and worksheets in the Science Classroom to cover the syllabus. We discussed the lessons during class, and the correct answers were given to the pupils. Through this module, I saw my pupils happily discuss each other. They are eager to try the given activity and ask me when they do not understand.*

Teacher 2: *I love to play with the pupils. Sometimes, I set up a game, such as a board game, but it was not easy to handle, and I lacked time. Through this module, my pupils love to ask questions and are less frightened. They seem to actively participate and discuss tasks with each other to complete them.*

Teacher 3: *I feel more confident about doing classroom-based assessment. The knowledge I have was verified through the subject matter expert during the webinar. Time is very packed to arrange the activities, but pupils seem happy and actively involved.*

Students' Engagement and Performance

Six groups were observed during their STEM lessons. The collaborative elements observed during the STEM Lessons are presented in Table 1.

Table 1

Observations on Collaborative Elements

Items	Collaborative Elements	G1	G2	G3	G4	G5	G6
1	Leadership – Group Leader and task division	/	/	/	/	/	/
2	Drafting the ideas	**x**	/	**x**	/	**x**	/
3	Active communications among the members	/	/	/	/	**x**	**x**
4	Time management – Completed Task on time.	/	/	**x**	/	**x**	/
5	Responsibility - Every member participated	/	**x**	/	**x**	/	/
6	Refers to the teacher regularly	/	**x**	**x**	/	/	/
7	Peer support during presentations	/	/	/	/	/	/

The teachers also generally give oral feedback to their students after the STEM Lessons. The feedback aligned with the topic they chose and mapped to standard performance according to the DSKP. The collaborative elements characteristic is stated in Table 1. The teachers' response is as follows:

Teacher 1: *I can detect the TP 5 and 6 pupils after they have undergone this module. Their presentation was quite amazing compared to before.*

Teacher 2: *Actually, they managed to understand the topic when discussing with friends. Easy for me to do CBA after this through this project-based learning.*

Teacher 3: *It was not easy to implement these strategies, but it was meaningful. Easy to align with CBA. Easy to assess the pupils and enhance performance.*

Discussions

Student Involvement in Collaborative Elements

Observations during the STEM lessons involving six student groups revealed various levels of collaboration. All groups successfully appointed group leaders and divided tasks, ensuring a foundational structure of teamwork. Most groups (G1, G2, G4, and G6) demonstrated active communication and completed their tasks on time. Peer support during presentations was observed across all groups, indicating that students were engaged in helping one another succeed publicly.

However, there were inconsistencies in how groups developed ideas and demonstrated responsibility. Groups G1, G3, and G5 showed gaps in idea drafting, and G2 and G4 struggled with equal participation among members. Notably, frequent reference to the teacher was recorded in four of the six groups, indicating a willingness to seek guidance and maintain engagement with the facilitator.

These findings indicate that the Ecosystem Module fostered a learning environment where students were more inclined to take on leadership roles, collaborate actively, and support their peers, key components in preparing students for higher-order thinking and project-based learning.

Teacher Reflections on the Ecosystem Module

Teachers reported significant changes in classroom dynamics and student engagement following the implementation of the Ekosistem Module. One teacher noted that previously, lessons focused heavily on textbook and worksheet use. With the module, students became more active, initiating peer discussions and eagerly participating in activities. Another teacher, who occasionally used games in class, found that the module reduced students fear and encouraged them to ask questions and collaborate more effectively.

Most notably, the third teacher emphasised a boost in confidence in conducting CBA. Through knowledge validation during webinars with subject matter experts, the teacher was better equipped despite the limited time. The students, in turn, were more enthusiastic and involved in the learning process.

Overall, teachers agreed that while the strategies introduced through the Ecosystem Module were time-consuming and required effort, they proved to be meaningful, aligned well with CBA practices, and enhanced student performance. Teachers found the project-based approach more effective at identifying students achieving Proficiency Levels 5 and 6, thereby supporting personalised and authentic assessment.

Conclusion and Recommendations

Impact on the Ekosistem Module in embracing collaborative elements

The implementation of the Ecosystem Module has significantly impacted both STEM education and the quality of CBA in several key areas.

Strengthening Collaborative Learning in STEM

The module encouraged collaborative elements among students, such as group leadership, shared responsibilities, peer communication, and mutual support. These are foundational to developing 21st-century STEM skills, including teamwork, problem-solving, and communication. Observations showed that students were more engaged and took initiative in completing tasks, indicating a shift from passive learning to active, student-centred experiences. The module enhanced collaboration among students, promoting active communication, role-sharing, and peer support. These collaborative practices are essential in nurturing STEM-related soft skills, including teamwork, leadership, and problem-solving, as emphasised by Mahmud and Wong (2022) and Pellegrino (2014).

Enhancing Student Engagement and Performance

Students demonstrated increased participation and motivation during STEM activities, particularly in project-based tasks. Teachers reported that students were more willing to ask questions and collaborate, which contributed to a better understanding of STEM concepts. Importantly, this engagement translated into measurable improvement, with more students reaching higher proficiency levels (TP 5 and 6).

Empowered Teachers through Professional Learning

Through the Ekosistem Module, teachers gained confidence and practical knowledge from experts by joining webinars and participating in collaborative planning with the school's managers, lecturers, and teachers. This finding is supported by Powell et al. (2021) and Rahman et al. (2022). They reported improved teachers' competency in conducting CBA with specific tools or approaches that are meaningful and manageable, will be more impactful, and will overcome time-limit challenges.

Improved Assessment Practices

The Ekosistem Module's integration of project-based learning (PBL) strategies supports the implementation of standards-based performance assessment in STEM lessons. In STEM education, standard performance refers to students' ability to demonstrate knowledge, skills, and scientific practices in authentic contexts rather than merely recalling factual information. Through project-based tasks, students are required to apply scientific concepts, solve problems, collaborate with peers, design solutions, and communicate their findings. These competencies reflect curriculum standards and higher-order thinking skills.

By aligning project-based strategies with CBA frameworks, teachers can assess students using observable, measurable performance indicators such as inquiry skills, application of concepts, creativity in design, data analysis, and reflection. This approach allows teachers to evaluate mastery levels more holistically and accurately, particularly in identifying whether students have achieved higher proficiency levels (e.g., TP/PL 5 and 6), which require application, analysis, and innovation.

This makes the assessment process more meaningful and better aligned with curriculum standards that prioritise scientific investigation, engineering design processes, and real-world problem-solving. As highlighted by ODoherty et al. (2018) and Pellegrino (2014), effective assessment in STEM should integrate learning and evaluation processes, ensuring that assessment tasks mirror the complexity of real-world applications. Therefore, the Ekosistem Module enhances standard performance in STEM lessons by enabling teachers to conduct structured, criteria-based, and authentic assessments that accurately capture students' conceptual understanding, practical competencies, and collaborative skills while maintaining alignment with CBA requirements.

Suggestions for future improvements to the Ekosistem Module

While the Ekosistem Module has shown promising outcomes in improving collaborative practices and enhancing STEM CBA, several areas for improvement have been identified for future development. Firstly, the integration of adaptive digital tools could further personalise learning experiences and assessments, allowing teachers to better track student progress in real time. Secondly, expanding the module to include interdisciplinary elements beyond STEM- such as Arts and Humanities- may enhance creativity and broaden students' critical thinking skills in line with the STEAM approach. Additionally, continuous feedback mechanisms from participants should be embedded in the module to refine its content and delivery in response to the evolving needs of educators and learners. Finally, incorporating more culturally responsive teaching strategies into the module could enhance its applicability across diverse educational contexts.

Recommendations for teacher training and support.

To ensure the effective implementation and sustainability of the Ekosistem Module, comprehensive and ongoing support for teachers is essential. Firstly, structured professional development workshops should be conducted to familiarise teachers with collaborative learning strategies, digital tools, and formative assessment techniques specific to the STEM context. These sessions should be both theoretical and hands-on, allowing teachers to experience the module's components in practice. Secondly, mentorship programs involving STEM experts and experienced educators can serve as a support system for novice teachers navigating the module. Thirdly, establishing dedicated time within the school schedule for teachers to participate in Professional Learning Communities (PLC) will foster sustained collaboration and reflective practice. Lastly, an online repository of teaching resources, exemplar lesson plans, and recorded webinars should be made accessible to teachers to support continuous learning and reduce preparation workload.

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