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INFORMATION SYSTEMS EDUCATION JOURNAL

Editors

Implementing Personalized Learning Pathways as Informed by the 5E Model: Digital Tools to the Rescue!

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Abstract

The growing diversity of students entering higher education presents challenges for instructors seeking to meet varied individual learning needs. A promising approach to addressing this issue is the implementation of personalized learning paths that are tailored to students' specific needs, learning styles, and levels of self-regulated learning. This study examined how using optional digital learning support tools (H5P technology in conjunction with Discussion forums) for building personalized learning paths affects the learning experience of postgraduate students in a Database Systems subject. Using LMS and Ed Discussion analytics from 543 postgraduate students across two cohorts studying Database systems in in 2025, this study found that completing more optional H5P activities was associated with higher final grades, with a stronger H5P-grade association in Semester 2 than Semester 1. Discussion board engagement, including active posting and passive viewing each independently predicted final grades alongside H5P engagement, with passive viewing showing a stronger standardized association with final grades than active posting. Follow-up analyses suggested these supports were additive, such that H5P engagement was unrelated to active discussion posting but positively related to passive discussion viewing, and these H5P-discussion forum associations did not vary by cohort. Overall, the findings indicate that H5P completion and discussion forum engagement are distinct, additive forms of learning engagement associated with higher academic performance, and that the strength of the H5P-performance association varies across cohorts. These findings imply that multiple optional digital tools, including scaffolded H5P activities and discussion forums can provide personalized learning pathways for students with diverse learning needs, and that the benefits of H5P engagement may depend on cohort context.

Keywords: H5P, Discussion forum, personalized learning pathways, scaffolding, self-regulated learning, Database Systems, Higher Education

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Implementing Personalized Learning Pathways as Informed by the 5E Model: Digital Tools to the Rescue!

Celeste Tipple and Tanya Linden

1. INTRODUCTION

The contemporary higher education landscape is marked by increasing diversity in students' academic preparedness, cultural backgrounds, digital literacy, and study skills. The growing diversity among students calls for integration of technology into pedagogical strategies that foster flexible, inclusive and engaging learning environments, ensuring equitable access to learning opportunities (Mendoza & Venables, 2023).

Many institutions have shifted towards student-centered learning approaches which emphasize learner autonomy, personalized engagement, and differentiated support (O'Neill & McMahon, 2005). Within this context, blended learning has significant potential to support students with diverse learning needs and preferences (e.g., flexibility, pacing, access to resources), and can be especially nourishing for self-regulated learners (Zhao et al., 2025). Self-regulated learners understand their learning needs, seek help sources to meet these needs, and overcome obstacles that impede their learning (Zimmerman, 1990). Self-regulated learning skills are crucial in both online and blended learning environments because students are expected to manage their time and task completion by themselves through self-discipline, motivation, and responsible behavior (Pintrich, 2000).

Instructors can provide support to self-regulated learners and foster their self-regulation skills by guiding them through the process of developing autonomy, learning strategies, and self-reflection skills (Nicol & Macfarlane-Dick, 2006; Vovides et al., 2007). One of the successful pedagogical approaches in supporting and strengthening self-regulated learning skills is the 5E model (Bybee et al., 2006). The model is built on constructivist learning theory, which posits that students construct knowledge from their own experiences making them active participants in discovering information and developing understanding. The model encourages students to ask questions, form hypotheses, and investigate problems.

Digital technology provides a range of tools which educators can utilize to implement the stages of the 5E model while providing personalized learning paths based on learners' individual needs (Warren et al., 2014). One of such tools is H5P (https://h5p.org/), short for "HTML5 Package", - a free, open-source tool that offers a range of activity types and can be integrated into learning management systems (LMS). H5P offers a range of digital activity types which can be adopted to build a learning path by offering a series of tasks with gradually increased difficulty while reducing provided support for building a solution. Students can follow the offered learning path, or if they find it too slow for their abilities, they can skip easier tasks and attempt more challenging ones. To keep learning effective, the important part of the process is for the educator to ensure that they provide formative feedback on every attempt. This can be implemented using asynchronous online Discussion forums which are available via LMS or through complementary technologies (e.g. Ed Discussions or Forum Channels in Discord).

Although H5P holds promise for enabling personalized learning paths that are tailored to individual student needs (Jacob & Centofanti, 2024), there has been a limited number of studies examining the effectiveness of H5P in higher education. A recent systematic literature review identified only 30 studies focusing on H5P in higher education, highlighting both the potential of H5P and the current gap in the literature (Ping, 2025). Among the studies that have examined whether H5P can improve student learning in grades, while some have reported positive effect (Clune et al., 2022; Sharmin et al., 2025), the findings are not consistent. For instance, Jacob and Centofanti (2024) and Unsworth and Posner (2022) found no significant difference in student performance outcomes when implementing H5P activities. Notably, despite the lack of measurable improvement in academic performance, students in Jacob and Centofanti's (2024) study reported positive experiences and high levels of engagement when using H5P activities, indicating that H5P has positive benefits for students' learning experiences. However, these limited and mixed findings in the literature point to the need

for further research to clarify whether H5P contributes to measurable improvements in student performance and learning outcomes in higher education contexts.

To address this research gap, this study explores how students engage with H5P-based personalized learning activities supported by help-seeking via discussion forums, and how these engagement patterns relate to academic performance. Drawing on the 5E model of learning as a primary framework, optional H5P activities provide weekly practice opportunities with increasing difficulty across key concepts in the subject, supporting students' learning through repeated application and feedback. In parallel, the asynchronous online discussion forum provided an additional means for students to seek clarification, feedback, and peer/instructor interaction, as students work through concepts and tasks. Since these digital learning tools support learning in different ways, engagement may not be uniform across learning processes: some students may preferentially invest in structured practice (H5P), whereas others may rely more heavily on forum-based support and explanation. Importantly, we recognize that discussion forum engagement is not a single behavior: students can engage passively by viewing and reading existing threads (exposure to explanations and solutions), or actively by posting questions, comments, and answers (articulating reasoning and help-seeking). Both active and passive engagement with online discussion posts are useful for learning (Smith & Smith, 2014; Wilton, 2018) despite the widely accepted, evidence-based postulate that active learning is more productive. Accordingly, this study differentiates discussion engagement into passive and active indicators to better capture how students access learning support outside of class and to examine whether these distinct forms of engagement show different relationships with H5P completion and final grades.

Using learning management system (LMS) analytics (H5P completion), discussion forum analytics (active posting and passive viewing), and final subject grades, the study examines whether H5P engagement predicts academic performance, and whether this association differs by semester cohort. The study also evaluates whether discussion forum engagement explains additional variance in grades beyond H5P engagement, and whether patterns of engagement across H5P and forums suggest co-occurring engagement versus selective engagement in one tool over the other.

2. LEARNING-CENTERED PEDAGOGY

Multiple theories and models on how students learn and how to best support their learning have been proposed and tested over decades. Modern theories advocate student-centered learning where the focus is shifted from teaching activities to learning processes that engage students in active problem-solving where individual needs, interests, and abilities guide the learning process (Cross, 2005). Many educational and learning theories are built on constructivism as a foundation which promotes active building of new knowledge based on the foundations of prior knowledge through meaningful participation in interactive processes (Elliott et al., 2000; Ertmer & Newby, 2013). One model strongly grounded in constructivist learning theory is the 5E model proposed by Bybee et al. (2006). Although the 5E model was originally developed for planning biology teaching including development of materials and teaching texts, it has since been widely adopted in other STEM subject areas, e.g. physics (Ergin, 2012), mathematics (Magsalay et al., 2019), and biology (Tanner, 2010), with a recent meta-analysis documenting positive effects on learning in STEM (Polanin et al., 2024).

The stages of the 5E model - Engage, Explore, Explain, Elaborate, Evaluate - support learning through the implementation of a structured, inquiry-based learning cycle through active engagement. The goal of the *Engage* stage is to ignite interest and connect to students' prior knowledge. This stage is critical because it inspires students to study the topic and provides instructors with insight into students' prior knowledge of the phenomenon, enabling instructors to design explanations of the concepts that align with students' learning needs. In the *Explore* stage, students investigate the topic through hands-on activities that help to identify misconceptions about the topic and develop their initial ideas while building on their prior knowledge. The *Explain* stage aims at deepening students' engagement with concepts. During this phase, the instructor introduces formal vocabulary, clarifies misunderstandings, and introduces key concepts while facilitating students' active participation and articulation of their understanding through solving problems of adequate difficulty. The *Elaborate* stage involves active problem-solving, where students apply their new understanding to new contexts while seeking clarifications on the "muddy" points of the topic. This is a stage where students, as self-regulated learners, reflect on their understanding and decide how much practice and what type of

practice they need (e.g. whether they need to repeat easier exercises again or to move to more complex ones). Finally, the *Evaluate* stage is when students' understanding and ability to solve problems is assessed. The Evaluate stage includes both formal assessment by instructors and student self-assessment, with self-regulated learners using feedback to decide whether to revisit easier tasks to consolidate concepts or to move to more challenging tasks. The key advantage of the 5E model is its scalability: the 5E model can be implemented within a single lesson, or span multiple lessons (e.g., when more complex topics require gradual scaffolding).

3. METHODS

Applying the 5E model in the educational context of Database Systems

We implemented phases of the 5E learning cycle using H5P interactive activities combined with the discussion forum in teaching a Database Systems subject in the Master degree of a university in Australia. Students enrolling in this subject come from a range of backgrounds, i.e. some of them completed IT-related Bachelor degrees whereas others come from non-IT backgrounds. Therefore it is necessary to provide individualized learning pathways that address variations in students' background knowledge.

Altogether 10 weeks of the 12-week semester offered at least two H5P activities incorporated in the learning materials supporting phases of the 5E cycles. Since the main goal of the H5P tasks was learning support, they were not part of the formal assessment and it was the students decision whether to attempt all, some or none of the tasks. These tasks were offered as supplementary optional tasks for students who needed or wanted to practice skills development. Within this context, students with self-regulated learning skills could identify their needs in additional practice themselves, whereas other students needed instructor recommendation to attempt additional tasks after classes to improve their knowledge and skills.

To support students outside of class time, they were encouraged to seek clarification of concepts and feedback on their solutions (especially if different from sample solutions) by posting on the subject Discussion forum (Ed Discussion https://edstem.org/).

In applying the 5E model within our subject Database systems (Figure 1), the first stage - *Engage* - takes the form of a face-to-face (in the lecture and tutorials) discussion of people's everyday activities, data they generate and data from database systems that everyday activities depend on. Through these discussions, students discover why IT professionals need sound understanding of database systems while teaching staff get insights into students' familiarity with database foundations and identify students from non-IT backgrounds who may need additional support and longer time to grasp the foundational concepts.

In the *Explore* phase, students are given simple hands-on activities. In addition to lecture explanation and tutorial exercises, a series of tasks was implemented as H5P activities which were based on a certain topic that needed to be mastered over 2-3 weeks. Students who wanted additional practice could complete these optional activities in their own time and seek feedback via Discussion forum or in in-person consultations as needed. Initial problem-solving tasks were illustrated through the H5P activity type "agamotto", a slide show that can be used to explain the step-by-step solution development from one slide to the next. Before presenting the slides, a simple case study was published on the LMS page (Figure 2). Then an explanation of how to create a data model was designed as "agamotto" slides with each slide showing a statement from the case study and how it should be modeled. Although this task is a one-way flow of instruction where students are passive learners, it is necessary to provide examples on how to split a case study into bits that can be easily modeled, as well as demonstrate the modeling notation.

The next step in the *Explore* phase would be another simple case study, but this time instead of the solution demonstration, an indirect approach was used. Students were given a H5P activity containing multiple-choice questions (MCQ) to help them make initial decisions on starting the solution (Figure 3). The important aspect of these activities is for the educator to embed feedback into every option of each MCQ. This formative feedback ensures that students learn from selecting incorrect answers as it is often important to understand why a particular decision may be problematic (especially in the long run) during database modeling. This use of simple tasks on concepts application aligned with the core purpose of the *Explore* stage - to facilitate understanding of foundational concepts through hands-on activities.

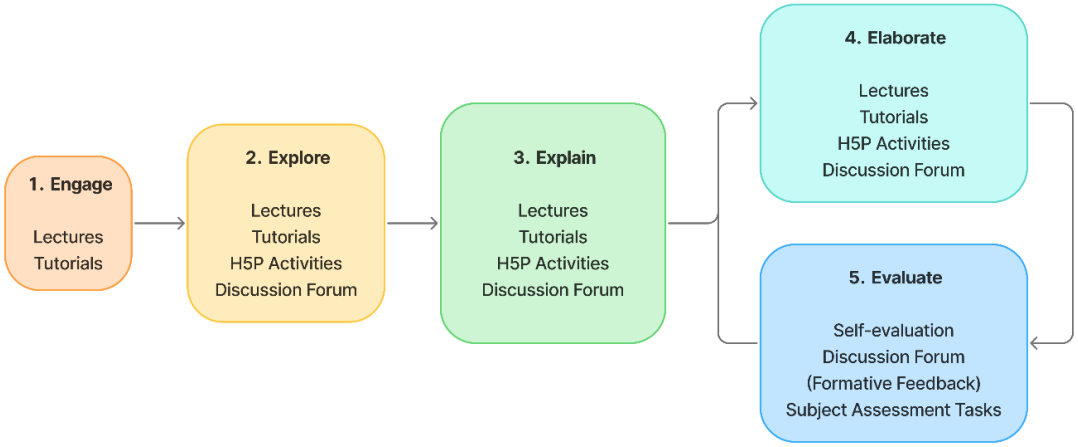

Figure 1: Implementation of the 5E model in Database Systems

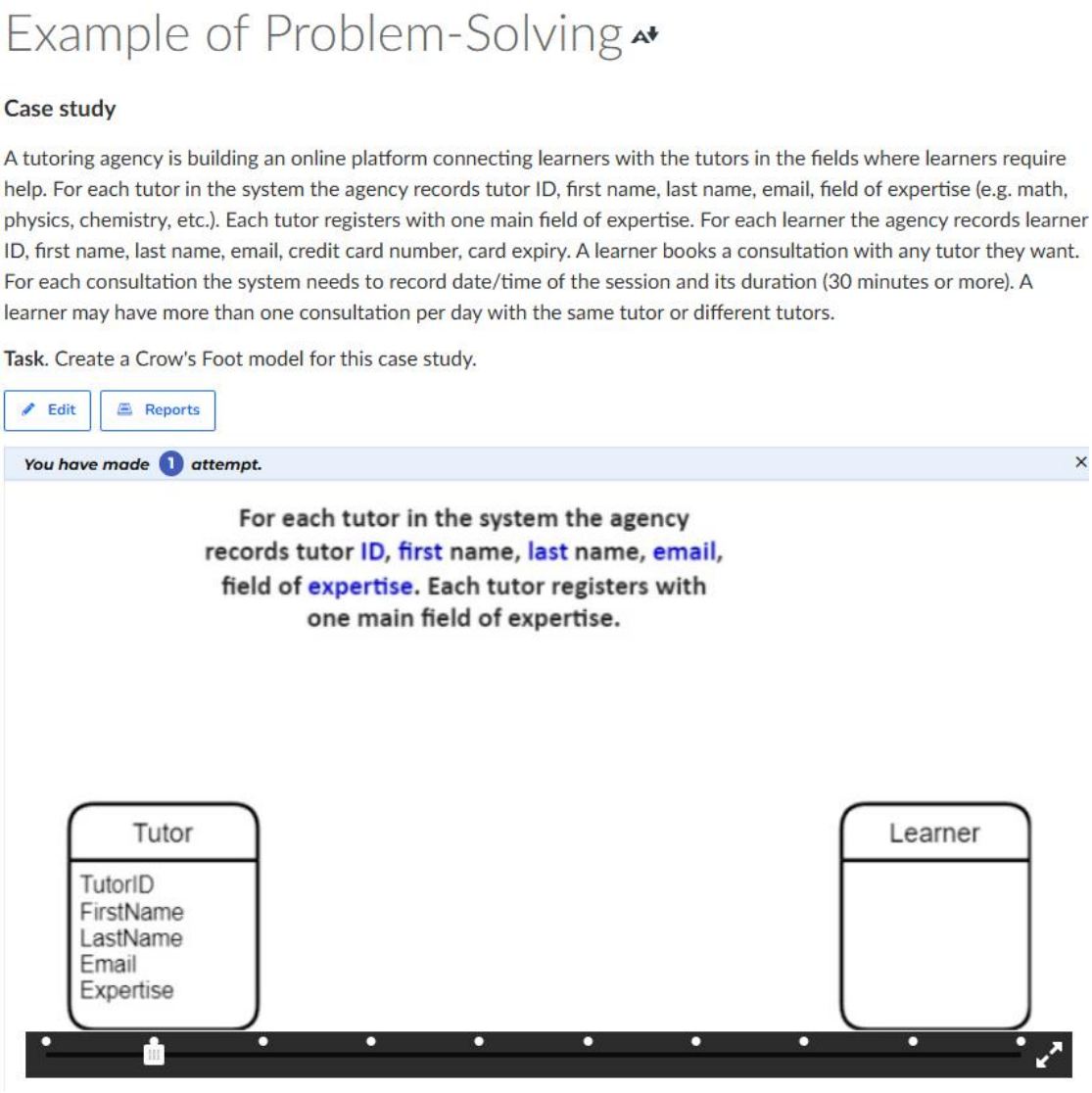

Figure 2: Step-by-step solution development using 11 slides. Currently selected is slide 2 corresponding to step 2 in the solution development

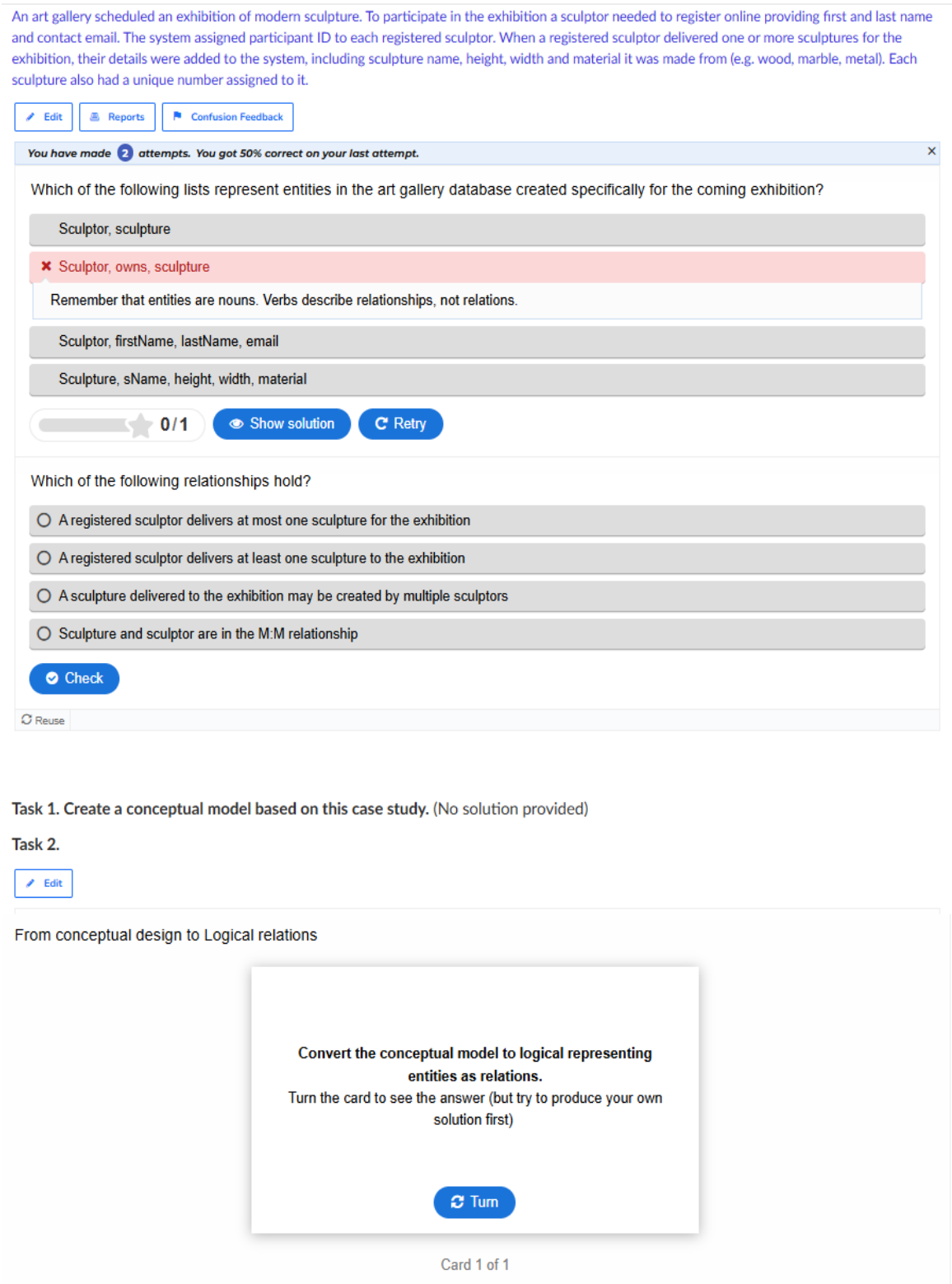

Figure 3: Practice task in week 2. The page shows a case study and questions based on that case study. Incorrect answer in MCQ1 results in feedback.

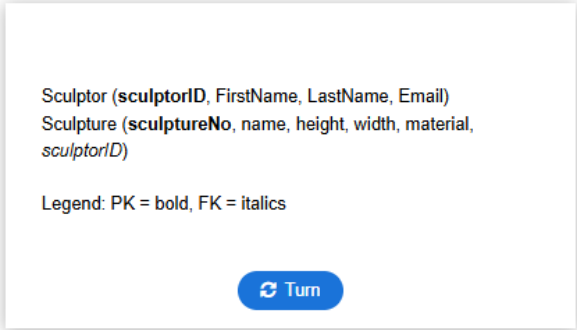

Figure 4: The other side of the dialogue card with the answer (for illustration of how the activity works)

Since in the Explore stage foundational concepts are explored by students, regular support in building correct understanding is crucial. To facilitate this process, students were encouraged to seek clarifications via the discussion forum. In our experience with database design topics students often experience difficulty in modeling weak entities, identifying cardinality (optional or mandatory participation of entities) and placing foreign keys. So after watching the "agamotto" slides, students may need additional explanation of reasoning behind modeling relationships between entities, i.e. how to interpret the case study statements and why a particular requirement in the case study is modeled in a certain way. Teaching staff answer students' questions on Ed Discussion which provides personalized help "on demand", without the need to wait for a class session or for a formal consultation time.

Then the instruction continued into the *Explain* stage, where open-ended questions on creating a logical relations model were first discussed in class sessions and also offered as additional H5P activities in the form of a turn-around dialogue card (Figure 4). The other side of the card contained a solution to the task so that students could compare their model with the expected solution. In this stage, students articulate their understanding of concepts at a more difficult level. Again, if a student's solution is different from the sample solution on the back of the Dialogue card, it is beneficial for the student to seek feedback on their solution, i.e. whether it is a good alternative solution or whether they made mistakes. Such Discussion threads became valuable for the student who made the initial post, as they sometimes turn into a several-step conversation, but also for other students who may improve their problem-solving by reading other students' posts, questions and comments.

Next, the *Elaborate* stage, aims to deepen learning by applying concepts to new situations. In this stage for the Database Design topic, we developed several open-ended modeling questions which were presented to students as H5P dialogue cards with a question on one side and the solution on the other side. This design gives students an opportunity to check their answer against the correct solution immediately. As continuous support to the learning process, students were encouraged to post questions on the Discussion forum to seek further clarification. Since at this stage the tasks become more challenging, some students can benefit from in person consultations.

Students' self-regulation within this subject manifested itself in their decision-making regarding their learning, as they tailored their engagement in H5P activities and discussion forums based on their learning needs. Students could choose either to complete all scaffolding exercises, or to skip tasks with detailed steps and move to more challenging ones which provide little to no guidance. Also, self-regulation was evident through students' decision-making on how to seek help, whether to post on Discussion forum, read existing posts, or seek in-person consultation.

Finally, the *Evaluate* stage was implemented through ongoing informal assessment where students judged their skills and decided on whether they were ready to progress to the next topic, alongside formal assessment in the form of assignments and tests. This is where *Evaluate*/*Elaborate* stages may overlap and create an internal cycle between the two stages, as students use feedback and self-assessment to decide whether to revisit earlier tasks, or attempt more challenging tasks. Help-seeking behavior also emerged from students' evaluation of their own learning progress in deciding between in-person consultation and posting questions on Ed Discussion.

The subject has formal assessment tasks that contribute to the final grade, however, since there are no resubmission options, it is hard to judge whether students acted on feedback from assignments and tests, except the cases where self-regulated learners attempted the assessments informally and sought feedback by posting on Ed Discussion.

Data Collection

The data was collected using learning management system (LMS) analytics and Discussion forum Ed analytics. LMS analytics has

been used effectively by educators to evaluate students' engagement which in turn could guide educators on which aspects of student learning need attention (Wang, 2017). We used LMS reports on students' access to pages containing H5P activities along with Ed Discussion analytics which capture students' discussion activity (posts, comments and views).

The sample in this study was comprised of postgraduate students with the majority of whom are international, i.e. English is their second language. In a sample like this, many students might find it challenging to understand in-class instruction. Although the subject has no pre-requisites, students come from different backgrounds, i.e. some of them have never studied any IT subjects, whereas others have significant exposure to IT knowledge through previous studies or work. Importantly, at postgraduate level, students are usually motivated and committed to their studies (Bergann et al., 2025). This study used the cohorts from two teaching semesters in the 2025 academic year, with a total of 543 students used in the analysis. Ethics approval was obtained before downloading LMS analytics reports (HREC approval 2025-33684-69852-2).

Study Design

This study employed an observational, correlational quantitative methodology to explore whether students' engagement in H5P activities can impact student performance in a Database Systems subject, and if this association differed by cohort across the 2025 academic year (consisting of two semesters). Primary analyses were conducted using moderated linear regression which tests whether an interaction exists between H5P engagement and Cohort (engagement × cohort) in predicting final grades. To further contextualize these associations, additional statistical models examined whether discussion forum engagement (active participation [ActiveDB] and passive viewing [PassiveDB]) explained unique variance in grades beyond H5P engagement, and whether H5P engagement was associated with discussion engagement across cohorts. All analyses were conducted using IBM SPSS Statistics Version 29 and Hayes PROCESS Macro for SPSS Version 4.2 (Hayes, 2017). The participants included in the analysis were students who completed all assessments in each respective semester, resulting in a final sample of N = 543 (Semester 1 n = 345, Semester 2 n = 198) which exceeded the minimum sample size of N = 107 with a medium effect size (α = .05, power = .80, m = 3) for a moderated linear regression by Tabachnick and Fidell (2013).

4. RESULTS

Data preparation and analytic approach

Analyses were conducted at the student level (one row per student). Semester was treated as a binary cohort indicator (0 = Semester 1; 1 = Semester 2). H5P engagement was operationalized as the number of H5P activities completed (ENACT). Discussion forum engagement was operationalized as (a) ActiveDB (questions/posts/comments/answers) and (b) PassiveDB (views). Final grades were operationalized as students' overall subject mark (percentage out of 100) awarded at the end of the semester. Final subject scores were calculated from the combination of two assignments, short mid-semester test (MCQ + short answer questions), short end of semester quiz (MCQ only) and a 2-hour end of semester exam (short and long answer questions). Descriptive statistics indicated that discussion engagement variables were strongly right-skewed with many low/zero values and a small number of very high-engagement cases (see Table 1).

Given the highly right-skewed engagement variables (ActiveDB and PassiveDB) and the presence of many zero/low-engagement cases alongside a small number of very high-engagement cases, the assumption of homoscedastic (constant) residual variance was unlikely to hold. Accordingly, moderation models were estimated using heteroscedasticity-consistent (HC3) robust standard errors, which provide more reliable inference when residual variance differs across levels of predictors and when influential observations may be present. In addition, PROCESS generated 5,000-sample percentile bootstrap confidence intervals, and these were found to be broadly consistent with the HC3-based intervals reported in Tables 2-6, providing convergent support for the robustness of the calculated parameter estimates.

Primary analysis: Does engagement with H5P activities predict final grades, and does this differ by semester (cohort)?

A moderation model tested whether ENACT predicted final grade (FINGRA) and whether this association differed by cohort/semester (ENACT × Cohort). The model indicated that H5P completion was positively associated with final grades, and this relationship differed by semester (Table 2). Probing the interaction further showed that the ENACT-grade association was positive in

both cohorts, but stronger in Semester 2 than Semester 1 (see conditional effects in Table 3). This pattern suggests that completing additional H5P activities was associated with higher grades across both semesters, with a steeper "gain per activity" observed in Semester 2.

Secondary analysis: Does the H5P – grade relationship remain significant after accounting for discussion engagement?

This model was specified a priori as an adjustment/robustness check to evaluate whether the ENACT × Cohort effect was independent of concurrent engagement in any other learning supports available in the subject (in this case, discussion forums). Thus, to evaluate whether the cohort-specific association between H5P activities completion and grades could be statistically accounted for by engagement in posts and comments on Ed Discussions, ActiveDB and PassiveDB were added as covariates into the regression model. The covariate-adjusted moderation model remained significant (Table 4). Importantly, the ENACT × Cohort interaction also remained significant after adjusting for active posting (ActiveDB) and passive viewing (PassiveDB), indicating that (a) H5P completion explained variance in grades above and beyond discussion forum engagement, and (b) the stronger H5P-grade association in Semester 2 could not be explained by cohort differences in discussion forum engagement alone.

In addition, both forms of discussion engagement showed unique positive associations with grades when entered alongside H5P completion and cohort (Table 4). The relative strength of predictors (ActiveDB and PassiveDB) was compared in order to determine which type of discussion forum engagement was a stronger predictor of subject performance, so we re-estimated the covariate-adjusted model using z-standardized variables (i.e., FINGRA, ENACT, PassiveDB, and ActiveDB were converted to z-scores) and reported the resulting standardized coefficients (β). This standardized re-estimation does not replace the PROCESS results in Table 4 (which are reported in raw units) - it is included solely to support magnitude comparison between PassiveDB and ActiveDB. Thus, in this standardized model, passive discussion engagement (PassiveDB; β = .256) showed a stronger association with grades than active posting (ActiveDB; β = .159), although both effects were statistically significant.

Variable	Cohort 0 (Sem 1)	Cohort 1 (Sem 2)
Final grade (FINGRA)	*M* = 70.41, *SD* = 11.79	*M* = 70.42, *SD* = 11.70
H5P completed (ENACT; 0-35 activities)	*M* = 8.81, *SD* = 11.33	*M* = 17.05, *SD* = 12.11
Active discussion activity (ActiveDB)	*M* = 3.89, *SD* = 9.23	*M* = 2.94, *SD* = 5.92
Passive discussion (PassiveDB views) activity	*M* = 257.41, *SD* = 295.20	*M* = 186.04, *SD* = 195.79

Table 1: Descriptive statistics by cohort (semester)
Note. Cohort 0 = Semester 1; Cohort 1 = Semester 2.

Predictor	b	SE (HC3)	t	p	95% CI
Intercept	71.01	0.61	117.18	< .001	[69.82, 72.20]
ENACT (centered)	0.199	0.050	4.01	< .001	[0.102, 0.296]
Cohort	-2.66	1.091	-2.44	.015	[-4.801, -0.520]
ENACT × Cohort	0.196	0.080	2.46	.014	[0.040, 0.352]

Table 2: Moderation model predicting final grade from H5P completion and cohort (N = 543)
Note. Model fit. R^2 = .084, F(3, 539) = 19.00, p < .001. Interaction increment. ΔR^2 = .009, F(1, 539) = 6.07, p = .014. HC3 robust SEs were used. ENACT was mean-centered by PROCESS.

Semester	Simple slope (b)	SE (HC3)	t	p	95% CI
Semester 1	0.20	0.05	3.98	< .001	[0.10, 0.30]
Semester 2	0.40	0.06	6.36	< .001	[0.27, 0.52]

Table 3: Simple slopes of H5P completion predicting final grade by semester

Predictor	b	SE (HC3)	t	p	95% CI
Intercept	67.04	0.81	82.58	< .001	[65.45, 68.64]
ENACT (centered)	0.143	0.049	2.93	.004	[0.047, 0.239]
Cohort	-1.176	1.019	-1.15	.249	[-3.178, 0.826]
ENACT × Cohort	0.196	0.076	2.59	.010	[0.047, 0.345]
ActiveDB	0.228	0.086	2.66	.008	[0.060, 0.396]
PassiveDB	**0.011**	**0.003**	**4.13**	**< .001**	**[0.006, 0.017]**

Table 4: Moderation model predicting final grade from H5P completion and cohort, with discussion engagement as covariates (N = 543)
Note. Model fit. R^2 = .199, F(5, 537) = 19.25, p < .001.
Interaction increment. ΔR^2 = .009, F(1, 537) = 6.71, p = .010.
HC3 robust SEs and 5,000 bootstrap samples were used. ENACT was mean-centered.

Predictor	b	SE (HC3)	t	p	95% CI
ENACT (centered)	0.028	0.033	0.86	0.392	[-0.036, 0.092]
Cohort	-1.238	0.679	-1.82	0.069	[-2.572, 0.096]
ENACT × Cohort	**0.012**	**0.051**	**0.24**	**0.810**	**[-0.088, 0.113]**

Table 5: H5P completion predicting discussion engagement with ActiveDB as outcome (N = 543)
Note. Model fit. R^2 = .005, F(3, 539) = 1.43, p = .233.

Predictor	b	SE (HC3)	t	p	95% CI
ENACT (centered)	4.410	1.700	2.59	.010	[1.071, 7.750]
Cohort	-106.435	22.373	-4.76	< .001	[-150.383, -62.486]
ENACT × Cohort	-0.241	1.976	-0.12	.903	[-4.122, 3.640]

Table 6: H5P completion predicting discussion engagement with PassiveDB as outcome (N = 543)
Note. Model fit. R^2 = .053, F(3, 539) = 12.23, p < .001. HC3 robust SEs; ENACT mean-centered; Cohort coded 0 = Sem 1, 1 = Sem 2.

Exploratory follow-up: Does engagement in discussion boards complement or replace H5P engagement?

Since the covariate-adjusted model (Table 4) showed that both H5P completion and discussion forum engagement contributed unique variance in subject performance (FINGRA), we conducted exploratory follow-up analyses to clarify how these two forms of engagement (ENACT and discussion forum use) were related to each other. Therefore, to examine whether patterns of engagement differed across H5P and Discussion, we ran two separate additional moderation models with discussion engagement as the outcome (ActiveDB and PassiveDB) and H5P completion (ENACT) as the focal predictor, with Cohort as the moderator. For ActiveDB, neither ENACT, nor the ENACT × Cohort interaction was significant (Table 5), indicating no evidence that H5P completion was associated with active posting in either Cohort (semester). For PassiveDB, ENACT showed a positive association with discussion forum views, whereas the ENACT × Cohort interaction was not supported (Table 6). Overall, these results suggest that H5P completion (ENACT) was not meaningfully associated with active discussion forum engagement (ActiveDB), but was instead positively associated with passive forum engagement (PassiveDB; viewing). The ENACT-PassiveDB association did not vary by cohort (ENACT × Cohort, ns). However, cohorts differed in overall passive viewing, with Semester 2 students exhibiting substantially fewer PassiveDB engagement than Semester 1 students. Active posting did not differ significantly by cohort (Cohort p = .069), although the direction of the effect was consistent with lower ActiveDB in Semester 2.

5. DISCUSSION

The aim of this study was to examine whether engagement with H5P activities in a 5E-informed, scaffolded learning pathway that allowed students to self-select optional practice was associated with academic performance, and whether this association differed across two semester cohorts in 2025. As an exploratory extension to this primary aim, we examined whether LMS-tracked discussion forum

engagement (active posting in the form of posting and commenting, and passive viewing of posts, comments and answers by others) showed independent associations with grades and how it was associated with H5P engagement. The H5P activities were designed as optional scaffolded practice opportunities aligned with core database concepts, and discussion forums were available for clarification, feedback, and peer/instructor interaction. With the implementation informed by the 5E model as a framework, H5P completion can be viewed as one pathway supporting *Explore, Explain* and *Elaborate* stages as guided practice and application, whereas discussion forum engagement may support learning through both active contributions (e.g., asking/answering questions that help clarify reasoning; *Explore* and *Explain*) and passive viewing (e.g., reading explanations and worked solutions in subject materials and on Ed Dicussion). Notably, in this subject, the *Engage* phase was primarily implemented through in-class lecture/tutorial discussions that connected everyday activities to database-generated data - this component is pedagogically central but is not directly captured by LMS analytics.

To address the primary aim of the study, we examined whether engagement in H5P activities predicted final grades and whether this association varied by semester. Consistent with prior work (Abusalim et al., 2024; Linden & Tipple, 2025), this study found that students who completed more H5P activities tended to achieve higher final grades. However, this finding differed by semester (Cohort). The association was stronger in Semester 2 (b = .40) than in Semester 1 (b = .20), indicating that each additional completed H5P activity corresponded to a larger increase in grades for Semester 2 students. In the unadjusted model, Semester 2 students were estimated to have slightly lower grades than Semester 1 students at the overall mean of H5P engagement (i.e., at mean-centered ENACT = 0). However, after adjusting for discussion engagement, this difference became smaller and was no longer statistically significant (Table 4), suggesting that any semester-related difference in performance at average H5P engagement was small once forum engagement considered. This helps explain why the observed average grades were similar across semesters, even though Semester 2 students completed more H5P activities. Consistent with this pattern, model estimates suggest that at high engagement (approximately 14 activities above the mean; ~26/35 completed), Semester 2 performance would be expected to converge with, and slightly exceed, Semester 1. To illustrate the size of H5P engagement, completing 10 additional H5P activities corresponded to an estimated ~2-point increase in final grade (FINGRA) in Semester 1 and ~4 points in Semester 2, suggesting that structured practice through H5P activities was particularly beneficial for the second cohort compared to the first.

Importantly, the difference between semesters in the ENACT-grade slope remained when ActiveDB and PassiveDB were added as covariates into the model (Table 4). That is, the ENACT × Cohort term remained significant, indicating that: (a) H5P engagement explained variance in subject performance above and beyond discussion forum engagement (both active and passive), and (b) the stronger association between H5P completion and grades in Semester 2 was not explained by differences in discussion forum engagement. Furthermore, in the covariate-adjusted model, both ActiveDB and PassiveDB showed independent positive associations with grades alongside H5P completion, suggesting that H5P engagement and discussion forum engagement captured distinct aspects of learning rather than functioning as simple proxies for one another. When coefficients were standardized to compare magnitudes, passive forum viewing (PassiveDB; β = .256) was more strongly associated with final grades than active posting (ActiveDB; β = .159), although both were significant. This pattern of results is consistent with the possibility that accessing other students' explanations/solutions through passive discussion forum viewing supports subject performance, and that discussion forum viewing is a meaningful learning behavior, consistent with previous studies (Chiu & Hew, 2018; Smith & Smith, 2014; Wilton, 2018). Finally, follow-up models which further investigated whether there was a relationship between H5P activity attempts and discussion forum engagement provided little evidence of a trade-off between learning support options: lower H5P completion was not associated with higher active discussion forum posting, and passive discussion forum viewing tended to co-occur with H5P completion rather than substitute for it (Tables 5-6). This pattern of results suggests lower H5P engagement did not reflect a compensatory shift toward active forum participation, instead, it was more consistent with lower uptake of optional supports overall (particularly passive viewing), rather than a preference for the discussion forum as an alternative learning strategy.

In this subject context, H5P completion may reflect structured opportunities spanning Explore-Explain-Elaborate, including guided worked

examples (e.g., step-by-step demonstrations), formative concept-checking with feedback-rich MCQs, and more open-ended modelling practice (e.g., dialogue cards that prompt articulation and checking of solutions). Accordingly, H5P completion is not only an Explore indicator - it also captures students' engagement with scaffolded explanation and extension opportunities embedded in the pathway. Consistent with this interpretation, engagement with H5P differed substantially across the 2025 academic year, with 64.9% of students in Semester 1 completing at least one H5P activity compared to the 95% of students in Semester 2. This pattern suggests that the two cohorts may have differed in how they chose to engage with learning. In particular, Semester 2 students showed substantially higher uptake of the optional H5P pathway, whereas a sizeable proportion of Semester 1 students did not engage with H5P at all. Because the H5P activities were identical across semesters, this difference is unlikely to reflect changes in the resources themselves and instead points to cohort-level differences in engagement patterns, and the extent to which students opted into the optional H5P activities.

When considered alongside the engagement trends for the discussion forum and H5P, the data indicated that Semester 2 students showed lower passive discussion engagement (views) alongside much higher uptake of H5P activities. In contrast, active discussion posting did not show strong evidence of cohort differences, suggesting that cohort variation was more pronounced for H5P completion and passive viewing than for active posting. Interpreted through the 5E model, this pattern is consistent with Semester 2 students making greater use of H5P as a structured pathway for practice and feedback (i.e., Explore/Explain/Elaborate-aligned learning opportunities embedded in the activities), while Semester 1 students' relatively higher forum viewing may reflect greater reliance on asynchronous exposure to explanations and worked solutions outside class. Importantly, because the Engage phase was primarily implemented in class and was not captured by LMS analytics, these interpretations should be treated as indicative rather than direct measures of 5E phases. This pattern is also consistent with the follow-up analyses of active and passive discussion forum activities, which did not support the idea that lower H5P completion was offset by increased active discussion forum posting, and instead, suggested limited evidence of substitution or preference between learning support options. Possible explanations for this pattern of engagement include differences between cohorts in educational background, learning preferences, and self-regulated learning behaviors that influence which learning support options students use most often. Other explanations for cohort effects include some students deeming core materials (e.g., lecture slides/recordings, tutorial solutions, practice exam tasks) sufficient for their learning needs. More broadly, this suggests that some students may have perceived the additional optional learning opportunities as unnecessary given their existing strategies or prior knowledge, rather than making an explicit decision to follow a self-directed learning pathway.

The lack of engagement with H5P activities suggests that some students may be less likely to make effective use of optional learning supports, whether due to self-regulated learning challenges, competing demands, or uncertainty about how to integrate activities effectively, rather than a lack of capability per se. The issue of students frequently not engaging with provided resources for the benefit of their learning has been identified in the past research (Clarebout & Elen, 2006). However, lack of engagement with the additional materials could also be explained by poor self-regulated learning skills or poor time management. For example, students who struggle to plan, prioritize, or monitor their study progress may be less likely to take advantage of additional, non-mandatory learning activities offered, such as H5P. Importantly, low engagement with H5P activities is not unique to this study. Other studies such as Jacob and Centofanti (2024) and Rahmi et al. (2024) report low and declining engagement in H5P activities, citing reasons such as poor perceived value, visibility and accessibility, technological barriers, reduced novelty, and repetitiveness in activity formats can reduce motivation for students to engage in H5P activities. To address concerns with engagement, educators could consider embedding H5P activities more explicitly into the curriculum and emphasize their relevance, aligning or signposting H5P activities as being closely relevant to assessment tasks, or providing guidance on how and when to use them. From a 5E-aligned design perspective, this could include signposting which activities support Explore for particular concepts, and using the online asynchronous discussions forum strategically to answer questions and prompt Explain and Elaborate (e.g., "show your reasoning" prompts, troubleshooting threads) to provide individualized support to everyone, regardless of their self-regulation skills.

When comparing the two forms of forum engagement, passive viewing showed a stronger association with grades (PassiveDB; β = .256) than active posting (ActiveDB; β = .159), although both were positively related to performance. Interpreted through the 5E model, this pattern is consistent with the idea that the discussion forum may function as an ongoing Explain resource that students repeatedly return to as they Elaborate their understanding through practice and prepare for assessment. In other words, revisiting explanations, worked solutions, and peer/instructor clarifications may support the Elaborate–Evaluate cycle by helping students check their reasoning, identify gaps, and refine their approach while preparing for assessments. Active posting may still be important for targeted help-seeking and articulating reasoning (for example, allowing students to engage in multiple cycles of solution resubmission for the purpose of getting feedback and learning), but the present findings suggest that exposure to explanations via discussion forum viewing is particularly salient in this subject context. In this way, active posting on the discussion forum may reflect a different type of engagement that is used by fewer students, but is more targeted (e.g., help-seeking, checking reasoning, and clarifying misunderstandings). This would fit with the finding that ActiveDB predicted final grades despite showing little association with H5P completion.

Additionally, since H5P activities were identical across semesters, the stronger engagement–grade association in Semester 2 cannot be explained by the activities themselves. Instead, it suggests that cohort or semester conditions influenced how effectively engagement translated into student performance. One possibility is that Semester 2 students were more likely to use H5P activities in a way that supported the Elaborate–Evaluate loop (e.g., returning to activities after feedback, selecting tasks strategically, or integrating activity feedback into assessment preparation), whereas in Semester 1, engagement may have been more intermittent or less tightly coupled to assessment demands. These interpretations remain tentative because the current observational design does not directly measure how students used feedback or made learning decisions across the 5E stages. More broadly, because engagement was self-selected and the design is observational, the reported associations may also reflect unmeasured differences between students (e.g., prior knowledge, motivation, time availability, or assessment-related study strategies), rather than causal effects of H5P or forum engagement. In practical terms, the results highlight that the benefits of H5P depend not only on the activities provided, but also on student uptake, their self-regulated learning skills, and the learning context that supports their use.

The results of this study showed that the 5E model provided a pedagogically sound way for students to follow a customized learning path. However, decision-making on how to construct this path through selection of optional H5P tasks, and how to seek learning support was up to individual students and depended on their self-regulated learning skills. The 5E model also offers a useful interpretive lens for understanding how different forms of engagement may relate to learning within this scaffolded, student-choice pathway, while recognizing that the present study does not directly measure all phases of the 5E stages. Taken together, these findings suggest that H5P engagement combined with the Discussion forum support is a meaningful but modest contributor to subject performance within this sample, and that H5P activities may function most effectively as a scaffold that supports learning alongside other factors. Interpreted through the 5E model, the H5P pathway may have supported students cycling between *Elaborate* (applying concepts to new problems and extending understanding through increasingly complex practice tasks) and *Evaluate* (checking understanding via embedded feedback, comparing solutions, and using feedback from staff via Discussion forum to decide whether further practice or help-seeking is needed). In this sense, H5P completion may function as a reflection of students' participation in the 5E iterative learning cycle, which would be expected to relate to stronger performance outcomes. Consistent with this interpretation, discussion forum engagement showed unique positive associations with grades when included alongside H5P completion, suggesting that multiple learning opportunities across the cycle (e.g., H5P practice and forum-based clarification) can contribute additively rather than acting as substitutes in improving overall subject performance. Overall, the findings point to two related but distinct patterns of engagement with optional subject learning supports. One pattern involves H5P completion alongside passive forum viewing, which may reflect a "practice and feedback" learning mode by accessing available explanations and worked solutions. The other involves active posting on Ed Discussion to seek additional feedback, which appears to capture a more participatory form of engagement (e.g., articulating reasoning and help-seeking) that is not simply an extension of H5P activities

engagement.

5. CONCLUSIONS

This study examined the combined use of two digital tools - H5P and asynchronous online discussion forum – to implement personalized learning paths in the context of teaching a Master level subject Database Systems. Guided by the 5E framework, the subject materials incorporated multiple H5P activities combined with options to seek clarifications and feedback on solution attempts via Ed Discussion tool. Unlike past studies which relied on self-reported data (e.g. Gil-García et al., 2023; Jacob & Centofanti, 2024), our study offered greater opportunities for addressing individual learning needs and a stronger basis for evaluating how combining these tools impacts student learning and performance.

In line with many previous studies, our research confirms that H5P, if used in a pedagogically sound way, has significant potential in supporting students learning, especially for students who mastered self-regulated learning skills. Unlike previous studies, these research findings indicate that H5P activities yield greater learning value when integrated with opportunities of seeking additional help (e.g. in this study mainly via online asynchronous discussion forum). Also similar to previous studies, it was determined that passive viewing of discussion forums is a valuable learning opportunity which should be encouraged. Although considered passive, students' viewing of posts and comments by others that clarify concepts and provide alternative solutions and explanations, supports learning in a meaningful way.

Although the data was collected from one postgraduate subject only, the alignment of findings with the previous studies enhances their contribution and supports the potential for broader generalizations to similar higher education contexts. Future research could consider implementing H5P in conjunction with asynchronous online support in multiple subjects and comparing engagement data across longer periods.

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