JOURNAL OF BALTIC SCIENCE EDUCATION

ISSN 1648-3898 /Print/
ISSN 2538-7138 /Online/

This is an open access article under the Creative Commons Attribution 4.0 International License

DESIGNING CONTRAST TO SUPPORT LEARNING IN SCIENCE AND TECHNOLOGY COURSES THROUGH RHYTHMIC ENGAGEMENT PEDAGOGY (REP)

Yen-Sheng Chen

Abstract. *Active learning in higher education science and technology courses is often discussed through pedagogical approaches or in contrast with lecture, with less attention to how engagement is organised over educational timescales. This study examined Rhythmic Engagement Pedagogy (REP), a contrast-based design that coordinates recurring shifts between teacher explanation and student activity across the macro, meso, and micro course timescales, with rhythm referring to this temporal pattern rather than to music. Using a cross-course, cross-semester quantitative design, the study compared three 2025 REP offerings with non-REP offerings in a theory-oriented circuit course, a mixed theory–practice antennas course, and a practice-centred microwave laboratory course. Attendance records and final grades were analysed between semesters, and pre- and post-course questionnaires assessed behavioural, cognitive, and emotional engagement. The REP offerings had attendance rates 17.3, 13.4, and 15.9 percentage points higher and final grades 17.7, 9.2, and 11.7 points higher, respectively. Post-course ratings exceeded pre-course expectation ratings in all nine course-by-dimension comparisons, with the largest differences observed in the theory-oriented course. REP addresses this temporal dimension by coordinating lecture, student activity, and assessment across multiple course timescales without prescribing a fixed set of active-learning activities.*

Keywords: *active learning, course design, higher education, science and technology education, student engagement*

Yen-Sheng Chen
National Taipei University of Technology, Taiwan

Introduction

Research Problem

Higher education science and technology courses often involve abstract concepts, symbolic representations, cumulative prerequisite knowledge, and step-by-step reasoning within limited class time. Because these courses rely heavily on derivations, calculations, procedural problem solving, and questions with standard answers, class time is often dominated by teacher explanation. As a result, students may spend much of the lesson listening, taking notes, and following worked examples rather than actively working with the content. Under these conditions, behavioural engagement may decline, cognitive engagement may become focused on answer correctness rather than underlying reasoning and assumptions, and emotional engagement may weaken when lessons become routine. When these forms of engagement decline together, students may prepare less, participate less, and develop only partial understanding, while teachers may need to spend more time explaining concepts and correcting misunderstandings.

Active learning addresses this problem by shifting class time towards student response, reasoning, and discussion. This can strengthen behavioural, cognitive, and emotional engagement, a pattern broadly consistent with classroom electrodermal activity data (Poh et al., 2010). Prior work has discussed active learning in higher education science and technology courses at two main levels. At the course scale, recurring participation is organised across several weeks or an entire semester. Examples include course-based undergraduate research experiences and linked-course communities (Ramsey et al., 2025; Rodenbusch et al., 2016); studio courses, Student-Centred Active Learning Environment for Undergraduate Programs (SCALE-UP) classrooms, and team-based learning (Greetham & Ippolito, 2018; Soneral & Wyse, 2017); and learning assistant models, peer-led team learning, and specifications grading (Howitz et al., 2021; Rosa & Lewis, 2020; Van Dusen & Nissen, 2020). At the lesson scale, shorter activities alter participation without changing the wider course structure. These include short writing and pause-for-reflection tasks (Aquino Nunez et al., 2025), Think-Pair-Share and triad or jigsaw discussions (Calkins & Rivnay, 2022; Gok, 2018), flipped classroom designs, peer review, and online questioning cycles (Cho et al., 2021; Hilton et al., 2022;

https://doi.org/10.33225/jbse/26.25.819

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Moon et al., 2018), and role-play, brainstorming, simulation, and hands-on work (Al-Samarraie & Hurmuzan, 2018; Banda & Nzabahimana, 2021; Martin et al., 2019).

In this literature, active learning has usually been discussed either at the course level or within a lesson. What remains less clear is how these levels should be connected in practice, how session types should be sequenced over time, and how these arrangements should relate to the continuing role of teacher explanation in science and technology courses (Chen et al., 2026).

Research Focus

To address this gap, the present study examined Rhythmic Engagement Pedagogy (REP), a design that links active learning at three levels. In the present framework, REP is not conceptualised as a form of music education or movement-based rhythmic pedagogy. Accordingly, the term rhythmic does not refer to the use of musical beat, dance, bodily movement, clapping, chanting, or synchronised action in teaching. Rather, rhythmic refers to a deliberately recurring pattern of pedagogical contrast. Teacher explanation and student participation are placed in relation to one another across time, with planned changes in the dominant instructional mode rather than the uninterrupted continuation of a single mode. At the macro level, contrast occurs between content-focused teaching and applied activities over the semester; at the meso level, between sessions with different degrees of interactivity; and at the micro level, between teacher explanation and student activity within a class. These recurring contrasts connect semester structure, neighbouring sessions, and within-class participation.

Research Aim and Research Questions

The study examined REP as a design-based revision of existing courses in formal higher education settings. Evidence was drawn from three science and technology courses with different course conditions: Circuit Theorem II, a theory-oriented undergraduate course; Antennas, a mixed theory–practice graduate course; and Microwave Engineering Experiments, a practice-centred undergraduate laboratory course. Although the data were collected at one institution, these course conditions reflect recurring forms of higher education science and technology teaching. The shared design problem is how to distribute explanation, participation, application, and assessment over time, allowing REP to be tested and adapted in other institutional and national settings. Attendance and final course grades were compared between offerings with and without REP, while pre- and post-course questionnaires were used to examine behavioural, cognitive, and emotional engagement within the REP offerings. In the questionnaires, behavioural engagement covers attendance, participation, sustained involvement, and task completion; cognitive engagement covers explanation, connection, application, and revision of understanding; and emotional engagement covers interest, willingness to ask questions, involvement, and confidence. The study addresses the following research questions.

RQ1. How can active learning be organised at the macro, meso, and micro levels of course design in higher education science and technology courses?

RQ2. How can lecture-based explanation be retained within such a design without crowding out student response, discussion, and application?

RQ3. How is REP enacted in science and technology courses that differ in course orientation, learning goals, student level, and class size, and how are these differences reflected in attendance, final course grades, and behavioural, cognitive, and emotional engagement?

Research Methodology

General Background

Science and technology courses require students to engage with disciplinary knowledge through several teaching conditions, including explanation, worked examples, discussion, problem solving, design, and practical work. Engagement may change as these conditions change. Alonso-Tapia et al. (2023) have found that levels of behavioural, cognitive, emotional, and agentic engagement vary in lectures, practical tasks, text-based study, group

https://doi.org/10.33225/jbse/26.25.819

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

work, and practical classes. Davidesco et al. (2023) have also observed fluctuations in engagement within the same university video lecture and linked these momentary changes with retention. The course-design problem is thus temporal as well as methodological: students encounter different opportunities for engagement at different points in a lesson or semester. REP addresses this problem through rhythm, referring to the way pedagogical conditions change and recur over the duration of a course.

A related difficulty concerns the common assumption that increasing student activity will produce stronger learning. In science and technology education, some content requires extended explanation, procedural demonstration, or worked development before students can use it productively. Martella et al. (2024) have found that a greater proportion of activity supports learning for one topic, while different pedagogical mixtures produce similar outcomes for a topic with greater conceptual complexity. Lim et al. (2024) have shown that the effectiveness of student-led and teacher-led discussion also depends on the preceding learning activity. Self-study prepares students more effectively for student-led discussion, whereas lecture preparation produces stronger outcomes before teacher-facilitated discussion. These results direct attention to the functional relation among content, preparation, explanation, and activity. REP uses this relation to determine how much time is assigned to teacher explanation and student work, where each is placed, and what educational function it serves at a given point.

A further problem appears when suitable activities are included but arranged as isolated events. The educational value of an activity can depend on what students encounter before it and what they must do afterwards. Samani and Pan (2021) have found that interleaving physics problems from different topics strengthens later recall and performance on unfamiliar problems by requiring learners to identify the relevant principle and select an appropriate procedure. Sana and Yan (2022) have similarly reported stronger delayed science learning when retrieval questions from different concepts are interleaved. These studies have shown that returning to related knowledge under changed demands can renew discrimination, retrieval, and strategy selection. REP applies this sequence-sensitive view by arranging repeated encounters with disciplinary content through explanation, inquiry, discussion, application, production, and consolidation. Contrast arises when the dominant learning demand changes, and rhythm develops as such contrasts recur over time.

The sequence-sensitive rationale also helps explain why contrast can support engagement across course time. Snyder (2005, 2007) has used beat structure to show how successive stages alter the dramatic situation, stakes, or direction of a screenplay; each change gives the audience a new development to follow and makes the larger progression perceptible. Duarte (2010) has made the attentional function of contrast explicit in presentation design: the repeated juxtaposition between "what is" and "what could be", together with shifts in content, emotion, and delivery, creates an unresolved gap, gives the presentation pulse and contour, and renews attention as the argument develops. The relevance to science and technology education lies in this temporal function. Changes in teaching conditions can likewise redirect what students attend to and how they work with disciplinary knowledge. REP uses recurring contrast for this purpose, linking explanation, activity, application, and consolidation within an extended learning sequence that renews attention while preserving disciplinary development.

Macro-Level Contrast

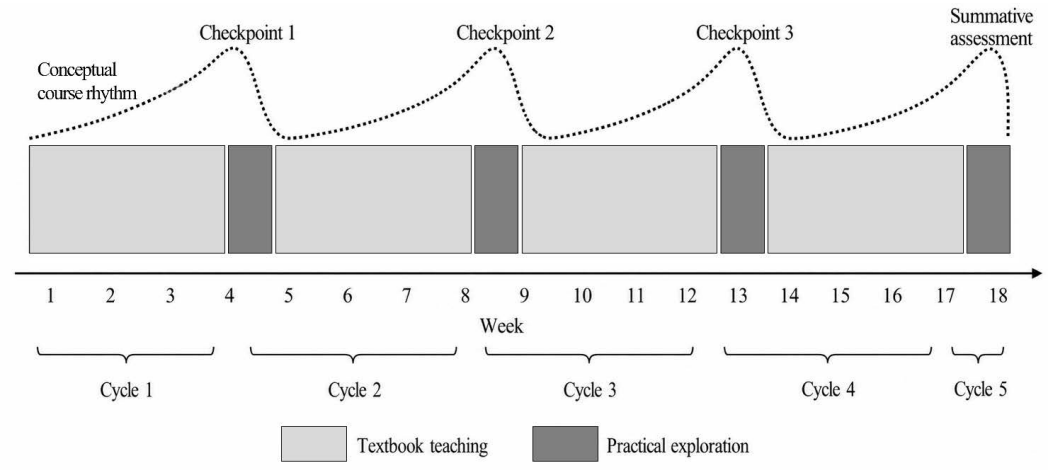
At the macro level, REP creates contrast between textbook-based teaching and practical exploration over the semester, as shown in Figure 1. Textbook-based teaching supports the systematic development of disciplinary concepts, principles, and procedures, while practical exploration requires students to use that knowledge through inquiry, problem solving, design, production, or application. Their recurrence defines the macro-level component of REP and connects knowledge development with its use in preparation for the final course outcome.

Practical-exploration checkpoints may draw on project-based learning, inquiry-based learning, course-based undergraduate research experiences (Rodenbusch et al., 2016), problem-based learning, and structured peer support or revision through peer-led team learning, learning assistant models, or specifications grading (Howitz et al., 2021; Rosa & Lewis, 2020; Van Dusen & Nissen, 2020). At these checkpoints, students may formulate a problem, investigate a case, develop a product, revise earlier work, or prepare for a cumulative task. Placing such checkpoints among weeks centred on textbook-based explanation creates the planned macro-level contrast and gives students successive opportunities to use disciplinary knowledge in increasingly demanding ways towards the final course outcome.

https://doi.org/10.33225/jbse/26.25.819

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Figure 1
Macro-Level Contrast Between Textbook-Based Teaching and Practical-Exploration Checkpoints Over the Semester



Micro-Level Contrast

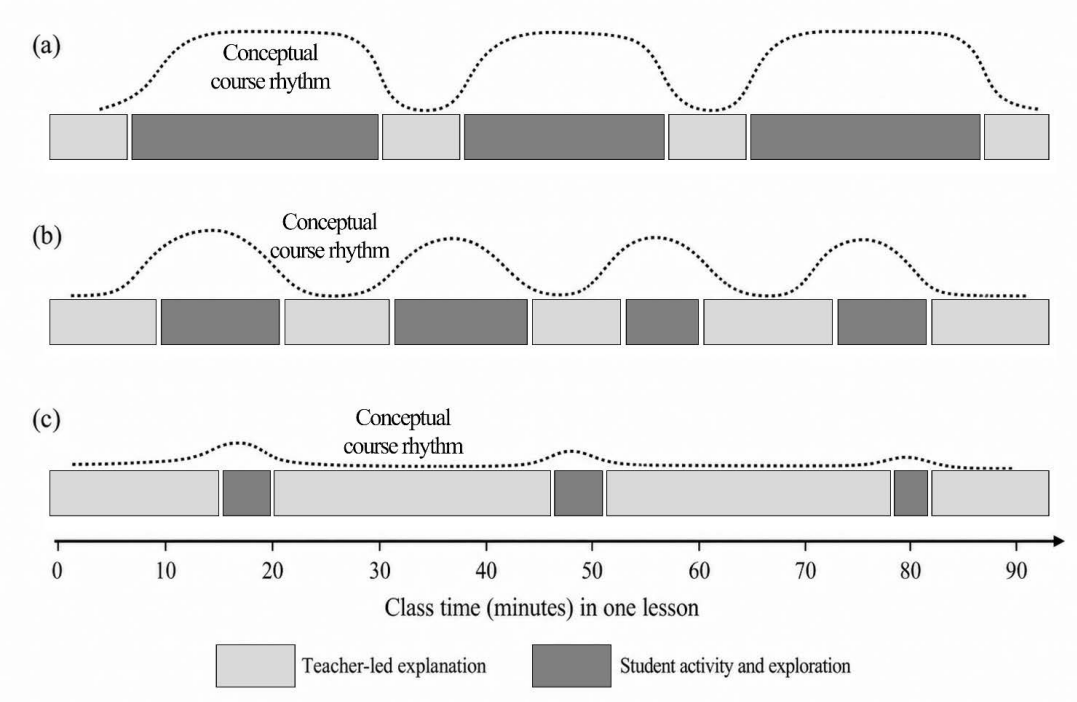
At the micro level, REP organises contrast within a lesson through deliberate changes in the proportion and placement of teacher explanation and student activity, as shown in Figure 2. Here, the micro level denotes the within-lesson timescale of course design. Highly, moderately, and slightly interactive sessions represent different arrangements of these two teaching functions. Rhythm forms through the recurrence of these contrasting educational functions within the lesson, with their relative emphasis determined by the content, students' preparation, and the purpose of the session.

Existing active-learning studies have examined many formats for participation, including simulation, extended collaborative problem solving, flipped-class sessions, peer instruction, discussion, short writing, and reflection (Al-Samarraie & Hurmuzan, 2018; Aquino Nunez et al., 2025; Banda & Nzabahimana, 2021; Calkins & Rivnay, 2022; Cho et al., 2021; Gok, 2018; Hilton et al., 2022; Martin et al., 2019; Moon et al., 2018). REP coordinates these activities with teacher-led explanation within the same lesson. Deliberate shifts between explanation and student work create micro-level contrast, while their recurrence forms a lesson rhythm that preserves rigorous conceptual development and recurring opportunities to test, apply, and communicate understanding.

https://doi.org/10.33225/jbse/26.25.819

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Figure 2
Micro-Level Contrast Between Teacher Explanation and Student Activity



Note. (a) Highly interactive session; (b) moderately interactive session; (c) slightly interactive session.

Meso-Level Contrast

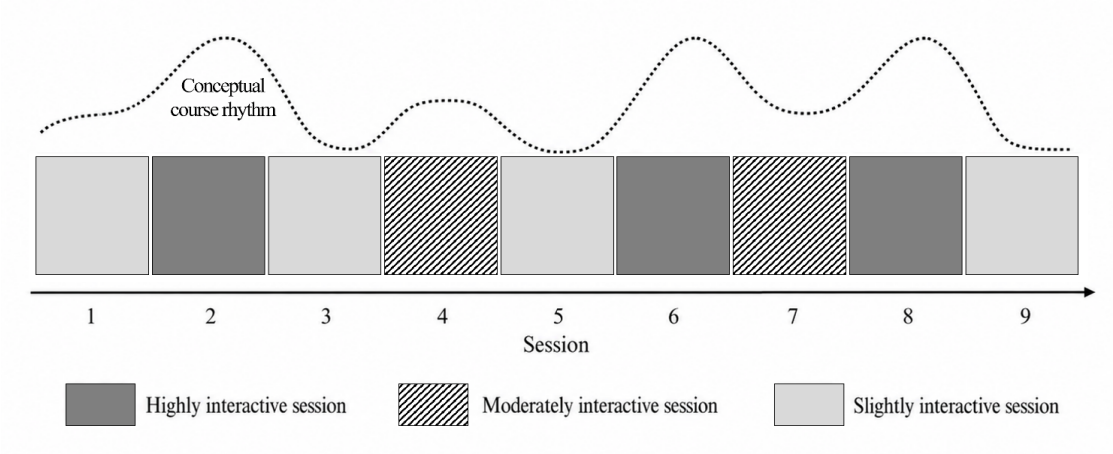
At the meso level, REP organises contrast across consecutive weeks or course units by alternating highly, moderately, and slightly interactive sessions, as shown in Figure 3. This cross-session level is a key distinction between REP and approaches that describe a pedagogy mainly at the scale of a lesson, unit, or semester. Even when individual lessons contain internal variation, a course may still become monotonous if the same interaction pattern is repeated over several meetings. REP treats the sequence of neighbouring meetings as an explicit object of course design.

Lecture-based or slightly interactive sessions provide sustained time for explanation, derivation, worked examples, and the organisation of disciplinary knowledge (Kirschner et al., 2006; Stains et al., 2018). REP treats their placement relative to highly and moderately interactive sessions as a course-design variable and avoids extended sequences of a single session type. A highly or moderately interactive session may follow several conceptually dense lessons to renew student attention, while a slightly interactive session may follow activity-intensive work to formalise, clarify, or consolidate learning. Meso-level rhythm arises from this sequencing, allowing lecture and student-centred activity to recur at different stages of learning without one interaction pattern dominating the course.

https://doi.org/10.33225/jbse/26.25.819

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Figure 3
Meso-Level Sequencing of Highly, Moderately, and Slightly Interactive Sessions Across Consecutive Course Units



Participants

The participants comprised 161 students enrolled in six course cohorts: 74 students in three 2025 offerings in which REP was implemented and 87 students in the corresponding 2024 offerings without REP. The six cohorts were included to examine REP across three science and technology courses with contrasting course conditions, including student level, duration, meeting format, and expected end-of-course performance. All three courses were elective in both years, and the corresponding 2024 and 2025 cohorts were drawn from the same academic level within each course. Within the undergraduate courses, Circuit Theorem II enrolled second-year students and Microwave Engineering Experiments enrolled third- and fourth-year students in both years. The 2025 REP offerings incorporated Formative-Linked Exam Weighting (FLEX) assessment (Chen et al., 2026), in which students accumulated learning-progress points through formative activities that contributed to their course grades and progressively reduced the weighting of summative assessments. FLEX was not present in the corresponding 2024 offerings. Course-specific enrolment and summative assessment arrangements are described below.

Circuit Theorem II was a large undergraduate course taught over an 18-week semester with two weekly meetings, one lasting 1 hour and the other 2 hours. Although the course content was motivated by practical applications, students were not required to build or test physical systems. The course emphasised conceptual understanding, procedural mastery, and analytical reasoning, so its main summative assessment was a final examination covering material from the full semester. Enrolment was 48 in Spring 2025 and 53 in Spring 2024.

Antennas required both conceptual understanding and practical realisation. This graduate course was taught over an 18-week semester and met once per week for 3 hours. Students were expected to understand antenna theory and apply it to the design, fabrication, and measurement of an antenna component. The course used two major summative assessments: a final examination for conceptual mastery and a final project assessing practical performance, with peer evaluation included. Enrolment was 13 in Spring 2025 and 19 in Spring 2024.

Microwave Engineering Experiments placed the strongest emphasis on practice. This undergraduate laboratory course was offered in summer with a total of 30 contact hours and centred on experimental tasks, instrument operation, and the interpretation of results. Unlike the other two courses, it did not use an examination to assess learning. Its summative assessment was a final project in which students were expected to build, test, and evaluate a practical implementation. Enrolment was 13 in Summer 2025 and 15 in Summer 2024.

Instrument and Procedures

REP was implemented in all three courses through the same three-level structure, but each enactment was adjusted to the intended course outcome. Each course used backward design, beginning with the summative as-

https://doi.org/10.33225/jbse/26.25.819

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

sessment and then determining macro-level checkpoints, micro-level relations between explanation and activity, and meso-level sequencing of session types.

In Circuit Theorem II, backward design began with the demands of a theory-intensive course. Students were expected to understand major circuit-theory concepts, apply appropriate mathematical methods to transient and steady-state responses and larger circuits, translate practical situations into circuit models, and use those models to analyse and solve problems. REP was aligned with these outcomes across three levels: macro-level checkpoints connected cumulative theory development with inquiry-based application, micro-level arrangements matched explanation and activity to the immediate learning purpose, and meso-level sequencing distributed sessions according to the need for derivation, discussion, application, or consolidation. At the macro level, design centred on two summative endpoints: a final examination covering formal circuit-theory knowledge, and an inquiry-based project involving the development of a serious game or teaching-support tool for Circuit Theorem. The project was designed to transform circuit-theory knowledge into a form that could support learning, visualisation, explanation, and classroom use. Most weeks remained theory-centred, but three checkpoint weeks redirected students towards project development. Checkpoint 1 in Week 4 addressed what makes a learning game or teaching tool engaging, usable, and educationally meaningful. Checkpoint 2 in Week 8 required students to convert circuit-theory concepts into rules, visual logic, interaction structures, or guided explanations. Checkpoint 3 in Week 12 focused on prototype refinement and preparation for classroom use. In Weeks 16 and 17, students demonstrated their products by allowing classmates to play the game or use the tool, with peer evaluation used to assess design quality. At the micro level, highly interactive sessions involved direct discussion, game-based activity, or simulation. These included flipped-classroom meetings, serious games such as Kirchhoff's Revenge, and simulation-based teaching with tools such as "Circuit Simulator", in which students manipulated circuit structures and responses rather than only following worked derivations. Moderately interactive sessions retained lecture as the primary teaching mode while incorporating worksheets, scenario-based design choices, brainstorming, and guided discussion, including tasks in which students compared circuit specifications, argued for one option over another, or identified potential hallucinations in AI-generated solutions to circuit problems. Slightly interactive sessions were used when sustained teacher explanation was the most direct way to present conceptually demanding content, with Mentimeter concept checks, calculation prompts, and short response tasks inserted during or after explanation. At the meso level, these session types were alternated rather than repeated in blocks, so that theory-dense sessions did not create extended periods of listening and highly interactive sessions did not displace the analytical progression of the course.

In Antennas, REP was designed for combined theoretical and practical outcomes. By the end of the course, students were expected to understand major antenna parameters and basic antenna forms, interpret how those parameters relate to performance requirements, and translate theoretical knowledge into a design that could be fabricated and measured. Macro-level design again worked backwards from two summative endpoints: a final examination assessing conceptual learning across the semester and a semester project centred on a student-designed and fabricated digital television (DTV) antenna. Each student was required to design and implement a DTV antenna, connect it to a DTV device, conduct a reception test under real-world conditions, and present the work. Reception performance and peer-evaluated presentation quality were both included in the summative task. Most weeks remained theory-centred, but checkpoint weeks redirected students towards project development at regular intervals. At an early stage, students defined the intended design and its practical relevance through the Three Minute Thesis (3MT)-style preparatory presentation described in the course announcement. Later stages addressed design justification, expected performance, fabrication planning, test readiness, performance analysis, and preparation for the final demonstration. At the micro level, highly interactive sessions were used when design constraints, feasibility judgements, or measurement procedures required sustained participation. These sessions included extended discussion of whether a specified antenna requirement could be met under fixed physical constraints and hands-on work involving calibration, cable choice, procedural steps, and peer-supported measurement. Moderately interactive sessions combined lecture with guided design reasoning, simulation interpretation, peer critique, and structured comparisons of competing solutions. The graduate-course format allowed more time for trade-off discussion, design review, and critique of technical decisions. Slightly interactive sessions were used when the lesson required concentrated development of antenna theory, parameter definitions, and analytical interpretation, with short concept checks and response prompts inserted into longer periods of explanation. At the meso level, the course alternated theory-heavy, design-oriented, and measurement-oriented sessions rather than separating them into large blocks, keeping the project visible while technical explanation, design work, and measurement practice recurred throughout the semester.

https://doi.org/10.33225/jbse/26.25.819

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

In Microwave Engineering Experiments, REP was designed for a mainly practical outcome. By the end of the course, students were expected to operate instruments, interpret measured responses, understand the role of matching and reconfigurable elements, and apply those abilities in a final implementation task. The macro-level design began from a project endpoint rather than a written examination. The final task required students to construct a reconfigurable matching network that would allow a DTV antenna, originally outside the Wi-Fi band, to connect to Wi-Fi equipment and receive Wi-Fi signals after matching adjustment. Macro-level contrast was created by interleaving regular experimental sessions with project checkpoints that redirected attention towards the final engineering task. Early project work introduced the practical meaning of matching and the use of reconfigurable devices such as switches or varactors. Later stages focused on matching-network design, integration with the antenna, and preparation for final testing, allowing the project to develop through a sequence of engineering decisions rather than being postponed until the end. At the micro level, highly interactive sessions were used when direct operation, situated observation, or real-time questioning formed the core of the lesson. These sessions included VR-based operation of a network analyser, a live remote connection to an anechoic chamber for observing measurements and asking questions, and flipped-class sessions in which students prepared in advance and then demonstrated instrument use or presented screen outputs during class. Moderately interactive sessions combined short technical briefings with guided troubleshooting, worksheet-based interpretation, peer comparison of measured and expected behaviour, and collaborative discussion of the interpretation of matching responses and the adjustment of the network. Slightly interactive sessions were used when a compact lecture segment was needed to explain matching theory, the role of reconfigurable components, or the logic of a measurement procedure before students began operating the equipment. In this practice-centred course, micro-level contrast involved varying the relation among briefing, operation, interpretation, and debriefing rather than simply adding activity to a lecture-heavy environment. At the meso level, sessions emphasising direct operation, interpretation, and teacher-guided explanation were alternated so that the course did not become a repetitive sequence of similar laboratory tasks.

Student engagement was measured with parallel pre- and post-course questionnaires using a five-point response scale from 1 (strongly disagree) to 5 (strongly agree). Pre-course items were framed as expectations, and the corresponding post-course items referred to students' experience during the course. Behavioural engagement comprised four paired items concerning regular attendance, active participation when questions or tasks were presented, continued involvement during periods requiring sustained concentration, and completion of assigned pre-class or in-class tasks. Four cognitive items examined whether students considered why an answer was correct, connected new ideas with prior knowledge, applied course knowledge to problems or practical situations, and revised an initial understanding when it proved incomplete or incorrect. Emotional engagement was represented by interest in course content, willingness to ask questions or express uncertainty, continued engagement across the semester, and confidence in remaining involved when the content became difficult. Two items concerning English comprehension and expression and four post-course evaluations of course design were separate from these engagement subscales.

Data Analysis

Attendance was compared descriptively across semesters at four course stages. Final course grades were compared between independent cohorts using Welch's t test because the cohort sizes and variability differed; Hedges' g was used as the standardised effect size, and Mann–Whitney U tests served as robustness checks. Pre- and post-course questionnaire scores were analysed as paired data using paired-samples t tests, with d_z used as the paired effect size; Wilcoxon signed-rank tests served as robustness checks. In all t tests, t denotes the test statistic, df denotes the degrees of freedom, and p denotes the p value. Internal consistency was assessed using Cronbach's α separately for each four-item behavioural, cognitive, and emotional engagement subscale. Gain scores (Δ) were calculated by subtracting pre-test scores from post-test scores and were compared across courses using one-way analysis of variance (ANOVA), with F denoting the test statistic and η^2 denoting the proportion of variance accounted for by course context. Post-course items on course design were summarised descriptively because they had no pre-test counterparts.

https://doi.org/10.33225/jbse/26.25.819

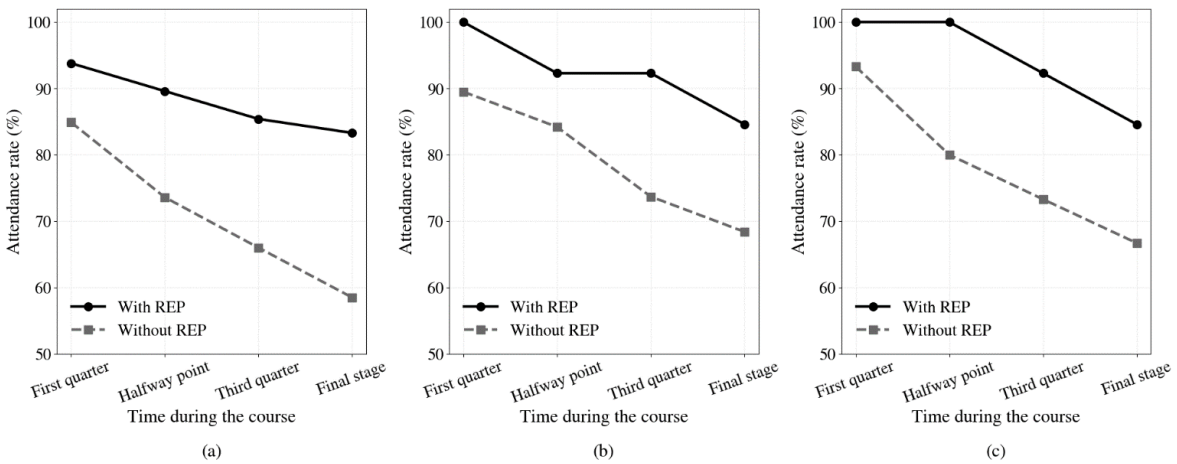
ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Research Results

Attendance was examined first as an indicator of whether students continued attending when attendance was voluntary and carried no grade credit. Figure 4 shows the REP and non-REP attendance trajectories at four stages of each course: the first quarter, the halfway point, the third quarter, and the final stage. In all three courses, attendance declined over time in both offerings, but attendance remained higher in the REP offering at every stage.

In Circuit Theorem II, the attendance gap widened from 8.9 percentage points at the first quarter to 24.8 percentage points at the final stage. In Antennas, it increased from 10.5 to 16.2 percentage points. In Microwave Engineering Experiments, it rose from 6.7 percentage points at the first quarter to 17.9 percentage points at the final stage, with the largest separation appearing in the middle of the course. Averaged across the four stages, attendance rates in the REP offering were higher by 17.3 percentage points in Circuit Theorem II, 13.4 percentage points in Antennas, and 15.9 percentage points in Microwave Engineering Experiments. In all three courses, the decline from the first quarter to the final stage was also smaller in the REP offering. Absolute attendance levels nevertheless differed among the three courses. Circuit Theorem II, as a larger undergraduate elective, showed the lowest baseline attendance in both semesters. Antennas began from a higher level, which was consistent with a small graduate course in which students usually monitor degree progress more closely and move through the course in a smaller cohort. Microwave Engineering Experiments also maintained relatively high attendance despite being an undergraduate course, which was compatible with its smaller enrolment, summer format, and laboratory-based structure, where absence more directly interrupts experimental continuity.

Figure 4
Attendance Trajectories in REP and Non-REP Offerings Across Four Course Stages



Note. (a) Circuit Theorem II; (b) Antennas; (c) Microwave Engineering Experiments.

Final course grades were compared between semesters as a course-level indicator of learning performance. Table 1 summarises the results. On the same 100-point scale, mean grades were higher in the REP offering for all three courses: Circuit Theorem II, from $M = 63.0$ ($SD = 9.6$) to $M = 80.7$ ($SD = 13.5$); Antennas, from $M = 80.6$ ($SD = 9.4$) to $M = 89.8$ ($SD = 7.4$); and Microwave Engineering Experiments, from $M = 74.3$ ($SD = 12.5$) to $M = 86.0$ ($SD = 6.7$). The corresponding increases were 17.7, 9.2, and 11.7 points, respectively. In Circuit Theorem II, one student in the REP offering and five students in the earlier offering withdrew and were excluded from the grade analysis. Welch's t tests were significant in all three courses: Circuit Theorem II, $t(82.87) = 7.39$, $p < .001$, Hedges' $g = 1.51$; Antennas, $t(29.40) = 3.10$, $p = .004$, Hedges' $g = 1.04$; and Microwave Engineering Experiments, $t(21.89) = 3.15$, $p = .005$, Hedges' $g = 1.11$. Mann–Whitney U tests were also significant in all three courses, with higher grades in the REP offerings.

https://doi.org/10.33225/jbse/26.25.819

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Table 1
Final Course Grades in REP and Non-REP Offerings by Course

Course	Without REP, *M* (points)	With REP, *M* (points)	*t(df)*	*p*	Hedges' *g*
Circuit Theorem II	63.0	80.7	7.39 (82.87)	< .001	1.51
Antennas	80.6	89.8	3.10 (29.40)	.004	1.04
Microwave Engineering Experiments	74.3	86.0	3.15 (21.89)	.005	1.11

The larger grade difference in Circuit Theorem II was considered in relation to its assessment structure. The 2025 offering incorporated FLEX assessment, providing formative assessment opportunities through checkpoint-based learning progress points in a course that had previously relied more heavily on high-stakes examinations. This change may have influenced final grades more strongly than in Antennas and Microwave Engineering Experiments, where practical and process-oriented assessments were already part of the earlier course designs. The final examination in Circuit Theorem II retained a comparable role and difficulty, so the grade difference was interpreted in relation to both assessment structure and course performance.

The questionnaire analysis used matched pre- and post-course responses from the REP offerings. Table 2 summarises the common questionnaire structure across Circuit Theorem II, Antennas, and Microwave Engineering Experiments. Both Paired-samples *t* tests and Wilcoxon signed-rank robustness checks were significant in all nine course-by-dimension comparisons. Cronbach's α ranged from .83 to .93 for behavioural engagement, .78 to .93 for cognitive engagement, and .91 to .97 for emotional engagement.

Table 2
Dimensions and Item Structure of the Common Pre- and Post-Course Questionnaire

Dimension	Number of core items	Focus of the pre-test items	Focus of the post-test items
Context	2	Initial self-rated ability to follow content and express ideas in English	Reported ability to follow content and express ideas in English after the course
Behavioural engagement	4	Expected attendance, participation, sustained involvement, and task completion	Reported attendance, participation, sustained involvement, and task completion
Cognitive engagement	4	Expected explanation, connection, application, and revision of understanding	Reported explanation, connection, application, and revision of understanding
Emotional engagement	4	Initial interest, willingness to ask questions, expected involvement, and confidence	Reported interest, willingness to ask questions, sustained involvement, and confidence
Course design	4	—	Ratings of alternation, session variety, checkpoint learning progress points, and overall learning support

Table 3 reports the pre-test and post-test means, standard deviations, *t* values, *p* values, and d_z values for the three engagement dimensions in each course. In all nine comparisons, post-test means exceeded pre-test means. These differences were statistically significant for behavioural, cognitive, and emotional engagement in all three courses. Table 4 examines whether the magnitude of the pre–post rating differences varied among the courses.

https://doi.org/10.33225/jbse/26.25.819

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Table 3
Pre- and Post-Course Behavioural, Cognitive, and Emotional Engagement Scores by Course

Dimension	Course	Pre-test *M (SD)*	Post-test *M (SD)*	*t(df)*	*p*	*dz*
Behavioural engagement	Circuit Theorem II	3.42 (0.68)	4.13 (0.71)	15.75 (39)	< .001	2.49
	Antennas	4.33 (0.53)	4.50 (0.50)	2.92 (12)	.013	0.81
	Microwave Engineering Experiments	4.25 (0.53)	4.44 (0.47)	3.83 (12)	.002	1.06
Cognitive engagement	Circuit Theorem II	3.34 (0.70)	4.16 (0.75)	16.37 (39)	< .001	2.59
	Antennas	4.23 (0.45)	4.50 (0.48)	2.94 (12)	.012	0.82
	Microwave Engineering Experiments	3.92 (0.58)	4.33 (0.43)	4.62 (12)	< .001	1.28
Emotional engagement	Circuit Theorem II	2.50 (0.73)	3.31 (0.90)	14.33 (39)	< .001	2.27
	Antennas	3.65 (0.75)	3.92 (0.68)	2.69 (12)	.020	0.75
	Microwave Engineering Experiments	3.62 (0.72)	4.10 (0.53)	6.68 (12)	< .001	1.85

Table 4 compares gain scores. The between-course differences were significant for behavioural engagement, $F(2, 63) = 33.70$, $p < .001$, $\eta^2 = .517$; cognitive engagement, $F(2, 63) = 18.31$, $p < .001$, $\eta^2 = .368$; and emotional engagement, $F(2, 63) = 13.90$, $p < .001$, $\eta^2 = .306$. In all three dimensions, the largest gain appeared in Circuit Theorem II. Pairwise comparisons further showed that Circuit Theorem II had significantly larger gains than Antennas and Microwave Engineering Experiments, whereas the difference between Antennas and Microwave Engineering Experiments was not statistically significant.

Table 4
Between-Course Comparison of Behavioural, Cognitive, and Emotional Engagement Gain Scores

Dimension	Circuit Theorem II Δ, *M (SD)*	Antennas Δ, *M (SD)*	Microwave Engineering Experiments Δ, *M (SD)*	*F*(2, 63)	*p*	η^2
Behavioural engagement	0.71 (0.29)	0.17 (0.21)	0.19 (0.18)	33.70	< .001	.517
Cognitive engagement	0.81 (0.31)	0.27 (0.33)	0.40 (0.32)	18.31	< .001	.368
Emotional engagement	0.81 (0.36)	0.27 (0.36)	0.48 (0.26)	13.90	< .001	.306

The post-test also included four items on students' evaluation of REP-related course design. Because these items had no pre-test counterparts, they were not analysed as change scores. Table 5 shows that all four items received mean ratings above 4.0 in all three courses, with the highest rating being $M = 4.62$ ($SD = 0.51$) for checkpoint learning progress points or other staged activities in Microwave Engineering Experiments.

https://doi.org/10.33225/jbse/26.25.819

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Table 5
Student Ratings of REP Course-Design Features by Course

Post-course item	Circuit Theorem II *M (SD)*	Antennas *M (SD)*	Microwave Engineering Experiments *M (SD)*
The alternation between teacher explanation and classroom activities helped me stay involved	4.20 (0.69)	4.31 (0.48)	4.38 (0.51)
Different session types helped me approach the content from more than one angle	4.20 (0.72)	4.46 (0.66)	4.38 (0.51)
Checkpoint learning progress points or other staged activities helped me stay on track	4.18 (0.64)	4.08 (0.64)	4.62 (0.51)
This course helped me learn the subject content effectively	4.03 (0.86)	4.46 (0.66)	4.38 (0.51)

Discussion

Interpreting REP Across Science and Technology Courses

The findings showed a consistent pattern in the three courses. The REP offerings were characterised by higher semester-long attendance and final grades, together with statistically significant differences between pre-course expectation ratings and post-course ratings in all three engagement dimensions. This pattern was observed in a theory-oriented undergraduate course, a mixed theory–practice graduate course, and a practice-centred laboratory course.

The magnitude of the pre–post rating differences varied among the courses. Circuit Theorem II showed the largest differences in the behavioural, cognitive, and emotional dimensions. The most pronounced shifts occurred where the existing course rhythm was centred on conceptual explanation and analytical development. In courses where project-based or laboratory work was already established, the direction of change remained positive, but its magnitude was smaller.

Attendance, final grades, and questionnaire responses captured different aspects of the observed outcomes. Attendance remained higher throughout the semester, while final grades were also higher in the REP offerings, indicating that the observed pattern extended beyond students' questionnaire responses. The questionnaire results showed higher post-course scores in behavioural, cognitive, and emotional engagement in all three courses, although these responses may have been affected by social desirability, demand characteristics, and retrospective judgement. The three data sources were interpreted together, with the largest differences occurring in Circuit Theorem II, where the earlier course format provided fewer opportunities for varied participation.

Theoretical Positioning of REP in Relation to the Research Questions

REP can be interpreted in relation to four established research domains: the efficacy of active learning in science and technology education, participation structures at different levels of course organisation, sequence-sensitive accounts of learning, and the role of teacher guidance alongside traditional lectures. These domains provide a basis for addressing RQ1, RQ2, and RQ3 and for clarifying how REP extends prior research in different science and technology education contexts.

Prior research has shown the value of recurring course structures and within-class shifts in participation (Crouch & Mazur, 2001; Freeman et al., 2014; Theobald et al., 2020). These findings address RQ1 by supporting the value of coordinating engagement at several course-design timescales. In this study, macro-level checkpoints created recurring opportunities to apply disciplinary content, micro-level variation provided repeated opportunities to work with content within lessons, and meso-level sequencing varied participation between neighbouring sessions. Existing theories of engagement, including the Interactive, Constructive, Active, and Passive framework, distinguish forms of participation within a learning episode (Chi & Wylie, 2014).

https://doi.org/10.33225/jbse/26.25.819

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Sequence-sensitive research offers a related perspective. Research on productive failure and interleaving has shown that order and alternation can affect later understanding and transfer (Kapur, 2016; Kapur & Bielaczyc, 2012; Rohrer & Taylor, 2007). This literature directs attention beyond method labels and towards arrangement over time. However, it usually treats sequence at the level of task order, problem order, or the relation between problem solving and later instruction. In relation to RQ1, the present study extends that discussion by suggesting that sequence also matters at the level of course design, including how explanation, discussion, application, checkpoint work, and performance are distributed over weeks and neighbouring sessions. Sequence should be treated as a multi-timescale course-design issue rather than solely as a local pedagogical choice.

Research on teacher guidance also informs RQ2. Education research has warned against equating pedagogical improvement with minimal guidance when learners still need explanatory structure to work productively with unfamiliar material (Kirschner et al., 2006). Observation-based studies of university science teaching also show that lecture remains a substantial part of classroom practice (Stains et al., 2018). The present findings indicate how lecture can retain an academic function within REP. In the three courses, mean ratings ranged from 4.20 to 4.38 for the alternation between teacher explanation and classroom activities, from 4.20 to 4.46 for different session types, and from 4.03 to 4.46 for subject-content learning effectiveness. The higher post-course cognitive engagement ratings further suggest that lecture retains an academic function without remaining the unbroken default. This interpretation does not provide a general defence of lecture. It suggests that lecture can remain productive when its timing, density, and relation to other participation modes are planned as part of the course design.

RQ3 concerns the portability of REP under different course conditions. Broad active-learning studies have shown that participation improves outcomes in many science and technology courses, but they are less specific about what remains stable when a pedagogy is applied to courses that differ in learning goals, assessment structures, class size, or theory-to-practice emphasis (Freeman et al., 2014; Theobald et al., 2020). The findings showed two patterns. The direction of the differences remained consistent: attendance remained higher throughout the semester, final grades were higher, post-course ratings exceeded pre-course expectation ratings in all nine comparisons, and the main design features of REP were favourably rated in all three settings. The magnitude varied by course context. This combination of consistent direction and varied magnitude indicates that REP functions as a flexible contrastive design logic rather than a fixed set of activities.

Applying REP Across Course Conditions

Applying REP in other courses does not require teachers to reproduce the activities used in the present study. The starting point is the intended course outcome and the teaching pattern that currently dominates the course. Contrast can then be introduced at the level where repetition is most likely to occur: at the macro level when content-focused teaching continues for long periods without application, at the meso level when the same session type recurs over neighbouring meetings, or at the micro level when a lesson remains in one instructional mode.

In courses dominated by explanation, highly or moderately interactive sessions can interrupt extended lecture sequences. In project-based courses, checkpoints can correspond to design milestones and alternate with review, critique, and preparation. In laboratory courses, contrast can be created among briefing, operation, interpretation, and troubleshooting. The purpose is not to maximise activity, but to coordinate different teaching functions so that neither lecture nor highly interactive work continues long enough to produce monotony, fatigue, or loss of focus.

Limitations and Future Work:

A limitation of this study is that REP is presented as a qualitative design approach rather than a parameterised pedagogical model. Although macro-level checkpoints and meso-level session types show that REP can be enacted under varied course conditions, they do not specify the design in a form that permits systematic comparison or adjustment. The current results indicate that contrast matters, but they do not identify the degree, frequency, spacing, or intensity of contrast associated with stronger outcomes in different course contexts. A further limitation concerns the concurrent implementation of REP and FLEX assessment in the 2025 offerings. This combined implementation limits the attribution of the observed between-cohort differences in attendance and final course grades to the independent effect of REP.

Future research should parameterise REP at the macro, meso, and micro levels. Session types could be measured by the proportion of class time allocated to explanation and activity, the duration of interaction segments, or the intervals between sessions of the same type. Checkpoints could be specified by their frequency, task intensity,

https://doi.org/10.33225/jbse/26.25.819

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

and the degree to which they displace content-focused teaching. Defining these parameters would permit systematic comparison among different configurations and help identify which patterns are associated with stronger behavioural, cognitive, and emotional engagement and learning performance. Such work would move REP from a flexible design towards a tunable model of course architecture.

Conclusions and Implications

REP was examined as a contrast-based design for science and technology education. Across the three implementations, REP was adapted to different theory–practice profiles while the specific activities varied with course conditions. REP treats the timing and recurrence of explanation, participation, application, and assessment as part of course design. For science and technology educators, the practical implication is to identify where one instructional mode persists for too long and introduce contrast at that timescale while preserving the explanation, practice, and assessment required by the intended learning outcomes.

Ethical approval and informed consent statements

Formal institutional review board approval was not required for this study under the administrative and institutional requirements applicable to this Ministry of Education-funded teaching practice research project. The study involved regular educational activities and the analysis of non-sensitive student engagement and course-performance data. It did not involve the collection of clinical, mental health, or other sensitive personal information. No ethics committee approval or reference number was issued.

Written informed consent was obtained from all participating students before their data were included in the study. Participation was voluntary, and students were informed that non-participation or withdrawal would not affect their course grades, academic evaluation, or other rights. All data were de-identified before analysis and reporting.

Disclosure Statement

The author declares no competing interests.

Declaration of Generative AI Use

ChatGPT (OpenAI) was used after completion of the manuscript solely for grammar and language checking during manuscript revision. All substantive aspects of the work, including the research design, literature selection, data collection, statistical analysis, interpretation of results, and conclusions, were developed by the author. The author reviewed all language changes and completed the final editing of the manuscript.

Data Availability Statement

De-identified data supporting the findings of this study may be made available from the author upon reasonable request, subject to ethical and institutional restrictions.

Funding

This work was supported by the MOE Teaching Practice Research Program, Taiwan, under Grant MOE-115-TPREE-0025-001Y1.

References

Alonso-Tapia, J., Merino-Tejedor, E., & Huertas, J. A. (2023). Academic engagement: Assessment, conditions, and effects—A study in higher education from the perspective of the person-situation interaction. *European Journal of Psychology of Education, 38*, 631–655. https://doi.org/10.1007/s10212-022-00621-0

Al-Samarraie, H., & Hurmuzan, S. (2018). A review of brainstorming techniques in higher education. *Thinking Skills and Creativity, 27*, 78–91. https://doi.org/10.1016/j.tsc.2017.12.002

https://doi.org/10.33225/jbse/26.25.819

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Aquino Nunez, W., Scott, M. C. B., & Morgan, D. E. (2025). Metacognitive mapping: Developmental biology students struggle with higher-order cognitive skills in multiple course formats. *Journal of Microbiology & Biology Education, 26*(2), Article e00139-24. https://doi.org/10.1128/jmbe.00139-24

Banda, H. J., & Nzabahimana, J. (2021). Effect of integrating physics education technology simulations on students' conceptual understanding in physics: A review of literature. *Physical Review Physics Education Research, 17*(2), Article 023108. https://doi.org/10.1103/PhysRevPhysEducRes.17.023108

Calkins, S., & Rivnay, J. (2022). The jigsaw design challenge. *Journal of Effective Teaching in Higher Education, 4*(3), 19–35. https://doi.org/10.36021/jethe.v4i3.249

Chen, Y.-S., Rieker, J., & Doran, M. (2026). Enhancing engagement and performance through a Formative-Linked Exam Weighting (FLEX) assessment. *Studies in Educational Evaluation, 89*, Article 101596. https://doi.org/10.1016/j.stueduc.2026.101596

Chi, M. T. H., & Wylie, R. (2014). The ICAP framework: Linking cognitive engagement to active learning outcomes. *Educational Psychologist, 49*(4), 219–243. https://doi.org/10.1080/00461520.2014.965823

Cho, H. J., Zhao, K., Lee, C. R., Runshe, D., & Krousgrill, C. (2021). Active learning through flipped classroom in mechanical engineering: Improving students' perception of learning and performance. *International Journal of STEM Education, 8*, Article 46. https://doi.org/10.1186/s40594-021-00302-2

Crouch, C. H., & Mazur, E. (2001). Peer instruction: Ten years of experience and results. *American Journal of Physics, 69*(9), 970–977. https://doi.org/10.1119/1.1374249

Davidesco, I., Glaser, N., Stevenson, I. H., & Dagan, O. (2023). Detecting fluctuations in student engagement and retention during video lectures using electroencephalography. *British Journal of Educational Technology, 54*(6), 1895–1916. https://doi.org/10.1111/bjet.13330

Duarte, N. (2010). *Resonate: Present visual stories that transform audiences*. John Wiley & Sons.

Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the National Academy of Sciences, 111*(23), 8410–8415. https://doi.org/10.1073/pnas.1319030111

Gok, T. (2018). The evaluation of conceptual learning and epistemological beliefs on physics learning by think-pair-share. *Journal of Education in Science, Environment and Health, 4*(1), 69–80. https://doi.org/10.21891/jeseh.387489

Greetham, M., & Ippolito, K. (2018). Instilling collaborative and reflective practice in engineers: Using a team-based learning strategy to prepare students for working in project teams. *Higher Education Pedagogies*, *3*(1), 510–521. https://doi.org/10.1080/23752696.2018.1468224

Hilton, C. B., Goldwater, M. B., Hancock, D., Clemson, M., Huang, A., & Denyer, G. (2022). Scalable science education via online cooperative questioning. *CBE—Life Sciences Education, 21*(1), Article ar4. https://doi.org/10.1187/cbe.19-11-0249

Howitz, W. J., McKnelly, K. J., & Link, R. D. (2021). Developing and implementing a specifications grading system in an organic chemistry laboratory course. *Journal of Chemical Education, 98*(2), 385–394. https://doi.org/10.1021/acs.jchemed.0c00450

Kapur, M. (2016). Examining productive failure, productive success, unproductive failure, and unproductive success in learning. *Educational Psychologist, 51*(2), 289–299. https://doi.org/10.1080/00461520.2016.1155457

Kapur, M., & Bielaczyc, K. (2012). Designing for productive failure. *Journal of the Learning Sciences, 21*(1), 45–83. https://doi.org/10.1080/10508406.2011.591717

Kirschner, P. A., Sweller, J., & Clark, R. E. (2006). Why minimal guidance during instruction does not work: An analysis of the failure of constructivist, discovery, problem-based, experiential, and inquiry-based teaching. *Educational Psychologist, 41*(2), 75–86. https://doi.org/10.1207/s15326985ep4102_1

Lim, J., Shin, Y., Lee, S., Chun, M.-S., Park, J., & Ihm, J. (2024). Improving learning effects of student-led and teacher-led discussion contingent on prediscussion activity. *The Journal of Experimental Education, 92*(4), 626–643. https://doi.org/10.1080/00220973.2023.2221394

Martella, A. M., Swisher, M., & Mayer, R. E. (2024). How much active teaching should be incorporated into college course lectures to promote active learning? *Contemporary Educational Psychology, 79*, Article 102316. https://doi.org/10.1016/j.cedpsych.2024.102316

Martin, D. A., Conlon, E., & Bowe, B. (2019). The role of role-play in student awareness of the social dimension of the engineering profession. *European Journal of Engineering Education*, *44*(6), 882–905. https://doi.org/10.1080/03043797.2019.1624691

Moon, A., Zotos, E., Finkenstaedt-Quinn, S., Gere, A. R., & Shultz, G. V. (2018). Investigation of the role of writing-to-learn in promoting student understanding of light–matter interactions. *Chemistry Education Research and Practice*, *19*(3), 807–818. https://doi.org/10.1039/C8RP00090E

Poh, M.-Z., Swenson, N. C., & Picard, R. W. (2010). A wearable sensor for unobtrusive, long-term assessment of electrodermal activity. *IEEE Transactions on Biomedical Engineering, 57*(5), 1243–1252. https://doi.org/10.1109/TBME.2009.2038487

Ramsey, L. R., Kling, T., & Yu, W. (2025). STEM linked-course communities can increase student success: Results from a randomized controlled trial. *Research in Higher Education, 66*, Article 28. https://doi.org/10.1007/s11162-025-09846-6

Rodenbusch, S. E., Hernandez, P. R., Simmons, S. L., & Dolan, E. L. (2016). Early engagement in course-based research increases graduation rates and completion of science, engineering, and mathematics degrees. *CBE—Life Sciences Education, 15*(2), Article ar20. https://doi.org/10.1187/cbe.16-03-0117

Rohrer, D., & Taylor, K. (2007). The shuffling of mathematics problems improves learning. *Instructional Science, 35*(6), 481–498. https://doi.org/10.1007/s11251-007-9015-8

Rosa, V., & Lewis, S. E. (2020). Introducing randomization tests via an evaluation of peer-led team learning in undergraduate chemistry courses. *Chemistry Education Research and Practice, 21*(1), 287–306. https://doi.org/10.1039/C9RP00187E

https://doi.org/10.33225/jbse/26.25.819

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Samani, J., & Pan, S. C. (2021). Interleaved practice enhances memory and problem-solving ability in undergraduate physics. *npj Science of Learning, 6*, Article 32. https://doi.org/10.1038/s41539-021-00110-x

Sana, F., & Yan, V. X. (2022). Interleaving retrieval practice promotes science learning. *Psychological Science, 33*(5), 782–788. https://doi.org/10.1177/09567976211057507

Snyder, B. (2005). *Save the cat! The last book on screenwriting you'll ever need*. Michael Wiese Productions.

Snyder, B. (2007). *Save the cat! Goes to the movies: The screenwriter's guide to every story ever told*. Michael Wiese Productions.

Soneral, P. A. G., & Wyse, S. A. (2017). A SCALE-UP mock-up: Comparison of student learning gains in high- and low-tech active-learning environments. *CBE—Life Sciences Education, 16*(1), Article ar12. https://doi.org/10.1187/cbe.16-07-0228

Stains, M., Harshman, J., Barker, M. K., Chasteen, S. V., Cole, R., DeChenne-Peters, S. E., Eagan, M. K., Jr., Esson, J. M., Knight, J. K., Laski, F. A., Levis-Fitzgerald, M., Lee, C. J., Lo, S. M., McDonnell, L. M., McKay, T. A., Michelotti, N., Musgrove, A., Palmer, M. S., Plank, K. M., . . . Young, A. M. (2018). Anatomy of STEM teaching in North American universities. *Science, 359*(6383), 1468–1470. https://doi.org/10.1126/science.aap8892

Theobald, E. J., Hill, M. J., Tran, E., Agrawal, S., Arroyo, E. N., Behling, S., Chambwe, N., Laboy Cintrón, D., Cooper, J. D., Dunster, G., Grummer, J. A., Hennessey, K., Hsiao, J., Iranon, N., Jones, L., II, Jordt, H., Keller, M., Lacey, M. E., Littlefield, C. E., . . . Freeman, S. (2020). Active learning narrows achievement gaps for underrepresented students in undergraduate science, technology, engineering, and math. *Proceedings of the National Academy of Sciences, 117*(12), 6476–6483. https://doi.org/10.1073/pnas.1916903117

Van Dusen, B., & Nissen, J. (2020). Associations between learning assistants, passing introductory physics, and equity: A quantitative critical race theory investigation. *Physical Review Physics Education Research, 16*(1), Article 010117. https://doi.org/10.1103/PhysRevPhysEducRes.16.010117

Received: *July 22, 2026* Revised: *August 06, 2026* Accepted: *October 04, 2026*

Cite as: Chen, Y.-S. (2026). Designing contrast to support learning in science and technology courses through rhythmic engagement pedagogy (REP). *Journal of Baltic Science Education*, *25*(5), 819–834. https://doi.org/10.33225/jbse/26.25.819

Yen-Sheng Chen PhD, Professor, Department of Electronic Engineering, National Taipei University of Technology, 1, Sec. 3, Zhongxiao E. Rd., Taipei 10608, Taiwan.
E-mail: yschen@ntut.edu.tw
ORCID: https://orcid.org/0000-0002-3155-479X