2026 ASEE ANNUAL CONFERENCE June 21–24, 2026 | Charlotte Convention Center, NC
Host Sponsor UNC Charlotte
Paper ID #52382

Integrating Generative AI to Enhance Engagement in Asynchronous Courses

Dr. Kimberly LeChasseur, Worcester Polytechnic Institute

Dr. Kimberly LeChasseur is a researcher and evaluator with the Worcester Polytechnic Institute. She holds a dual appointment with the Center for Project-Based Learning and the Morgan Teaching and Learning Center. She holds a PhD in Educational Leadership

Koksal Mus, Worcester Polytechnic Institute

Dr. Koksal Mus is an Assistant Teaching Professor in the Electrical and Computer Engineering Department at Worcester Polytechnic Institute (WPI). His research focuses on cryptography, side-channel attacks, and the integration of AI into STEM education. He is also actively involved in Project-Based Learning (PBL) initiatives, exploring how generative AI can support personalized and inclusive learning for Generation Alpha. In addition to his teaching and research, Dr. Mus mentors numerous student projects and contributes to global education collaborations, including the development of WPI's Istanbul Project Center.

WIP: Integrating Generative AI to Enhance Engagement in Asynchronous Courses

I. Introduction

Asynchronous learning provides flexibility and self-pacing but often risks becoming passive, with limited interaction or scaffolding [1]. Research shows mixed results: some studies report lower performance compared to in-person or synchronous formats [2-4], while others highlight positive outcomes, particularly when interactive elements are included [5]. Students value flexibility but cite challenges such as reduced feedback and accountability [1]. If not carefully designed, asynchronous courses risk lowering engagement, reducing peer interaction, and weakening the development of higher-order cognitive skills.

A common obstacle to offering asynchronous learning more widely is the start-up effort required of faculty, which requires learning a new set of teaching practices, alongside additional time and effort dedicated to managing students when there is not a dedicated synchronous course experience [6]. The integration of generative AI/LLM tools offers a promising way to provide scaffolding, interactivity, and personalization while lowering the demand on faculty. This study uses two courses offered in an asynchronous format to investigate the potential of leveraging Generative AI/LLM tools. The case study of these courses allows us to explore strategies that can minimize the effort required of faculty to offer engaging, effective asynchronous learning.

This work-in-progress paper details the course design and structure, provides examples of project activities, presents key results used to refine the course for a second offering, and posit future directions. The study contributes to the scholarship of teaching and learning by offering insights into how Generative AI/LLM tools can enhance engagement and learning outcomes in asynchronous education across disciplines.

II. Course Redesign Motivations, Frameworks, and Process

A. Motivation

The course explored in this work-in-progress paper is a Cryptography and Data Security course. It was offered in Fall 2025 as an asynchronous version of an existing in-person course. The course section enrolled 14 students.

The motivation for this work is to move beyond the traditionally passive structure of asynchronous courses and create a learning environment that actively promotes engagement, interaction, and higher-order skill development. While asynchronous formats provide flexibility, they often limit opportunities for collaboration and meaningful dialogue, which are essential for deep learning in engineering and computing disciplines. At the same time, industry expectations are rapidly evolving, requiring graduates to demonstrate not only technical competence but also creativity, critical thinking, and the ethical use of emerging technologies such as AI and large language models (LLMs).

To address these gaps, this course redesign introduces interactive components, collaborative activities, and project experiences that better align with contemporary skill demands. The course redesign process presented in this paper can be understood as moving from passive learning to active learning, from faculty-centered teaching to project-based teaching, and from LLM-based tools being accessed outside the course structure to being embedded intentionally with guidance. The frameworks that shaped the redesign process are outlined in the following section, along with summaries of relevant evidence of their efficacy, as grounded in the research literature.

B. Frameworks for Redesigning Teaching & Learning

Active learning is understood within this study through the ICAP framework [7]. This conceptual model of active learning categorizes cognitive engagement into four levels of learning modes: interactive, constructive, active, and passive. At the lowest level of cognitive engagement, passive activities involve are those that involve learners who are "oriented toward and receiving information from the instructional materials without overtly doing anything else related to learning" [7]. In a lecture-based class context, this might involve listening to the lecture without doing additional activities such as taking notes, synthesizing those notes, or discussing the topics of the lecture with peers. The full taxonomy is presented in Table 1.

In addition to defining this taxonomy, the ICAP framework outlines knowledge-change processes and cognitive outcomes associated with each mode (see Table 1). The relationships between these teaching practices and student learning have been extensively examined. A meta-analysis of 225 studies found that undergraduate students were 1.5 times more likely to fail STEM courses when they were taught using passive lecturing techniques than when they were taught using active learning instructional activities [8]. Student learning outcomes, as measured with standardized and equivalent assessments, were 0.47 standard deviations higher in the classes with active learning than in those with more traditional passive lectures.

There are a wide variety of experiential learning activities that can be adopted to move cognitive engagement from the passive end of the ICAP spectrum to the constructive and interactive end. The institution at which this study took place has widely adopted project-based learning as a signature pedagogy to structure learning opportunities. In this study, we use the design principles of project-based learning developed by the Center for Project-Based Learning at Worcester Polytechnic Institute [9]. The framework encourages instructors to use a design ethos to backwards design from student learning objectives for the course through learning activities [9].

Table 1. ICAP Framework

Mode	Passive Learning	Active Learning	Constructive Learning	Interactive Learning
Description	Receiving information	Manipulating information	Generating information	Dialoguing about information
Differentiator	Being oriented toward the lesson content without doing anything beyond paying attention	Physically engaging the curricular materials or content	Creating new ideas that go beyond what is provided in the learning materials	Engaging with others in which multiple people take turns offering each other primarily new ideas
Example of Learning Activities	Reading a text either aloud or to oneself (without highlighting, underlining, taking notes, etc.)	Summarizing key points in notes for oneself in preparation for an exam or other assignment	Writing an essay arguing which actions would be justified in a given situation and why	Debating which actions would be justified in ways that critique the other's position & defend one's own position

The framework then offers seven design principles that reflect the aspects of project-based learning that maximize its impact on student learning: ground the project in real-world problems or questions; value people and process, as well as products; engage theory and practice; explore multiple perspectives; assign ownership over learning to students; build in connectedness, psychological safety, and stretch; and provide clarity of meaning. These aspects of high-quality project experiences were used to shape the course activities.

Project-based learning has been demonstrated to strengthen opportunities for students to engage in STEM [10], learn professional skills alongside disciplinary content [11-13], and prepare to enter high-demand STEM fields after graduation [14]. [10] found that enrolling in one or more project-based courses in the first two years of college increased students' self-reported STEM skills, attitudes towards the value of STEM courses, and STEM career aspirations. Their quasiexperimental study included nearly 500 students enrolled in natural science and engineering courses of study at a single university.

Researchers have also begun to establish how embedding AI tools within project-based learning can assist student learning. [15] described their integration of generative AI tools into project-based learning within the context of online learning. They emphasized their approach's authentic challenges and included opportunities for students to iterate solutions and to engage in self-reflection; these three features are aligned with the PBL framework adopted in this course redesign.

In a quasi-experiment, [16] found that data science students taught with AI-integrated project-based learning exhibited greater development of problem-solving, critical thinking, and creative thinking skills, as compared to students taught using project-based learning without AI tools. They attributed these gains to students' use of AI as a cognitive scaffold as they employed it to expand their exploration of topics and for rapid feedback during project activities. A similar function for integrating AI into project-based learning has been found by others [17], yet remains underexamined, particularly within the context of higher education in the United States.

C. Three-Phase Learning Cycle

Using the goal of learning activities being interactive and constructive while also following PBL design principles, the course was structured around a repeating three-phase learning cycle: priming, discussion and reflection, and synthesis, with students working in fixed groups with rotating roles. In each cycle, one group was assigned the role of the Designer group, while the remaining groups served as Attacker groups. This role rotation ensured that all students engaged in both constructive design and critical evaluation throughout the course.

Phase 1: Priming

During the Priming phase, students independently engaged with core course materials, including pre-recorded lectures, assigned readings, and worked examples of key concepts on their own schedules and pace. Students were permitted to use AI-based tools to support comprehension, make connections across topics, and scaffold gaps in prior knowledge, thereby reducing barriers to entry for complex material and enabling more equitable participation in later phases.

Concurrently, the Designer group began work on an assigned real-world project. Each project was grounded in a standard or baseline algorithm, which the group was tasked with improving along one or more dimensions, such as efficiency, security, performance, or conceptual simplicity. The Designer group prepared a structured project deliverable, including written documentation that justified design decisions and described implementation details. In addition, they recorded a short explanatory video outlining their modifications to the baseline algorithm and rationale, and, when appropriate, provided supporting artifacts such as code, simulations, or experimental results.

Phase 2: Discussion and Reflection

In the Discussion and Reflection phase, the Attacker groups critically analyzed the Designer group's project with the explicit goal of identifying weaknesses, limitations, or vulnerabilities and proposing alternative solutions or improvements. These critiques formed the basis for structured, peer-led discussions, with AI tools intentionally integrated as a pedagogical intervention to deepen analytical reasoning and creativity by enabling students to explore attack surfaces, generate counterexamples, compare design alternatives, and refine their critiques. The Designer group actively supported this process by clarifying technical details, responding to critiques, and facilitating deeper discussion when needed. Across all groups, AI functioned as a cognitive scaffold rather than a substitute for reasoning, reinforcing student ownership of analysis while emphasizing collaborative problem-solving and reflective dialogue.

Phase 3: Synthesis

In the Synthesis phase, the Designer group consolidated insights from the discussion and produced a reflective report summarizing the key findings, critiques, and proposed improvements. Based on this feedback, they revised and refined their original design, explicitly addressing identified weaknesses or opportunities for enhancement.

The Attacker groups, in turn, evaluated the Designer group's revised work using the provided grading rubrics and assessment tools. This peer-evaluation process reinforced accountability, encouraged thoughtful critique, and provided additional perspectives on design quality and learning outcomes.

III. Methods

A. Methodology

This work-in-progress paper presents an exploratory case study of an asynchronous course with AI/LLM tool integration. Case study methodology is particularly useful when the boundaries between the phenomenon of interest—in this case, the use of AI tools in asynchronous courses—and the context (i.e., the specific expertise and teaching practices of an instructor) are not yet clear [18]. The study offers a representative case for mid-career faculty with experience using active learning and/or project-based learning who are redesigning courses to leverage generative AI and other LLM-based tools. Because we are examining multiple units of analysis, this can be considered an embedded case [18]: the study explores course-level teaching practices, as well as student-level learning experiences, behaviors, and outcomes.

The study uses what [19] called "progressive focusing" to refine the guiding questions, data collected, analysis, and interpretation iteratively over the course of conducting the study. Ultimately, three research questions motivated and organized the case:

RQ 1: How were generative AI and LLM-based tools used to engage students in asynchronous courses?

RQ 2: How was student engagement managed asynchronously using redesigned learning activities and generative AI and LLM-based tools?

RQ3: What were the obstacles to leveraging generative AI and LLM-based tools in an asynchronous class and how were they addressed?

B. The Case

The study focuses on the case of redesigning cryptography and data security undergraduate courses to leverage AI tools when offered asynchronously. The context of the case where data were collected in Fall 2025 was a private R1 university in the Northeast region of the United States. The course instructor is a mid-career tenure track professor with 10 years of experience teaching the course using more traditional approaches. Students enrolled in the course major in either electrical and computer engineering or in computer science.

C. Data Collection

The study uses multiple sources of data, as is typical in case studies, to offer a multifaceted view of the redesigned courses' curriculum and the instructor's pedagogical decisions. Data sources for the embedded unit of the course included the following:

Course documents for the redesigned course offering, including the syllabus and the descriptions of assignments as presented to students, were collected from the instructor, along with course documents for past offerings of the same course by this instructor (e.g., syllabi, assignments).

The class Canvas (LMS) pages were made accessible. Notes on relevant features observed in the Canvas pages were taken by Author B and included in the data.

Two in-depth interviews [20] with the instructor were conducted by Author B. The first interview focused on how the course was designed, deployed, and revised; the second was used to address questions that arose during analysis of the first interview and of other data. Each interview was approximately one hour long, was conducted in person, and notes were taken by the interviewer to record the resulting data.

Data sources for the embedded unit of the student included the following:

AI interaction logs were submitted with each assignment throughout the course by all students.

Rubrics were applied to each assignment and the scores and feedback were collected, along with the assignments as originally submitted and as revised. Final course grades were also made available.

Students in the course were invited to complete a survey of student learning outcomes at the end of the course. We used the validated tool Student Assessment of their Learning Gains, a customizable assessment constructed as a less-biased alternative to course evaluations with support from the NSF [21]. The tool has been widely validated to capture gains in learning, despite being a post-only measure [22-24]. The survey included measures of gains in conceptual knowledge, collaboration, communication, and self-efficacy. Survey responses were solicited virtually in the final week of class.

Course evaluations were also collected after being made available to the instructor.

D. Analysis

Analysis involved both inductive and deductive coding to address the research questions guiding the study. Deductive codes based on the ICAP framework and PBL design principles were applied to each data source describing the course organization and learning activities. Inductive codes were developed from data describing student experiences, behaviors, and learning outcomes. As in all case studies, triangulation was a critical part of data analysis; that is, patterns in each source of data were assessed against the patterns in other sources of data. Each data source was coded first in isolation. A matrix summarizing findings within each data source was constructed to compare patterns. The instructor engaged in peer debriefing with a member of the university's teaching and learning center during analysis to validate interpretations [25].

IV. Findings

A. Use of Generative AI and LLM-based Tools

The first question shaping the case was how generative AI and LLM-based tools were used to engage students asynchronously. Students used AI tools to meet a variety of objectives (e.g., to clarify complex concepts, to brainstorm a broad set of project ideas). Their usage was designed in to each phase of the course's modules, mimicking the ever-present tools professionals might access at various points in their cybersecurity roles.

In each course module's priming phase, students use LLM-based tools to access support on background, asking questions to clarify the content, explain content in different ways, and generate additional examples. This use of LLM tools provides several benefits to students: it allows support to be on-demand, available whenever students have scheduled this coursework; it personalizes the support to the specific learning needs of the individual; and it allows students to rapidly move back and forth from conceptual explanations to examples of practical applications to strengthen their ability to understand both in tandem.

In the discussions and design phase, students use LLM-based tools while either designing or critiquing a cybersecurity product. The project is designed to engage students acting as Designers in beginning with a standard algorithm and modifying or repurposing it to serve a specific design objective, such as improving computational speed, reducing memory consumption, or achieving another performance-related goal. Throughout this process, Designer students are encouraged to leverage LLM-based tools as a means of brainstorming alternative approaches and exploring potential design enhancements. The students serving as Attackers are also encouraged to use LLM-based tools to explore ideas about how they might identify and exploit weaknesses in the design presented.

Finally, in the Synthesis phase, student Designers are asked to produce a written report that outlines potential improvements to their design, documents the specific attacks conducted against their project, and explains how these vulnerabilities could be mitigated or prevented in future iterations. They are encouraged to utilize LLM-based tools as needed to dig deeper into the attackers' tactics and to determine how best to address them. They are also required to include in the report logs of all LLM-based usage to document the sources for their work in a professional manner.

B. Managing Student Engagement

Next, the case addresses the issue of how student engagement was managed asynchronously using redesigned learning activities and generative AI and LLM-based tools. By flipping the delivery of content into videos and short readings in the priming phase of each module, students are able to self-select the level of support they need. This cuts down on alienating the most advanced students who may already be familiar with the module's main concepts or who may more easily master new content. It allows the instructor to track which topics are viewed multiple times and identify concepts or processes that students' are struggling with at the beginning of the module. Flipping the content delivery also gives students the opportunity to personalize their support as they are encouraged to use LLM-based tools--alone or in addition to meeting with the instructor--to address any confusion or questions they have.

Perhaps the most unique feature included in the redesign to increase student engagement addresses the role of students not presenting in any given module during the discussions and design phase. These students were not passive audience members for the project presentation - they were assigned the role of Attackers, charged with assessing the weaknesses in the cybersecurity product being proposed. Not only does this necessitate that attacker students pay attention during the presentation, it also motivates sustaining that engagement as Attacker students consider whether their initial ideas for attack are viable and, if so, what they would require. This activity is at the highest level of the ICAP framework for active learning, interactive.

One of the ways the course is designed to manage engagement is to scaffold the activities in this phase. The first project is not designed by a group of students, but is provided as a sample with all students participating as attackers. This introductory activity is designed to illustrate the expected deliverables, model the structure of future projects, and provide students with a low-stakes opportunity to become comfortable with the assignment format.

Finally, during the synthesis phase, both designers' and attackers' engagement is encouraged in the type of assignments they are asked to submit. Designers are expected to incorporate the cyberattacks they faced in the second phase into their final design. Including this iteration cycle requires the designers to engage cognitively at a more rigorous and creative level similar to what cybersecurity professionals face on the job.

The attackers complete a peer review rubric for the projects being presented. This requires them to pay attention to the presentation at a different level while also directing their attention to particular design elements expected in high-quality cybersecurity work. Having a structured rubric demands that students attend to sufficient detail to determine rating levels for each of the ten criteria (see Appendix C). This activity moves students from the passive end of the ICAP framework for active learning (as passive receivers of presentations) to the second-most engaging level, constructive (as constructors of peer reviews).

C. Managing Common Obstacles to Leveraging Generative AI and LLM-based Tools

The instructor reported facing three primary challenges in the first redesign and their response to these issues are outlined here.

Timeline and Responsibilities

The first challenge was in reimagining how time would be spent. Moving from a lecture-based format to constructive projects and interactive presentations of potential cybersecurity solutions requires making decisions about what to include in the expectations of how students will spend their time for the course, as well as the pacing. With rotating project roles, this becomes more complicated and communicating clarity around roles and the timing of each person's functions is critical for providing clarity of meaning – one of the PBL Design Principles for high-quality implementation.

Below is a sample project timeline for a 14-week semester involving four student groups and one introductory sample project (see Table 2) and a summary of responsibilities during the phases (see Table 3). For larger class sizes, the cohort can be divided into parallel project tracks, with two or more designer groups operating simultaneously to maintain manageable presentation and review cycles. During the project window, designer groups may also evaluate and attack one another's designs, creating additional opportunities for dynamic interaction, cross-group learning, and deeper engagement with core security concepts.

Table 2. Timeline of Group Projects

	Projects	Priming	Project Window	Synthesis
All groups	Sample Project	N/A	Week 2 & 3	End of Week 4
Group 1	Project #1	Week 3	Week 4 & 5	End of Week 6
Group 2	Project #2	Week 5	Week 6 & 7	End of Week 8
Group 3	Project #3	Week 7	Week 8 & 9	End of Week 10
Group 4	Project #4	Week 9	Week 10 & 11	End of Week 12

Table 3. Summary of Student Responsibilities by Role for Each Phase of Class

	Project Phase		
Role	Priming	Project Window	Synthesis
Designers	Design Document Present	Answer questions Facilitate discussions	Summarize report Document
Attackers	No tasks	Analyze Attack Discuss	Peer grading

Project Grading

Utilizing a project-based learning approach to active learning involves changes to course grading. When lectures are no longer the primary mode of knowledge transfer, exams may not be the best fit to assessing student learning. The instructor reported that exams hold very little ecological validity in the field of cybersecurity where novelty and creative application of technical skills play foundational roles. Consequently, grading the projects in this redesigned course needed to take into account the dependence of each student on team members; professional skills displayed, such as documentation, creativity, and communication; and the ability to critique a given solution effectively.

In the redesigned course, each project is worth some number of points, determined by calculating the number of students in the group multiplied by 100 points. This total is then distributed among students based on their contributions, as reported by themselves and by their teammates. Designers (members of the group presenting) earn credit through the quality of their implementation, presentation, documentation, and how effectively they manage attacks and discussions (see Appendix C for a sample grading rubric).

Attackers are also graded per project. They can earn credit by identifying meaningful attacks and clearly presenting their findings. The final grades reflect both the strength of the designs and the performance of the attacks. By assigning grades to both sets of students, the grading policy emphasizes the importance of both roles to the industry and reinforces the skills needed to effectively engage in both functions.

V. Discussion

A. Limitations and Next Steps

As a work-in-progress, this paper details the findings related to the embedded course-level unit. The guiding questions do not include assessing any causal or correlational relationships between the two levels of the case; we do not include in this analysis an examination of student learning as a result of the redesign process. We plan to analyze data related to the second embedded unit, student experiences, as we continue this work in progress. This will involve a deeper analysis beyond assessing the course grade distribution to explore the development of specific skills the redesign intended to address (e.g., creativity, critical thinking, communication) and which types of experiences students attribute their learning to in this course modality.

Determining whether the course activities are equally or more effective at supporting student learning than more traditional asynchronous courses would be an important next phase. To do so might begin with expanding this work into a comparative case study.

B. Conclusions

This exploratory case study found several areas of tension and promise in redesigning a course in cryptography and data science into an asynchronous modality. Course grades reflected a similar distribution as in-person offerings of the course led by the same instructor at the university [26]. The redesign process led to an acceptably high-quality teaching and learning classroom experience that aligned with interactive and constructive tenets of the ICAP framework and implemented PBL Design Principles in place of traditional lectures.

One purpose of exploratory case study methodologies is to yield directions for future research and theoretically-relevant research questions. This case study yielded several: How do the students interpret the rationale for the various design choices in learning activities? Is the success of design principles dependent on students' recognition of them? To what extent were activities sufficiently clear to be managed by students, yet open and challenging enough to demand creativity of the students? What other learning activities might further support social engagement and skills development in an asynchronous modality, more fully leveraging the potential of project-based learning? What are the costs and affordances of using AI tools in similar ways in courses with larger enrollments? These and other areas of interest continue to emerge as the case study is further developed by the two authors.

References

[1] Kittur, J., Brunhaver, S. R., Bekki, J. M., & Thomas, K. (2024). A Systematic Literature Review of Trends in Research and Practice Among Asynchronous Online Course Offerings in Formal Engineering Curricula. *Studies in Engineering Education, 5*(2).

[2] Gregori, P., Martínez, V., & Moyano-Fernández, J. J. (2018). Basic actions to reduce dropout rates in distance learning. Evaluation and Program Planning, 66, 48–52.

[3] Willging, P. A., & Johnson, S. D. (2009). Factors that influence students' decision to dropout of online courses. *Journal of Asynchronous Learning Networks, 13*(3), 115–127.

[4] Simpson, O. (2010). "22%—can we do better?": The CWP retention literature review. Report to the Centre for Widening Participation, Open University.

[5] Han, X. (2025). Associations between effectiveness of blended learning, student engagement, student learning outcomes, and student academic motivation in higher education. *Education and Information Technologies, 30*(8), 10535-10565.

[6] Zhou, Z. (2025). Artificial Intelligence and Student Engagement in Online Learning: A Literature Review. *American Journal of Distance Education*, 1-23.

[7] Chi, M. T. H., & Wylie, R. (2014). The ICAP framework: Linking cognitive engagement to active learning outcomes. *Educational psychologist,* 49(4), 219-243.

[8] 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, 8410–8415.

[9] LeChasseur, K., Wobbe, K., Clark, J. E., Bakermans, M., Madan, R., Pfeifer, G., & Stanlick, S. (2026). Designing a new framework for project-based learning: Reclaiming higher education's purpose in a time of change. Presented at the Annual Meeting of the American Association of Colleges and Universities, 1/23/26, Washington, DC.

[10] Beier, M. E., Kim, M. H., Saterbak, A., Leautaud, V., Bishnoi, S., & Gilberto, J. M. (2019). The effect of authentic project-based learning on attitudes and career aspirations in STEM. *Journal of Research in Science Teaching*, *56*(1), 3-23.

[11] Ahern, A., Dominguez, C., McNally, C., O'Sullivan, J. J., & Pedrosa, D. (2019). A literature review of critical thinking in engineering education. *Studies in higher education*, *44*(5), 816-828.

[12] Hart, J. (2019). Interdisciplinary project-based learning as a means of developing employability skills in undergraduate science degree programs. *Journal of Teaching and Learning for Graduate Employability*, *10*(2), 50-66.

[13] Stolk, J. D., & Martello, R. (2015). Can disciplinary integration promote students' lifelong learning attitudes and skills in project-based engineering courses. *International Journal of Engineering Education*, *31*(1), 434-449.

[14] Ralph, R. A. (2016). Post secondary project-based learning in science, technology, engineering and mathematics. *Journal of Technology and Science Education*, *6*(1), 26-35.

[15] Suwannatip, Rattana, Krich Sintanakul, and Jiraphan Srisomphan. "A Learning Model using Design Thinking in an Online Environment, Integrating Project-Based Learning with Generative AI Tools for Design." In *2025 International Conference on Power, Energy and Innovations (ICPEI)*, pp. 1-5. IEEE, 2025.

[16] Wan, Yingliang. "A Study on the Impact of AI-Assisted Project-Based Learning Design on Innovation Ability." *Frontiers in Interdisciplinary Educational Methodology* 2, no. 3 (2025): 210-223.

[17] Dai, Yi, Jia-Ying Xiao, Yizhe Huang, Xuesong Zhai, Fan-Chun Wai, and Ming Zhang. "How generative AI enables an online project-based learning platform: An applied study of learning behavior analysis in undergraduate students." *Applied Sciences* 15, no. 5 (2025): 2369.

[18] Yin, Robert K. *Case study research: Design and methods*. Vol. 5. sage, 2009.

[19] Parlett, M., & Hamilton, D. (1972). " Evaluation as Illumination: A New Approach to the Study of Innovatory Programs". Occasional Paper.

[20] Boyce, Carolyn, and Palena Neale. *Conducting in-depth interviews: A guide for designing and conducting in-depth interviews for evaluation input*. Vol. 2. Watertown, MA: Pathfinder international, 2006.

[21] Seymour, Elaine, Douglass Wiese, A. Hunter, and Susan M. Daffinrud. "Creating a better mousetrap: On-line student assessment of their learning gains." In *National Meeting of the*

American Chemical Society, pp. 1-40. San Francisco, CA, USA: National Institute of Science Education, University of Wisconsin-Madison, 2000.

[22] LeChasseur, K., Wodin-Schwartz, S. J., Sloboda, A., & Powell, A. (2025). Validity of a self-report measure of student learning in active learning statics courses. *International Journal of Mechanical Engineering Education*, *53*(4), 751-771.

[23] Canelas, D. A., Hill, J. L., & Novicki, A. (2017). Cooperative learning in organic chemistry increases student assessment of learning gains in key transferable skills. *Chemistry Education Research and Practice*, *18*(3), 441-456.

[24] Vishnumolakala, V. R., Southam, D. C., Treagust, D. F., & Mocerino, M. (2016). Latent constructs of the students' assessment of their learning gains instrument following instruction in stereochemistry. *Chemistry Education Research and Practice*, *17*(2), 309-319.

[25] Figg, Candace, Melanie Wenrick, Christy Youker, Joanne Heilman, and Cynthia Schneider. "Implications and benefits of a long-term peer debriefing experience on teacher researchers." *Brock Education Journal* 19, no. 1 (2009).

[26] Author A & Author B. [Redacted for blind review].

Appendix A

Example of a Sample Project

Cryptanalysis of a Modified ChaCha Stream Cipher

Objective:
In this assignment, you will explore the security of a *modified version of the ChaCha stream cipher*

Presentation Link

GitHub Link

Your task is to analyze the cipher using **established cryptanalytic techniques** and to evaluate how these modifications affect its security properties compared to the original ChaCha design.

Instructions:

1. **Familiarize yourself with ChaCha:** Review how the original ChaCha stream cipher works (round function, key schedule, nonce handling).
2. **Study the Modified Version:** Carefully examine the provided modified cipher implementation and identify the differences from the original design.
3. **Apply Cryptanalytic Methods:** Using known methods such as:
    - Differential cryptanalysis
    - Linear cryptanalysis
    - Algebraic approaches
    - Statistical/randomness testing
    - Key/IV misuse analysis

      Apply at least one or more method to test the strength of the modified cipher.
4. **Leverage AI Tools:** You are encouraged to use **Large Language Models (LLMs)** (e.g., ChatGPT, Copilot, etc.) to:
    - Review how these cryptanalytic methods work
    - Generate experimental ideas or code snippets
    - Summarize literature related to ChaCha and similar stream ciphers

      Note: AI should support your work, not replace your analysis — document clearly where and how you used these tools.
5. **Deliverables:**
    - A written report (4–6 pages) including:
        - Explanation of the modifications and their implications
        - Methods you applied and why

        - Experimental setup and results (with code snippets if used)
        - Critical discussion of the modified cipher's strengths and weaknesses
        - Reflection on the role of AI tools in your process

Submission: Upload your report (PDF) and any supporting code/scripts by the deadline.

Sample Project Assignment 1

Project: Hash Functions

In this project, you will work with **hash functions** (instead of stream ciphers, like in Project 1). Designer Group should choose an existing hash function and **modify (tweak) it** for a clear purpose—for example, improving speed, reducing memory use, or adding a new feature.

Before the project window, your responsibilities are to:

- **Design and document** your modified hash function.
- **Create a short video presentation** explaining how your algorithm works.
- **Provide written documentation** that clearly describes the design and details of your algorithm.
  The designer group can use the dedicated page to share project documents, codes, and presentations.

Sample Project Assignment 2

In this project, you will design a Secure Anonymous Complaint Submission Protocol (details provided below).

Before the Project Window

The designer group can use this dedicated page to share project documents, codes, and presentations.

Overview

High-Level Idea

Design a protocol that allows users to **submit complaints, feedback, or reports anonymously**, while ensuring that each submission is **authenticated**, **unique**, and **verifiable** — without revealing the identity of the individual who submitted it.

This type of system is useful in settings where individuals must be able to raise concerns safely, such as workplace harassment reports, whistleblowing systems, or academic misconduct claims.

Core Security Requirements

1. **Anonymity:**
   No party (including admins) should be able to link a complaint to a specific user.
2. **Authentication:**
   Only authorized users can submit complaints (e.g., employees, students), but authentication must NOT break anonymity.
3. **One Submission Per User:**
   Each user should be able to submit **exactly one complaint** per reporting round — zero or one, but not multiple.
4. **Verifiability:**
   Anyone (or at least system auditors) should be able to verify that:
    - all valid complaints were included
    - no invalid complaints were injected
5. **Non-Repudiation (Optional):**
   Users cannot later deny having submitted a complaint *if* anonymity is not harmed by this requirement.
6. **Accountability (Optional Extension):**
   Detect duplicate submissions or fake inputs without violating anonymity.

Example Scenario

A university wants a system for reporting violations without exposing who submitted each report.
Students authenticate through the university network, receive a **one-time anonymous submission token**, and then use it to submit encrypted or committed complaints.

Learning Goals

This project helps students:

- Understand **anonymous authentication mechanisms**
- Apply **zero-knowledge proofs** to enforce constraints without revealing identity
- Explore **group signatures** or **blind signature-based systems**
- Analyze trade-offs between privacy and misuse prevention

Reason about **auditing**, **accountability**, and **trust assumptions**

Deliverables

a. **Design Document (PDF)** – A clear description of your proposed protocol, including setup, authentication, ballot casting, tallying, and verification steps. Address all required security properties.
b. **Recorded Presentation**– Present your design to the class, highlighting protocol steps, key security properties, and verifiability features.

c. **Discussion of Trade-offs** – If your design cannot fully achieve one of the properties, explain the limitation and any possible improvements.

Note for Participant (Attacker) Groups: Your task is to analyze another group's design, attempt to find weaknesses, and present your findings clearly.

Appendix B
Examples of Learning Activities in Each Phase of a Module

Priming (1 Week)

- **Presenter Group (Designers):**
  - Work in a group to design your modified algorithm, guided by the LLM/AI tools and/or the instructor.
  - Prepare and record a presentation explaining your design.
  - Share the presentation and project documentation on Canvas before the official project start.

During the Project Window (2 weeks)

Presenter Group:

- Answer clarification questions from Participants about the design.
- Respond to discussion questions online.

Participant Groups (Attackers): Analyze the design, attempt potential attacks, and share findings in online discussions.

All Groups: Engage in constructive discussions about the design, including defenses, attacks, and improvements.

Synthesis and Reporting of Projects (1 Week)

Presenter Group: Submit a final report that includes:

- A summary of the design.
- An overview of attacks and responses.
- Logs from the LLM/AI tools.
- Any supporting materials (documents, websites, etc.).

Participant Groups:

- Grade the project group: Participants grade the Presenter Group's work (design, presentation, and discussions) using a structured rubric.
- Grading Rubric is provided at the end.

Appendix C
Grading Rubric

1. Presentation (40%)

Criteria	Excellent (10)	Good (8)	Satisfactory (6)	Needs Improvement (4)
Clarity & Organization	Presentation is well-structured, logical, and easy to follow. Transitions between sections are seamless.	Mostly well-organized with minor gaps	Some structure, but ideas may be unclear at times	Lacks clear organization, hard to follow
Content Depth & Accuracy	Demonstrates deep understanding, explains concepts clearly with relevant examples.	Shows good understanding, though some points could be clearer.	Some understanding but lacks depth; explanations are incomplete.	Lacks understanding, with significant gaps or errors.
Use of Visuals & Examples	Effective use of visuals/examples enhances understanding	Visuals are appropriate but could be more engaging.	Visuals are present, but do not aid understanding much.	Poorly designed or no visuals, distracting rather than helpful.
Delivery & Communication	Confident, clear speech engages the audience well.	Clear speech but some reliance on notes; engagement is moderate.	Some issues with clarity or confidence, and limited audience engagement.	Reads directly from notes/slides, minimal engagement.

2. Project Quality (30%)

Criteria	Excellent (10)	Good (8)	Satisfactory (6)	Needs Improvement (4)

Technical Accuracy & Execution	In-depth research, strong critical analysis, insightful conclusions.	Good research, some analysis, and conclusions could be stronger.	Limited research, analysis is basic, lacks depth.	Minimal research, weak or missing analysis.
Creativity & Innovation	Highly original ideas, innovative solutions, and unique insights.	Some creativity, but not fully developed.	Limited creativity, relies on standard approaches.	No originality, lacks creative problem-solving.
Effort & Completeness	Exceeds requirements, extra effort evident	Meets expectations, effort shown	Meets basic requirements, minimal effort	Incomplete, little effort shown

3. Discussion & Engagement (30%)

Criteria	Excellent (10)	Good (8)	Satisfactory (6)	Needs Improvement (4)	Poor Responses (2)
Did the presenter provide clear, thoughtful, and well-supported responses to questions?	Responses were clear, detailed, and demonstrated a deep understanding.	Responses were mostly clear and well-supported, with minor gaps.	Responses were somewhat clear but lacked depth or support.	Responses were vague or confusing, with limited supporting information.	Responses were unclear, off-topic, or did not address the question properly.
Did the presenter engage with the audience by acknowledging and building on their ideas?	Actively listened, referenced audience points, and encouraged discussion.	Acknowledged audience input and responded thoughtfully.	Responded to questions but did not fully engage with audience ideas.	Provided minimal interaction with audience comments.	Ignored or dismissed audience contributions.

Did the presenter connect their responses to the broader course concepts or real-world applications?	Responses are effectively linked to course material or real-world examples, enhancing understanding.	Made good connections to course content or practical applications, though not always in depth.	Some connection to course concepts, but responses remained surface-level.	Limited attempt to relate responses to broader ideas.	No connection to course material or real-world relevance.