WIP: Active and Constructive Learning in Computing and Engineering Face-to-Face Courses: A Case for H5P Interactive Technology

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***Abstract*—This innovative practice work-in-progress paper describes using H5P-based activities to support student learning and engagement in face-to-face courses.**

Keywords—active learning, H5P, ICAP, instructional designer-faculty collaboration

I. Introduction (*Heading 1*)

This innovative practice work-in-progress paper describes using H5P-based activities to support student learning and engagement within face-to-face courses.

In the specialized fields of engineering and computing, the demand for innovative educational approaches that cater to diverse learning needs and facilitate a deep understanding of complex concepts is ever-present. Interactive online tools, like H5P (HTML5 Package) technology, promise to improve motivation and advance learning. These are often discussed in the context of online or flipped courses. However, these tools can also be used in traditional courses borrowing from the strengths of a fully flipped classroom approach. The authors (PI/lead of the competency team for the overall project, an instructional designer, and a computing faculty) will discuss their use of learning experiences created using H5P to support student learning and engagement in face-to-face CS1-CS2 undergraduate computing courses.

II. Background

A. About H5P Use in Higher Education

H5P, which stands for HTML5 Package, is a versatile tool for creating, sharing, and reusing interactive HTML5 content in educational contexts, especially in higher education. Its significance and utility in course design are substantial due to its integration capabilities, interactivity, and focus on enhancing student engagement and learning outcomes. The 50+ tools within the H5P framework allow educators to tailor content to meet diverse learning outcomes and types of assessment while fostering a more inclusive, accessible, and engaging learning environment. It is particularly effective in integrating formative assessments with just-in-time feedback, which enables students and faculty to identify areas for improvement and solidify their understanding of course materials. H5P can be easily integrated into any major LMS creating opportunities for seamless automated grading. Additional opportunities for a detailed review of student participation is also available as a separate option.

[1] Singleton & Charlton demonstrated the effectiveness of H5P activities in assessing and enhancing undergraduate students' understanding of subjects such as pathology, physiology, and anatomy, highlighting that H5P aids in achieving targeted learning outcomes and allows teachers to monitor students' progress comprehensively. [2] Wilkie et al showed that applying design principles through H5P can significantly increase student engagement and active learning by simplifying content presentation and enhancing interactive elements. Furthermore, MacFarlane & Ballantyne [3] and Rekhari & Sinnayah [4] leveraged H5P to promote active learning and address educational challenges faced by students in complex subjects, using interactive, mobile-friendly content to improve foundational knowledge and reduce cognitive overload.

In studies conducted across various educational settings, H5P has proven to be a versatile tool for both traditional and innovative teaching methods. For instance, Amali et al. [5] and [6] and Devi et al. utilized H5P to enhance e-learning and blended learning environments, respectively, improving the efficiency of learning systems and the utility of instructional videos by adding questions to the video content. While the prior research on the use of the tool is limited, what has been published has shown positive impacts on engagement, self-reported knowledge, student learning outcomes, and even improved pass and retention rates when compared with traditional face-to-face lectures. However, research has thus far been limited to H5P use in online learning environments.

B. Deeper Learning and the ICAP Framework

Deeper learning is possible through increasingly complex cognitive engagements. The ICAP framework [6] categorizes cognitive engagement activities into four distinct modes: Interactive, Constructive, Active, and Passive. Each mode represents a different level of student engagement and learning depth, ranging from the least to the most effective for fostering deeper understanding and cognitive development.

- **Interactive Mode:** The highest level of cognitive engagement in the ICAP framework, the interactive mode, involves collaborative or dialogical activities where students co-construct knowledge through

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interactions. This might involve debating, peer teaching, or group problem-solving, where learners must articulate their understanding and adjust it based on peer feedback and alternative perspectives. This mode is highly effective for deep learning because it combines all elements of the other modes and adds the dimension of social interaction, further enhancing cognitive processing and retention.

- **Constructive Mode:** This mode requires students to engage with educational content by generating their interpretations, inferences, or new ideas from the learned material. Constructive activities might include summarizing information, questioning, or explaining concepts to others, which encourages deeper cognitive processing and solidifies understanding by integrating new knowledge with existing knowledge.
- **Active Mode:** Active learning involves students engaging with the material through manipulation or interaction, such as highlighting text, underlining, or carrying out simple exercises. However, these activities do not require the student to generate new ideas or conclusions; they still interact with the material at a surface level. While more engaging than passive learning, the active mode still lacks the depth of higher cognitive processing. However, at this point, the new knowledge stimulates and connects to relevant pre-existing knowledge, which is an important step in knowledge building.
- **Passive Mode:** In this mode, students are primarily recipients of information without any physical or mental engagement beyond observing or listening. This typically involves activities like reading or listening to a lecture, where the student's interaction with the material is minimal. Passive engagement is considered the least effective in promoting deep learning because it does not encourage students to process information beyond its basic presentation.

III. Incorporating H5P into a Face-to-Face Computing Course: Our Collaborative Process

As part of the NSF grant, the educational research/instructional design team from an R1 university collaborated with computing faculty from a Minority-Serving Institution to integrate active learning opportunities into the lower-level in-person computing courses to integrate cross-disciplinary skills and dispositions and promote engagement and deeper learning. One of the aspects of such collaboration was the integration of H5P activities into the curriculum. We developed a systematic and collaborative process to develop resources to ensure that we meet students' needs and address the teaching preferences of the faculty. These steps included the following:

A. Review of Current Materials

The process began with a thorough review of the existing lectures, labs, assignments, and educational materials used in the course. In collaboration with course faculty, an instructional designer evaluated the content to identify gaps and areas where student engagement and understanding could be enhanced. This review helped pinpoint what types of interactive elements and new materials, such as videos, could be added to improve the learning experience.

B. Identification and Acquisition of New Materials

Once the gaps were identified, the instructional designer sourced new materials that could better convey the concepts under discussion. This involved curating educational videos, diagrams, or real-world case studies relevant to the course material. These resources were selected based on their ability to provide diverse learning experiences and meet learning objectives along the ICAP framework.

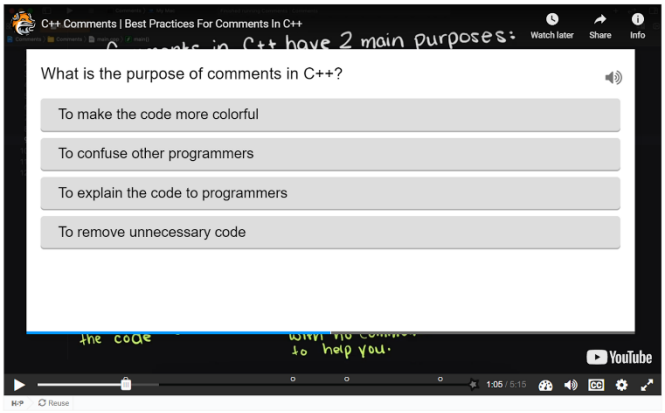
C. Development of Activities

With the new materials at hand, the instructional designer then developed interactive questions and activities using H5P. This included creating quizzes, drag-and-drop exercises, fill-in-the-blanks, or even more complex scenarios like branching case studies. The aim was to integrate these interactive elements seamlessly with the existing and newly acquired materials to enhance student learning. H5P activities developed as part of these efforts aligned with the ICAP framework as follows:

1) Development of Active Mode Activities

H5P offers a range of tools that enable students to interact directly with the material. This can include drag-and-drop activities, flashcards, or other practice exercises that require students to engage with the content actively but not create anything new from it. These activities require more cognitive effort than merely watching or listening, as students must manipulate information and make decisions (see Figures 1-3).

Fig. 1 Engaging with videos through built-in questions using the Interactive Video feature inH5P



For instance, an interactive video will pause and quiz the students on what they have just learned, providing a more robust learning experience that integrates visual learning with critical thinking.

Fig. 2 Identifying parts of a Linux command line syntax using a Mark the Words activity in H5P

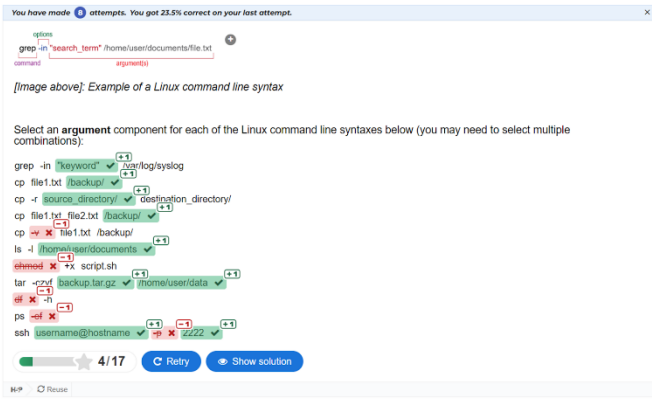
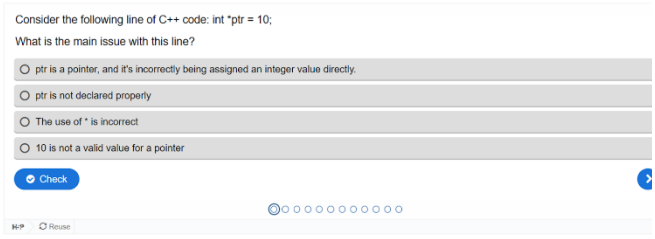


Fig. 3 Check your knowledge/understanding with a Question Set activity in H5P

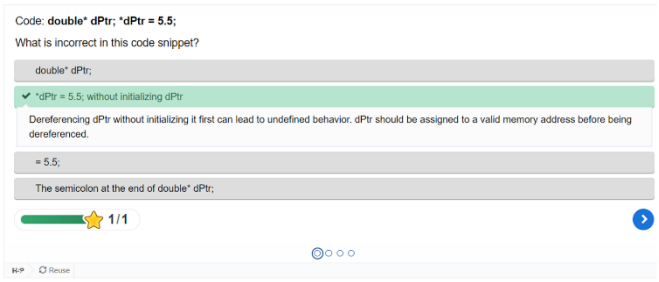


These activities were used as part of a larger lab where students would practice some of these steps, like syntax, before completing the next phase.

2) Development of Constructive Mode Activities

In the Constructive mode, students are encouraged to generate new understandings or reinterpretations of the material. Activities developed in H5P can focus on more in-depth knowledge building and problem-solving based on minim-scenarios. These types of activities not only encourage students to think deeply about the content but also to personalize their learning experience by integrating new knowledge with what they already know (see Figure 4).

Fig. 4 Use of a Question Set activity in H5P for more advanced types of questions with immediate feedback

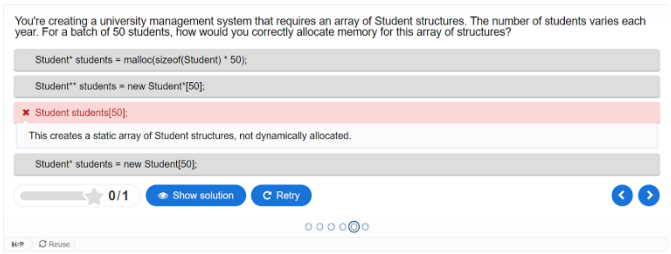


This type of activity was used as a way to let students "connect the dots" by applying the principles they have learned in new situations. The immediate feedback allowed them to identify and mitigate errors immediately.

3) Planning for Interactive Mode Activities

The Interactive mode represents the highest level of cognitive engagement, where students collaborate or discuss with others to co-construct knowledge. H5P facilitates this through case studies that could be presented as multiple choice questions or Branching Scenario tool, students can work in groups to explore different outcomes based on decision points, discussing and selecting paths together in a case study or a problem-solving scenario. This year, simple case studies were introduced (see Fig. 5). However, designs of branching case studies are underway as the next iteration of the course.

Fig. 5 Example of a scenario with multiple choice questions and immediate using a Question Set activity in H5P.



This serves as a scaffolding exercise for branching scenarios that are planned for future development. This activity was planned to be paired with in-class discussions where students could further clarify their ideas, thereby enhancing their learning through social interaction and multiple perspectives.

D. Review of Activities by Faculty

Once the initial set of activities was developed, the H5P modules were presented to the faculty for review. This step was crucial as it involved critical evaluation from a pedagogical perspective. Faculty members could suggest modifications, validate the accuracy of content, and ensure that the activities align well with the course objectives and learning outcomes. Their feedback was integral to refining the activities to meet learning objectives and student needs.

E. Final Development of Activities

Taking into account the faculty feedback, the instructional designer finalized the activities. This phase involved tweaking questions, adjusting the difficulty levels of the exercises, or enriching the materials with additional multimedia elements to better explain complex topics. The designer ensured that all interactive elements were functional, accessible, and user-friendly, preparing them for seamless integration into the course.

F. Implementation by Faculty

Finally, the new H5P activities were implemented by the faculty within the course framework in multiple formats - as part of classroom instruction and as homework exercises. At this point of implementation, we were not able to integrate H5P into an LMS due to issues outside of our scope, therefore, faculty requested students to submit screenshots of completed activities along with reflections (in some cases).

Evaluation and Continuous Improvement: The implementation of H5P activities was an impromptu decision to overcome the challenge of static content and lectures of a traditional classroom, as such the data collected was the anecdotal information from instructors and students. Post-implementation, the instructional designer and faculty reviewed student performance data and feedback to evaluate the

effectiveness of the H5P activities. Insights gained from this data helped in continuously improving the activities.

Lessons Learned

Based on the feedback received, the level of interactivity was engaging to students. The change of pace during a lecture inspired students to ask questions and engage in discussions, a behavior that the instructor had rarely seen during lectures in the past. Immediate feedback was also found helpful in assessing knowledge retention. However, the feedback feature was not available in videos based on the software design, which also means that more complex application questions would not be advised as part of the video question set.

Some activities did not work because of the lack of alignment with how the process of coding or quizzing was done in the classroom. For example, a multiple-choice test prep was created to help students prepare for their first exam. Immediate feedback was provided by responding to the choices students made. However, the multiple-choice items were different from the actual exam, which included a combination of writing out the response after doing some initial coding.

There were additional challenges to implementing activities during an in-class time. First of all, adding H5P activities during the "lecture" or "lab" session tended to disrupt the habitual flow of the class. Even short activities would require a change in pace, e.g., using a computer or a mobile device to access a learning activity, completing an activity (which may take different amounts of time for different students), and then creating screenshots of the "certificate of completion" to add to a document due to the lack of an LMS integration under the current setup of the class. Additionally, some students may need additional support on how to access and navigate the new platform, which may take additional class time Therefore, faculty need to preplan the integration and ways to support students (e.g., demonstrations; assistance from teaching assistants) to ensure success. While in an asynchronous online course environment this issue may not be as pronounced, the time limitation of meeting times in in-person courses adds significant constraints.

Finally, developing high-quality H5P content with relevant and quality feedback is time-consuming. Educators and instructional designers must invest significant time in learning the tool, developing content, and then testing and revising this content based on student feedback and learning outcomes. Without adequate time and resources, the quality and effectiveness of H5P content could suffer. However, once a resource is created, it can be re-used each semester, or easily adjusted as material changes.

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