SlideSpace: A Social Realtime Teaching and Learning Environment

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***Abstract*— In this Work in Progress, research [1] indicates that static curricula, with few interactions between instructors and students, reduces the number and quality of formative feedback opportunities for learners, and negatively impacts student learning outcomes. The means by which timely feedback can be captured, stored, analyzed, categorized, and shared with stakeholders may improve performance indicators. Our current work will build on prior work to create an enhanced active, effective learning environment for instructors and students. Major areas of focus include individualized learning assessment, the use of AI to identify pedagogy to active learning indicators, the ability to provide students with scaffolded learning prompts prior to instruction, while students are actively engaged and in improving the curricula and pedagogy for future students. Future work includes the optimization of feedback based on individual students, and addressing intellectual property and privacy concerns for students and instructors.**

Keywords—Learner engagement, pedagogy/andragogy, formative assessment, closed-loop learning, individualized instruction, feedback

I. Introduction

Research indicates that pedagogy, encompassing curriculum, and the learning environment combine to have a significant impact on learning outcomes. In addition, static curricula, pedagogy and communications do not address the specific learning needs of individuals [1]. Furthermore, research indicates that static curricula, with few interactions between instructors and students, reduces the number and quality of formative feedback opportunities for learners, and negatively impacts student learning outcomes [2].

Our objectives for this project are twofold. First, to test mechanisms by which the value of continuous, near real-time interactions and feedback between stakeholders in a higher education learning ecosystem (students, instructors, teaching assistants, alumni) can be made more contextually relevant, timely, automated and actionable, and whether doing so will improve individual learning outcomes (LOs), pedagogy, instructor continuous improvement and the collective educational experience. Second, to test mechanisms using automated machine learning models to dynamically augment the experience of stakeholders to provide customization and drive improved individual performance outcomes.

The following are some of the research questions to be addressed to achieve the Social Realtime objective:

Direct, human feedback:

- How does the integration of time-correlated, in-context (in-situ, etc.) feedback mechanisms improve the actionability of that feedback to stakeholders?
- For instructors, how can immediate student feedback result in measurable improvements to course curricula, pedagogical methods, or teacher/student interactions?
- Can patterns of student performance on live-polls, quizzes or tests be used to determine whether curricular learning outcomes have been met? What meaningful types of analysis can be provided to the instructor for this purpose?
- For students, how can more timely and contextually relevant feedback lead to better performance? How can this information be most effectively captured interactively in the classroom experience?

Random, social user interactions:

- In what ways do an increase in the number and nature of “just-in-time” interactions serve to increase student engagement, improve student learning, or increase their desire to complete their studies?
- How can we identify repeatable and reliable ways for students to interactively contribute to their personal learning experience, such that the overall learning experience can be improved?
- How might low-latency, low-bandwidth techniques increase participation, and drive improved outcomes for underrepresented and diverse student populations?

Automated augmentation of experiential factors to enhance performance outcomes:

- Based on user interactions and existing performance indicators, can we automatically identify and recommend supplemental resources to improve performance outcomes, and measure these changes in performance metrics over time?

- What improvements, if any, result from automated augmentation of search results beyond the scope of the specific course? For example, how might automatic recommendation of human resources (TA's and tutors) drive improved student outcomes?
- Can ML-based native language translation of transcribed material improve student performance?

Our hypothesis is that by improving the quality, quantity and timeliness of feedback, connecting feedback more closely with the relevant context, and augmenting human feedback with automated machine learning (ML) techniques, we can improve the value of actionable feedback in various stages of the teaching and learning triangle [3]. Such closed-loop improvements can drive an increase in the quantity and/or quality of timely positive change, and subsequently increase the mutual engagement between instructors and graduate students which has been shown to improve learning outcomes [4].

As part of our research, we have created a learning environment called SlideSpace, that has served as a living laboratory for experiments into human interactions. The system captures anonymized data related to content creation, distribution, consumption, user interactions, and study habits. To date, we have used this data for statistical analysis to: 1) explore users interaction with learning systems, curriculum, and each other - in live and time-shifted scenarios; 2) identify opportunities to develop enhanced features that improve the human experience and outcomes; and 3) identify and test mechanisms to create more accessible and inclusive learning systems.

Building on existing research [5], our research will focus on the means by which timely feedback can be captured, stored, analyzed, categorized, and shared with stakeholders in ways that may improve performance indicators. The data will be used to build on and contribute to prior work to help enhance an effective learning environment for instructors and students.

Our research advances the integration of appropriate, relevant and meaningful technology, and offers to make such technology accessible, inexpensive, and widely available. Finally, our approach will collect and integrate data into a continuous improvement process, which we perceive as the "living laboratory" capabilities of our platform that enhance our ability to test, measure, and conduct experiments in, curriculum development, assessment, measurement and evaluation and real-time teaching and learning.

II. About Social Realtime Learning

We designed and developed SlideSpace as a teaching and learning environment that supports a diverse community of educators and learners throughout their many workflows. The system also serves as a living laboratory that allows us to explore, test, and research new ideas in education, pedagogy, and curriculum development.

A central tenet of our work is that all learning is social and that our learning environment should enable, support, and nurture our sense of community. It should emphasize opportunities to make meaningful connections with teachers, mentors, tutors, peers, and alumni. To enable meaningful connections with members of our community, we need tools that allow us to engage and interact. While these interactions may be synchronous or asynchronous, our need for timely insight is both immediate and intimate. As a result, SlideSpace was designed with multifaceted real-time communications as a core platform capability.

Another essential aspect of a vibrant learning community is the presence of bi-directional interactions, individual growth, and feedback. Any stakeholder in the community should be able to initiate interactions, and contribute to the community. Contributed artifacts may include curriculum, quizzes, notes, study guides, discussion topics and posts, feedback, collaborative training, etc.

III. Areas of Research

Our program encompasses six major areas of research. The first area in learning assessment and tracing is critical to provide evaluative feedback on the efficacy of the feedback systems. Given the ability to measure these results, we have the option to provide assistance for students before they attempt to learn new material, while they are learning the material, or updating the curricula and pedagogy for future students. The final two areas are in the tuning and optimization of this feedback based on each individual, and the need to protect the intellectual property and privacy of students and instructors. Each of these areas are described in this paper.

A. Learning Assessment and Tracing

For educational research, it is critical to determine each student's success in applying the desired learning outcomes, and couple this back to actions that the instructor and student has taken [5]. This work involves the construction and mapping of course learning outcomes and analytical rubrics with each instructional section, student activities and additional materials that the students may access. If there are multiple means of measuring these, they can be coupled and their progression shown over time.

B. Pre-Learning Intervention

If we can identify a student's conceptual understanding, foundational for future concepts, then specific, targeted support can be offered to support future learning. If we can access the learning outcomes from a prior course or learning experience, then we could provide student feedback before they attempt to learn new material. For example, we are currently developing a three course sequence in which a free, short online course will be offered which addresses foundational concepts such as math (e.g., probability and statistics), programming (e.g., Python), and artificial intelligence (AI) and machine learning (ML) basics. In addition, we are creating a map of the dependencies in the conceptual capabilities within and between the three courses. The student's learning outcomes from the online short course, and each following course will be used to identify areas in subsequent courses that might require additional support, with specific information provided to the student to assist their learning.

C. In Process Learning Intervention

This same concept map can be used to see how students are perceiving the instructional information. This can be accomplished, for example, by having the students "take notes" by annotating what they consider to be important information, and what needs additional clarification. If students misidentify conceptual information, the instructor can take note and offer appropriate student feedback. Likewise, the instructor can use this information to continuously improve their instructional materials based on the student feedback. Other forms of feedback collected include class discussion comments, problem sets and formative assessments. Another source of information is related to the materials that the students access and how long, and in which order they access it. Recommendations can be made to students based on this information as ML can be used to identify student archetypes and provide predictive information on how to further students information processing. All of this can be correlated to the learning outcomes and learning results can be noted based on final student outcomes. A comparison can be made between student success in areas in which they are given the additional information based on their "note taking."

D. Future Learning Intervention

After the course is completed, an assessment of student learning outcomes can be collected. Areas in which students perform less well are areas in which the curriculum and pedagogy can be reviewed and possibly updated. These modifications can be compared to the prior students' results and the results in the improved course.

We will also be able to create and compare "heat maps" from prior years to determine how to improve courses in the future. We plan to analyze and correlate curriculum development costs, versus content utilization and student feedback. A Cross-Course Learning in Curricula and Pedagogy approach can be implemented, which will focus on how to learn from the work that is done with others. This approach will enhance the ability to illustrate, borrow and share research-based instructional practices broadly.

E. Feedback Optimization

Providing timely and targeted feedback to instructors and students can be beneficial. A 2005 study at Rowan University found a positive effect of the use of immediate interactive feedback [6]. Optimizing the precise latency and amount of feedback for each instructor and student is a difficult challenge. One way to address this variable is to observe and document how the system evolves. For example, what is the speed in which students interact and provide data to each other and the instructor, and how does this affect their learning outcomes? Identifying multiple confounding variables in this area will be elevated. However quantitative and qualitative documentation and perhaps an on-going, longitudinal ethnographic study could illuminate helpful findings.

F. Privacy and Intellectual Property (IP) Concerns

One of the issues with immortalizing the classroom experience, pertains to whether students want their intellectual information to be persistent? For example, do you want to be reminded (or a potential employer discovers) that low level question that you asked when you were a first year student being available forever? If you are an instructor, are you now liable for which students you addressed during a class (someone could collect the data and do the analytics to uncover unintended biases)? Does this mean an AI should be used to call out students? Or are all students' questions being addressed in a fair way? Do data analytics create issues for fairness, inclusiveness and equity? Proposals should be made to address these potential issues.

IV. Current Status

We are entering our third year of development, and the system has been used in over 20 course sections, totaling more than 1000 students. At present, the web-based system provides tools and features that serve three distinct contexts: 1) Creation and analysis tools for instructors; 2) a social learning environment for instructors and students; 3) an asynchronous studying environment for students.

A. Creation and Analysis Tools for Instructors

The environment provides a set of tools that support the development of modular curriculum using a modern drag-and-drop web-interface. Course modules can be created, edited, and shared across any courses to increase reusability. Modules contain course content and meta-data related to learning outcomes. All curriculum is automatically indexed and linked into an AI-driven search engine to assist students with discovery of relevant content. The content creation tools use a modern, theme-based presentation style that can be easily adapted.

B. In-class Presentation/lecture Tools

SlideSpace provides a useful set of Just-in-time tools for use during presentations. In-class tools include a dynamic drawing and annotation layer, "instant" feedback polls (web+mobile) that work without the aid of external hardware or time-consuming pre-course setup; non-disruptive real-time chat for students (in every modality) to ask questions of the instructor and other students during a course session. Students can provide "micro-feedback" related to course material as desired. All chat conversations are timestamped, and fully indexed for searching and aligned with course material; auto-transcription of the presentation is indexed, time-stamped, and synchronized with course material for future reference and review.

C. Studying and Collaboration Tools for Students

The environment was designed to engage and optimize the student, "personal learning experience". All course materials, in-class conversations, and session transcripts are fully-indexed and searchable to make engaging and studying more efficient. An integrated real-time discussion system allows students to ask questions to instructors and peers. We are presently integrating all course and real-time content into an AI-enabled chatbot to help students make better use of this rich set of materials.

Presently under development is a note-taking feature. Notes can be captured by students or instructors. Each note is time-stamped and synchronized with both curriculum and presentation transcripts. This permits students to study from materials that link curriculum, transcripts and their notes. We plan to measure the impact of this integration on student performance in the Fall of 2021.

All system tools are integrated into a data gathering layer to enable research into learning behaviors and outcomes. The system tracks when and how students engage with curriculum and each other, which tools were used, which content was viewed, by whom, and for how long. Instructors can view statistics related to student interest and comprehension of a particular unit of curriculum.

V. SlideSpace Use and Results

A class session consists of a sequence of slides provided in a web-interface for synchronous and asynchronous access. For remote teaching, these slides are generally shown using a video sharing platform like Zoom. Because of the highly interactive nature of SlideSpace, we find that most students access the slides in their own browser during class, so that they can participate directly.

While most presentations appear in a linear format, the environment is structured as a graph of reusable modules to allow for non-linearity. This adaptive design permits instructors to navigate to alternative curriculum as needed based on the in-class experience, supported by a set of integrated tools (polls, chats, coding, discussions, drawings).

Informal feedback from instructors that have used the system in the classroom suggest that it allows for a more fluid teaching experience. While it is possible to follow a predescribed lesson plan, the immediacy and simplicity of the integrated tools allows for some contextually meaningful improvisation.

Consider a recent classroom experience from a fourth-year software engineering course, focused on how to apply diagramming techniques to model complex relationships between systems. The presentation was shared with remote students via Zoom, and the screens of students viewing the presentation in their browser were automatically synchronized with the instructor's browser.

The presentation began with the instructor using the integrated drawing tools to demonstrate diagramming techniques, when a (remote/synchronous) student asked a question in the integrated chat. An unobtrusive notification of a pending question appeared on-screen. The instructor finished the topic in a few minutes, and then opened the integrated chat view, to reveal the student question. A discussion of the question ensued, leading to a hybrid conversation with some students using chat, while others spoke on their microphone.

To measure student comprehension of this material, the instructor opened an "instant poll" related to the onscreen content. Within a minute, more than 50% of the xx# attendees had responded to the poll, with 30% of the responses being submitted via mobile devices. One of the student questions was related to an ancillary topic. In the Zoom video, you can see the instructor open a "Related Topics" menu, and instantly branch to an alternate section with additional examples before returning to the primary discussion. The entire conversation was automatically transcribed and synchronized with the presentation for future review.

Interactions of this type occur frequently in classrooms that offer and value active-learning. How students choose to engage is a function of cultural, social, environmental, and technical factors. How instructors choose to engage is a function of where they are in the flow of presenting the idea, their ability to handle dynamic student exchanges, and the quality and usability of the tools they have at their disposal to adapt a presentation. The preponderance of research [7] suggests that students learn more when engaged with active and collaborative learning techniques. It is our hypothesis that the flexibility and immediacy of the SlideSpace environment with a set of well-integrated tools that are simple, reliable, effective, and easily accessible will lead to improved student outcomes.

VI. Future Research

Student feedback from 2020 and 2021 courses suggests the environment offers a more, engaging and motivational learning experience. At present, the evidence we have captured in the form of informal student surveys that produce consistently positive feedback. We plan to begin rigorous and formal testing and validating these techniques in the autumn of 2021. We also plan to implement and collect data on the following research questions using the system over the next several terms; what is the direct measurable impact on learning outcomes in the following areas:

- Providing AI-assisted detection of learning shortfalls and automating student notifications of additional curriculum and practice materials.
- Overall effectiveness of "instant polls", "instant coding", and dynamically revealed content to create a more effective learning experience.
- Use of auto-generated study guides for students (presentation, lecture notes, transcript).
- Allowing the student community to create and share course content, polls, quizzes, discussions with other students.
- Tracking learning-outcomes across the entire program of study on the overall student experience.
- Allowing students to directly access alternate curriculum (discovery-based learning) for the purpose of studying.
- Benefit of student-focused collaboration spaces during in-class active learning activities.

References

[1] Hargis,J., and K. Yee, K., "Indirect faculty development and the role of sociability", Journal on Centers for Teaching and Learning, vol. 4, pp. 61-78, 2012. (Hill et al. 2012)

[2] Opitz, B, Ferdinand, NK, and Mecklinger, A. (2011), Timing matters: the impact of immediate and delayed feedback on artificial language learning. Front Hum Neurosci. 2011;5:8. Published 2011 Feb 1.

[3] Henderson, M., "Conditions that enable effective feedback", Higher Education Research and Development, vol. 38, 2019.

[4] Wiggin, G. P., & McTighe, J. "Understanding by design (2nd ed.)," Pearson, 2005.

[5] Chen, J., & Kadlowec, J., & Whittinghill, D (2006, June), "Using Rapid Feedback To Enhance Student Learning", 2006 Annual Conference & Exposition, Chicago, Illinois, 10.18260/1-2--1093.

[6] Frank, B. M., & Behinaein Hamgini, B., "Collaborative cloud-based documents for real-time bi-directional feedback in large lecture activities," 2014 ASEE Annual Conference & Exposition, Indianapolis, Indiana. 10.18260/1-2--20171.

[7] Smith, K., "Pedagogies of engagement: Classroom-based practices, Journal of Engineering Education, January 2005.