Developing an open, algorithmically randomized problem bank

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Introduction

In this project, we developed a question bank for digital assessments based on an open physics textbook. The question bank contains algorithmically generated questions with randomized content that can be used to promote conceptual understanding, distributed practice, and other active learning pedagogies. The platform can generate unique algorithmically-generated questions so each student receives personalized problems and assignments. In the PrairieLearn system, student submissions are automatically graded instantly, providing immediate feedback, which is an important element of learning. These resources reduce the temptation to commit academic dishonesty while simultaneously encouraging students to work together. Additionally, without the access-time limitation of commercial offerings, instructors can re-use and expand the question bank indefinitely.

Objectives

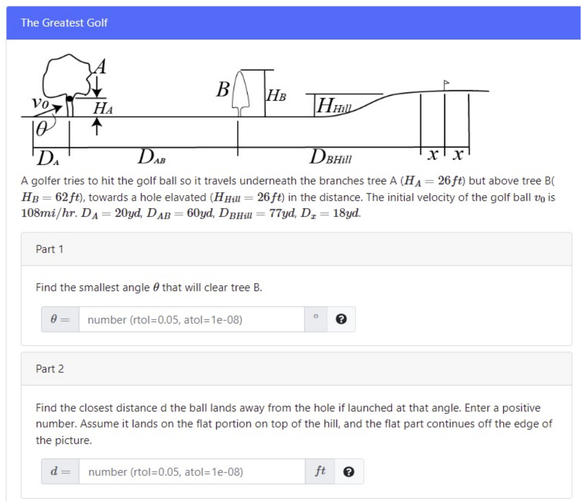
- Facilitate active learning and engagement, in both synchronous and asynchronous classes.
- Facilitate pre- and post-lecture assessment with instantaneous feedback
- Provide an equitable and inclusive learning environment by removing the financial barriers.
- Reduce the workload on instructors intending to provide active learning and close monitoring of attainment of learning outcomes.
- Reduce the temptation to commit academic dishonesty in online assessments.

Project Outcomes and Deliverables

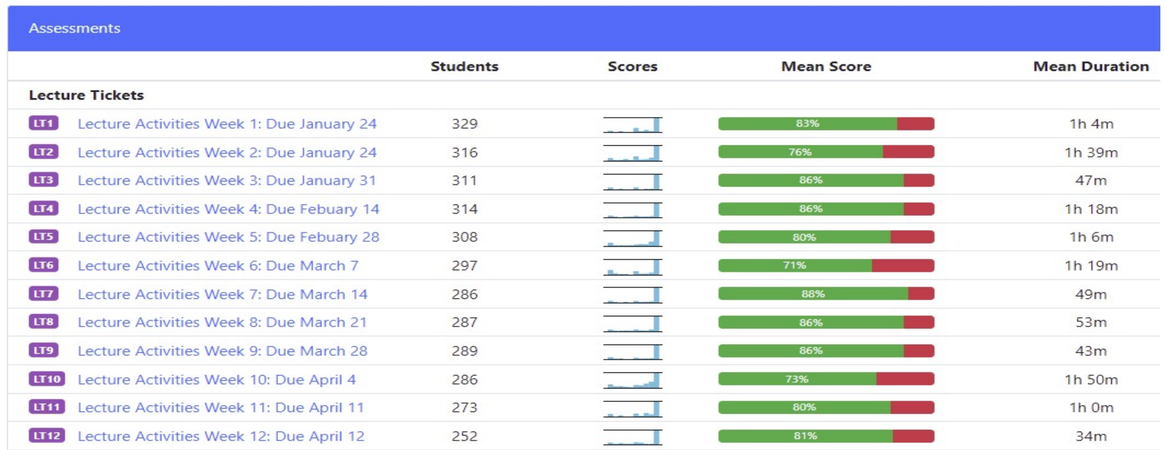
- This project has two phases. Phase (I) finished in the summer 2021, and currently, the team is working on phase (II). Below are the deliverables:
  - A bank of algorithmically generated questions for the open-source platform, PrairieLearn
  - Questions are categorized and tagged by topics and learning outcomes covering the syllabi of APSC181, PHYS111, PHYS121. Questions can also be used in any other calculus- or algebra-based introductory physics course.
  - A “sample course” with these problems for instructors wanting to replicate or adapt this course for their contexts.
  - Problem-solving videos on a lightboard for each practice set (e.g. Tutorials, assignments, lecture activities and conceptual practice set)
  - Resources for engaging flipped classrooms and hybrid courses.

PrairieLearn

PrairieLearn is an online learning system built on modern web technologies that is open source, and can be used to create and administer digital assessments. Questions can be written in pure Markdown and algorithmically randomized using the Python programming language. PrairieLearn also has several useful features such as dynamically generated questions, auto-grading, graphical drawing, symbolic algebra, as well as pen and paper student submissions.



Screenshot of a sample problem in APSC181 (Dynamics)



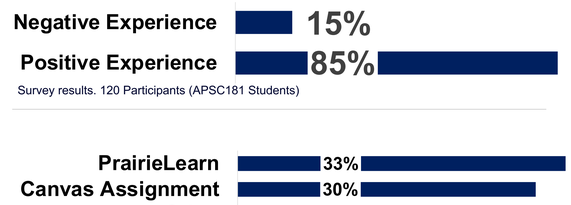
Assessments

	Students	Scores	Mean Score	Mean Duration
Lecture Tickets				
LT1 Lecture Activities Week 1: Due January 24	329		83%	1h 4m
LT2 Lecture Activities Week 2: Due January 24	316		76%	1h 39m
LT3 Lecture Activities Week 3: Due January 31	311		86%	47m
LT4 Lecture Activities Week 4: Due Febuary 14	314		86%	1h 18m
LT5 Lecture Activities Week 5: Due Febuary 28	308		80%	1h 6m
LT6 Lecture Activities Week 6: Due March 7	297		71%	1h 19m
LT7 Lecture Activities Week 7: Due March 14	286		88%	49m
LT8 Lecture Activities Week 8: Due March 21	287		86%	53m
LT9 Lecture Activities Week 9: Due March 28	289		86%	43m
LT10 Lecture Activities Week 10: Due April 4	286		73%	1h 50m
LT11 Lecture Activities Week 11: Due April 11	273		80%	1h 0m
LT12 Lecture Activities Week 12: Due April 12	252		81%	34m

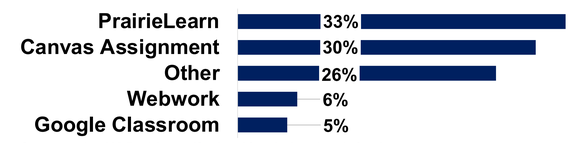
The Platform provides the instructor with information about students’ performance and practice time

Sustainability Plan

The developed practice resources are for fundamental engineering and science courses which are expected to be relevant for the foreseeable future. Updates can be made by simply editing the sequence of questions, text or diagrams by Instructors and/or TAs of the term to keep the content up to date, for example, to accommodate syllabus changes. Detailed instructions will be available for instructors/TAs to use to add newly designed/developed questions to the available resource. The solutions/hints can be available for students to practice after a certain due date, which may decrease students' temptation to pay for third-party commercial platforms. PrairieLearn has a large and dedicated community with partner institutions in the United States, Canada, and China. It is expected to remain available for the foreseeable future and the source code for the platform is freely available on GitHub. Furthermore, the questions are developed using plain text (Markdown) so scripts can easily convert the questions to other platforms if needed.



Survey results. 120 Participants (APSC181 Students)



Survey results. 120 Participants (Students’ favorite learning platform)

I feel that "Lecture Activity" assignments in this course helped me learn Dynamics...

Strongly Agree	**49.6%**
Somewhat Agree	**41.3%**
Neither Agree nor Disagree	**5.8%**
Somewhat Disagree	**1.7%**
Strongly Disagree	**1.7%**

Acknowledgement

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