Achieving "A's for All (as time and interest allow)"

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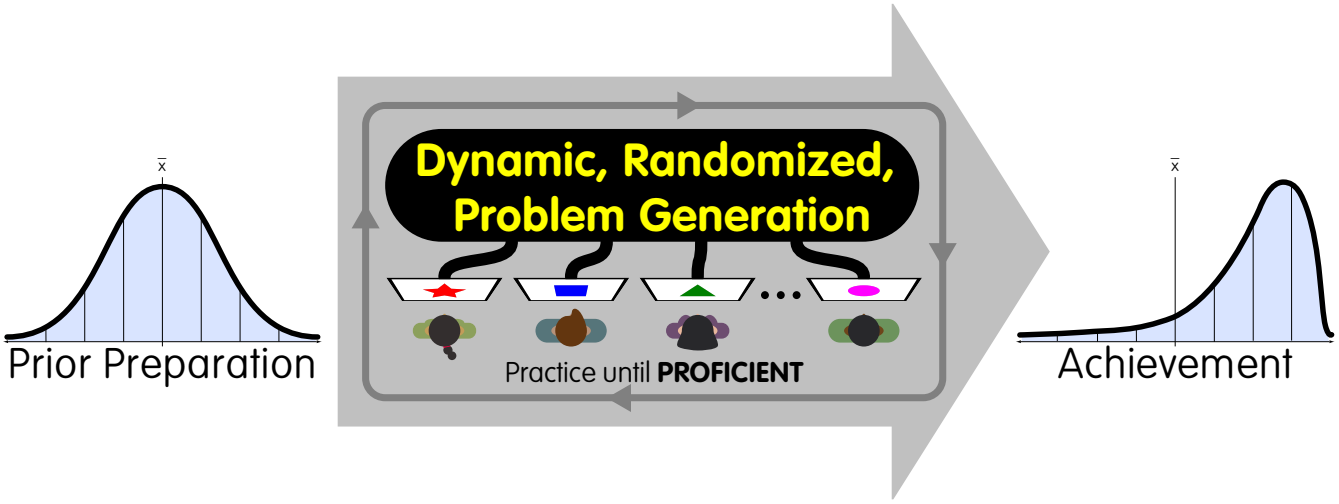

Figure 1: Our proficiency learning model.

CCS CONCEPTS

• **Social and professional topics** → **Student assessment**.

KEYWORDS

assessment, pedagogy, communities of practice, scalable

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1 BACKGROUND

The `SIGCSE-MEMBERS` mailing list of the ACM Special Interest Group in Computer Science Education is the main forum for educators worldwide to discuss computing education research, pedagogy, and curriculum [9]. In early 2022 it was abuzz with several connected movements: *growth mindset* [4, 6], *proficiency (aka mastery) learning* [2], *grading for equity* [1, 5], and *specifications grading* [8]. Each of these is an important step toward the Holy Grail: *A's for All (as time and interest allow)*; the "A" line doesn't move, but *every* student should be given an opportunity to achieve proficiency and earn it, as long as they are willing to put in the time and effort it might take [7]. The mantra is not *"fixed time, variable learning"*, but *"fixed learning, variable time"* [12]. The goal of this full-day workshop is to provide educators and administrators with tools to achieve it in their courses and institutions.

One useful analogy is that enrolling in a course is like taking a trip by bus: there is *one* speed for everyone, it lasts 10 or 15 weeks, and at the end of the trip a calculation is made regarding what percentage of the pile of points has been earned, and an A-F grade is assigned. What happens when someone needs (or wants) to travel slower, and as a result will get off the bus? Do they wait a whole term for the next bus? Can they work on their own? Do they get on the "local" bus that goes slower, perhaps with a supportive cohort who also needed to go slower? This is typically not allowed by our *assembly-line* model of learning [10], yet there are many ways that an institution *can* support these students, which we will address.

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From ten miles up, what are all the elements that have to align to allow it to happen? It helps to have a leader who is passionate about equity, supported by their administration, and willing to put in a significant amount of work up front. Many in this Learning@Scale community who have already moved their traditional University class to a MOOC will find those efforts bearing fruit here. If the course is the first through the gate to adopt this model, there may be socialization among colleagues that is needed.

1.1 Process Overview

The process often starts with faculty and students invested in the course co-creating a *Concept Map* that graphically represents all the knowledge and skills and conceptual dependencies. The next step is to provide a mechanism for students to have an almost limitless supply of *formative* and *summative assessments* using *Computer-Based Testing (CBT)*. Then comes the hard work of content creation — authoring these assessments (auto-graded projects and exams) into the system, and there are certainly best practices to be learned here. Institutional support plays a big factor as the course moves to the next stage, and starts to consider the logistics of allowing students to move asynchronously through the material, either during or after the term is over.

1.2 Concept Map

When moving a course to CBT, a detailed concept map can be useful to indicate the data dependencies between the knowledge concepts. During the course, it could be shared with students, and even programmatically color-coded to show the student where they were (e.g., by highlighting mastered concepts in green), where they might want to go next (e.g., by highlighting neighboring concepts in yellow), and what they probably weren't ready for yet (e.g., by greying-out the concepts when their prerequisites hadn't been satisfied). The students could then explore the knowledge space on their own, in a self-paced way, "reading ahead" to see what exciting ideas lay in store.

1.3 Computer-Based Testing

Affordable, secure, and scalable assessment delivery is an essential component of large university courses, whether online or in-person. The switch to Computer-Based Testing can have a surprising, and almost transformational effect on pedagogy. There exists innumerable online assessment tools, but our team has determined that PrairieLearn is the best platform for achieving *"A's for All"*, given that it was created with the intention of supporting proficiency learning.

PrairieLearn is a free and open-source student learning tool that provides almost unlimited flexibility in the types of questions it can support and auto-grade, and has been adopted at several universities. As such, it is often the platform of choice for computer-based assessment infrastructure. In this workshop, faculty with significant experience in teaching large-enrollment computer science courses will share their experiences with CBT and how it has changed their approach, pedagogy, and behavior.

Educational situations that embrace *"fixed learning, variable time"* typically require incredible patience (and creativity) from a human instructor, who must, on the fly, be able to generate question after question for a student who is struggling with a particular concept. That model just doesn't work at the scale of a higher education [3]. CBT allows faculty to put the work in up-front to author rich and authentic randomized question generators, which have the answers pre-encoded. Students work *as long as it takes* on different problems until they achieve proficiency, as shown in Figure 1.

PrairieLearn (PL) was developed at the University of Illinois, Urbana-Champaign as a platform for mastery-based online homework in STEM courses [11] and has evolved to support computer-based exams [13], formative assessments of many types, and auto-graded programming projects. It is currently being used in over 100 courses across a broad range of STEM disciplines (CS, Engineering, Math, Chemistry, Nutrition) and has seen significant recent uptake by other prominent large CS departments. Two aspects of the tool particularly appeal to CS instructors. The tool is free and open-source, so faculty maintain control of their content and can freely share it with students. Also, it provides an unconstrained question-authoring API that allows for sophisticated auto-grading question generators (rather than individual question instances).

In addition, PrairieLearn permits its questions to be used in a variety of contexts (in-class activities, homework, practice exams, exams, etc.). An investment in sophisticated question design pays off quickly for large courses, and the benefits grow over time, as well-crafted questions can be re-deployed semester after semester.

1.4 Content Creation

Content creation or migration is arguably the largest barrier to course-level adoption of a computer based assessment tool like PrairieLearn. The UIUC solution to this challenge – building content incrementally, supporting a vibrant community of practice, and sprinkling knowledgeable TAs throughout myriad courses – is replicated successfully at other universities.

1.5 Testimonial from UBC

What follows is a testimonial from Cinda Heeren, Teaching Professor at the University of British Columbia. With the support of UBC teaching improvement grants, she has nurtured a vital community of student developers.

In 2015, as an early adopter of computer-based assessment via PrairieLearn, I developed and facilitated simple multiple choice questions with limited variants, covering the main content of a traditional data structures course. In fall 2018, after I had moved to UBC and in response to a Dean's query about modernizing and economizing assessments, I reminisced about the infrastructure at my previous institution. The decision-makers in the Dean's office determined that PrairieLearn, together with its physical testing facility (CBTF), were worth our university's investment, and they contributed physical space and 0.75FTE programmer, together with funding to support TAs and project management. Shortly thereafter, I began the process of content development with fresh commitment to transforming our students' learning environment. Based on my experience developing materials in a new context, I have developed course-level strategies for content creation, considering both the details of question design, and the establishment of a TA community of question and assessment authors. Specific attention to each of these flattens the on-ramp to material deployment.

1.6 Institutional Support

Integration of new learning tools, especially those with the broad potential to modernize teaching and learning at scale, is expedited by development, support, and vision at the campus level. The University of Illinois campus has created a *Computer-Based Testing Facility (CBTF)* where students are proctored during their PrairieLearn sessions [13]. Their CBTF delivers over 50,000 mid-term and final exams for more than 6,000 unique students enrolled in more than 25 classes each semester. The facility employees proctors to oversee the students instead of using course staff support.

We recommend a trip with department leadership to see this facility — when the UC Berkeley EECS department chair returned from visiting UIUC, he exclaimed "Let's make this happen; what do you need?". That was a few months before COVID-19 hit; since then the focus on how to deliver high-stakes assessments remotely (while preventing cheating) has been an active conversation among many faculty, and furthered the resolve of the Chair and our Dean to bring the technology to our campus. The meta-lesson here is to get your leaders involved early, who can provide early advocacy and funding.

There were many conversations among campus leaders at UC Berkeley about this system, and what it could do for campus. From a financial standpoint, the fact that PrairieLearn was open-source software, and involved no licensing fees to acquire was a slam-dunk. From a technical standpoint, the software runs on an Amazon Web Services instance, which can be provisioned to handle whatever load is expected. The issue of authentication was the next hurdle, which allows students to access to the right exam in the right course at the right time. We are still building the last step, which is to push the grades to the right place into the campus gradebook when they're done. All of this has and will require many meetings to coordinate, but most of the heavy lifting has been by various departmental and campus IT groups, leaving faculty advocates to spend their valuable time authoring fun question generators!

2 ORGANIZERS

Dan Garcia is a Teaching Professor at UC Berkeley, and has used CBT in several classes, a non-majors CS0 class and a sophomore-level computer architecture class. He is passionate advocate about the *A's for All (as time and interest allow)* movement, and sees it as having the most potential for moving the equity needle as any effort he's seen in his lifetime.

Craig Zilles is an Associate Professor in Computer Science at the University of Illinois. He's one of the earliest adopters of PrairieLearn and is a co-founder of Illinois's CBTF.

Connor McMahon was one of the Head TAs in UC Berkeley's sophomore-level computer architecture class, which fully adopted CBT for its exams during the Fall of 2020 and has since adopted PrairieLearn for its homework assignments. She helped design questions for the exams and homework assignments that included autogradeable C and RISC-V programming questions.

Yuan Garcia has helped author CBT question generators for UC Berkeley's *Beauty and Joy of Computing* course. He has explored both *brittle* fill-in-the-blank programming auto-graders (that do string matching), and *resilient* auto-graders that do standard unit testing.

3 PRE-WORKSHOP PLANS

The University of Illinois runs a five-day training course, and recommends the following of its attendees before it begins[1]:

- Login to PrairieLearn so that the team can give access to it before the workshop starts.
- Join the PrairieLearn slack.
- Request course access. The team processes all the access requests using the PL Slack `request-course` channel.
- Bring a laptop with you.

4 WORKSHOP STRUCTURE

The full-day workshop will be broken into six elements, with breaks throughout:

- **Motivation and Advocacy.** We will present the case for making this seismic change to the way students are assessed, from a zero-sum model to one that allows all students to succeed, independent of the time needed for them to achieve proficiency. The resources we share will be available to all participants, who can repurpose them to make the case at their institution. This roundtable-style discussion will welcome all *"but how do you..."* and *"but what happens when..."* questions.
- **Concept Map Design.** Participants will group together by domain, learn the principles of designing a concept map through different examples, and create a concept map for material in the first few weeks of their course.
- **PrairieLearn Question Generators.** Again, grouped by domain, attendees will pair up and explore creating their first question generator (QG) using the PL web interface. They will be encouraged to explore different ways to assess the same concept.
- **Assessment Creation Best Practices.** We will share what we have learned after creating hundreds of question generators, from must-have PL features, to ways we have been able to assess that we never could have dreamed using traditional paper-and-pencil exams, to gotchas that have bitten us.
- **Policies.** We will have a round-robin discussion about the optimal institutional and course policies, and which might be appropriate in different settings. For example, if a student only achieves proficiency in the first half of a four-unit course, does it make sense for them to receive an incomplete to finish later, or an A grade for first two units? Should exams be take-home, proctored, or unproctored?
- **Question and Answer.** We will allocate plenty of time to support any remaining questions or concerns participants might have.

5 POST-WORKSHOP PLANS

We will create a channel on the PrairieLearn slack workspace so that participants (and workshop leads) can keep in touch as they return to their institutions and try to move their initiatives forward, supporting each other, and serving as a sounding board.

[1]The underlined text in this subsection are clickable links.

6 CALL FOR PARTICIPATION

There is a grassroots movement taking hold in higher education that promises to fundamentally change the way we look at student learning and success. It is grounded in the fundamental principles of "growth mindset", "grading for equity", "specifications grading", and "proficiency (aka mastery) learning". The initiative is called "A's for All (as time and interest allow)"; the "A" line doesn't move, but every student is given an opportunity to achieve proficiency and earn it, as long as they are willing to put in the time and effort it might take. The mantra is not "fixed time, variable learning", but "fixed learning, variable time". There are those of us who believe this has the potential to move the equity needle unlike anything we've seen in our lifetime.

The goal of this full-day workshop is to provide educators and administrators with tools to achieve this "holy grail" in their courses and institutions. It will take attendees through elements of advocacy, concept maps, hands-on randomized question generator design and implementation using the PrairieLearn computer-based testing system, assessment best practices, and course policies to reduce friction. We will have plenty of time for roundtable-style discussions to address *"but how do you..."* and *"but what happens when..."* questions. Attendees need only bring a laptop with them to the session, as well as complete a few pre-workshop housekeeping tasks to make it easy to onboard them with PrairieLearn.

Join us and let's grow the movement!

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