Current Issues in Emerging eLearning

Designing and Teaching Adaptive+Active Learning Effectively

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INTRODUCTION:

To broaden access to education, institutions of higher education have explored the possibility of enabling personalized learning for individuals with different skills, abilities, and interests. Faced with the challenge of scaling personalized learning, adaptive computer-based systems promise to guide learning experiences by tailoring instruction and/or recommendations based on the goals, needs, or preferences of the learner (Graesser, Hu & Sottilare, 2018). Despite the growth in adaptive courseware vendors and generous support through national organizations, successful implementation of adaptive systems is mixed (SRI Education, 2016). This article highlights the need for a system approach and illustrates this strategy through design decisions and facilitation skills that have contributed to the success of integrating adaptive learning at Arizona State University (ASU).

BACKGROUND:

More universities are expanding their mission to provide access to broader audiences. This has resulted in increased enrollment in *General Education* courses as students with diverse backgrounds and learning experiences seek a college education. To ensure student success in large enrollment courses, educational institutions require an instructional model and tools that can be implemented effectively and efficiently at scale for individuals of diverse skills, abilities, and interests. While efficient, lecturing, one of the most common instructional models for large groups, tends to be less effective, often resulting in lower percentages of learner success and retention (Feldman & Zimbler, 2012). Furthermore, to help learners engage and focus their efforts on striving to attain the desired learning outcomes, educational institutions need to develop instructional activities that motivate individuals and groups, make materials relevant, and foster employability skills (soft skills).

A SYSTEMS APPROACH:

To identify an instructional model including tools that meet the specific needs of introductory courses with large enrollments at ASU, a team composed of faculty, instructional designers, technologists and other support personnel approached the design, development, and implementation of the new solution from a systems view - wherein organizational and instructional systems are related and changes to one element impact other elements or even sub-systems (von Bertalanffy & Rapoport, 1956). Developers of the initiative discussed herein surveyed key stakeholders and their contexts, and aligned the initiative with ASU's overall charter of student success. The needs assessment indicated that the new instructional model should combine the implementation of adaptive courseware with active learning techniques.

DESIGN

Instructional Design is the systems approach to creating effective, efficient, and engaging instruction. It is the framework for developing learning experiences [programs, courses, modules, units, lessons, etc.], which promote the acquisition of specific knowledge and skills (Merrill, Drake, Lacy & Pratt, 1996). Although learning theories, such as behaviorism, cognitivism, and constructivism, generally describe learning and provide considerations for motivating individuals, learning theories generally lack concrete guidelines for designing learning experiences (Ulrich, 2008). Here, more prescriptive models or practices derived from instructional design models provide more guidance. For example, Engelmann's *Direct Instruction* (National Institute for Direct Instruction, 2015), which is deeply rooted in the learning theory of behaviorism, provides concrete sequences and steps on how to engage with learners. While effective and efficient under certain circumstances, a sixty-minute lecture can become less engaging and can lead students to disconnect quickly. In contrast, combining *Direct Instruction* with other models, such as problem-based learning, can lead to higher levels of engagement while also ensuring effectiveness (Winarno, Muthu & Ling, 2018).

Although it might be challenging to identify a single theory or instructional model that describes learning for all learners in all contexts, Ertmer and Newby (1993) explained that "as one moves along the behaviorist-cognitivist-constructivist continuum, the focus of instruction shifts from teaching to learning, from the passive transfer of facts and routines to the active application of ideas to problems" (p. 58). Instead of focusing on which learning theory might be best to design the learning experiences, one should consider the task to-be-learned including the audience and contexts. In other words, an instructional model is needed that is eclectic in nature and considers the various types of learning that can occur throughout a course.

One attempt to identify instructional models that supersede individual learning theories was conducted by David Merrill (2002). Merrill's *First Principles of Instruction* are "a set of principles that can be found in most instructional design theories and models and even though the terms used to state these principles might differ between theorists, the authors of these theories would agree that these principles are necessary for effective and efficient instruction" (p. 44). Beyond subject matter, context, and learner background, Merrill identified five principles which provide guidance on designing effective, efficient, and engaging instruction.

The following comprise Merrill's five principles:

1. Learning is promoted when learners are engaged in solving real-world problems
2. Learning is promoted when existing knowledge is activated as a foundation for new knowledge
3. Learning is promoted when new knowledge is demonstrated to the learner
4. Learning is promoted when new knowledge is applied by the learner
5. Learning is promoted when new knowledge is integrated into the learner's world

Considering real-world problems to be at the very core of learning experiences, Merrill further suggested sequencing instruction through the iteration of four individual phases - activation, demonstration, application, and integration.
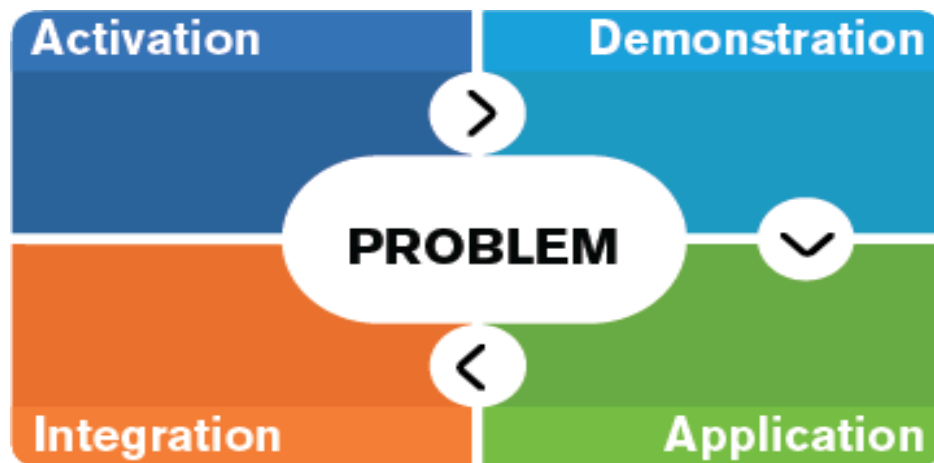

Figure 1. Phases of Effective Instruction, Merrill (2002)

Fundamental to Ertmer and Newby's arguments as well as Merrill's principles is the concept that there is a taxonomy of learning and that learning requires different tasks. According to Bloom's taxonomy (Bloom, Krathwohl, & Masia, 1984), learning can be broken down into various levels which become increasingly more difficult. For example, *seeing someone* drive a car [demonstration] does not necessarily imply that one *can* drive a car successfully based simply on having witnessed the act [application].

Furthermore, moving across the behaviorist-cognitivist-constructivist continuum as called for by Ertmer and Newby, the question arises which tasks can best be learned individually and which can best be learned collaboratively with peers? Cognitive science suggests the need to have learners actively involved in their own learning, – an idea further supported by Micki Chi's ICAP framework (Chi, 2009). Chi conducted a meta-analysis of educational research studies and determined that *active learning,* in which learners engage with peers or experts in dialog around an overt learning task, is more effective than passive learning. Recognizing that there is a taxonomy in which effective learning can be broken into individual and collaborative activities is particularly important to instructors and instructional designers as they create environments in which learning needs to be assessed (Chi, 2009, p. 76).

TEACHING

In addition to an instructional model applicable across diverse contexts, subjects, and audiences, the implementation or teaching of the design is an equal, if not more important, aspect of successful instruction. In short, teaching comprises the implementation of the design as well as the "... process of attending to people's needs, experiences and feelings, and intervening so that they learn particular things, and go beyond the given" (Smith, 2019, para. 2). The facilitator needs to be able to design learning activities and instructional interventions to enable student success and needs to recommend appropriate activities to help learners achieve the learning objectives.

Chickering and Gamson's *Seven Principles of Good Practice in Undergraduate Education* (1987) is one of the most prominent sets of educational practices for effective and engaging teaching in higher education. Drawing from over fifty years of education research, the principles highlight the contact between learners and faculty, the importance of engagement, and the need for meaningful feedback in a timely manner.

Specifically, the seven good practices Chickering and Gamson advocate are as follows:

1. Encourage contact between students and faculty
2. Develop reciprocity and cooperation among students.
3. Encourage active learning.
4. Give prompt feedback.
5. Emphasize time on task.
6. Communicate high expectations.
7. Respect diverse talents and ways of learning.

While these practices are proven to be effective, one needs to carefully examine the time, educational contexts, and audiences that were in place when these principles were developed. Certainly, society, audiences, and tools have changed since 1987. For example, today's learners can enroll in more modalities to pursue an undergraduate or graduate education such as online education. The principles may apply to online learning with studies examining their applicability to technologically-driven learning environments (Chickering & Ehrmann, 1996); however, the changes in society in the past 20 years due to rapid developments in technology need to be examined. Considering the changes in how we communicate and access information, one will need to expand on these principles.

Among those considerations is certainly the teaching of large enrollment courses due to increased access to higher education. According to the National Center for Educational Statistics (NCES, 2019), the undergraduate enrollment in degree-granting postsecondary institutions was 19.8 million learners in 2016, an increase of 12% from 2006 (17.8 million). Similarly, we see a more diverse population today than ever before (NCES, 2019) when, for example, it comes to age, ethnicity, and educational preparation. While broader access to education is much needed, the consequences of larger and more diverse classrooms require rethinking well-established teaching practices and principles. From an instructor perspective, a common challenge is to recognize who among the learners needs assistance with what concept or skills. In short, it is important to identify struggling students as early as possible so one then can administer appropriate interventions to help students succeed.

ADAPTIVE+ACTIVE LEARNING INITIATIVE AT ARIZONA STATE UNIVERSITY

The promise of student success through personalized learning resonates with the core values of ASU, a large public research university (~100K students). The university's charter states that "[we are] measured not by whom we exclude, but rather by whom we include and how they succeed."

In 2014, the university's leadership identified several high-enrollment *General Education* courses that consistently showed low retention and performance rates (e.g., introductory biology, psychology, college algebra). After extensive design and development, these courses were transformed from a traditional lecture-based model to an instructional model in which instructors and students harness the benefits of adaptive courseware and learner-centered pedagogy (active learning). As part of this large initiative, ASU partnered with adaptive courseware vendors to design, develop, and implement an introductory mathematics course (College Algebra), a beginning biology class, and two U.S. History survey classes. Under the leadership of the Adaptive Program Director and in collaboration with ASU departments and faculty, a cross-functional team consisting of instructional designers, media developers, technologists, librarians, and vendor personnel initiated the development of these courses.

This adaptive+active instructional model has significantly increased the student success rate in *General Education* courses enabling thousands of additional students to advance toward their degree (see figure 2). It also has provided ASU faculty and staff with unique insights and expertise regarding how to deliver on the promise of personalized learning at scale in education. By 2019, what began with pioneering work on an introductory mathematics class had grown to include over 25 courses across seven different disciplines enrolled by more than 90,000 students. In the academic year 2019-20, ASU projects that close to 27,000 students will enroll in a course that uses an adaptive+active instructional model.

Although the needs assessment identified additional interventions to support student success, including implementing effective student support and advising processes, this paper focuses on the instructional implications, in particular the design choices and teaching practices ASU has adopted.
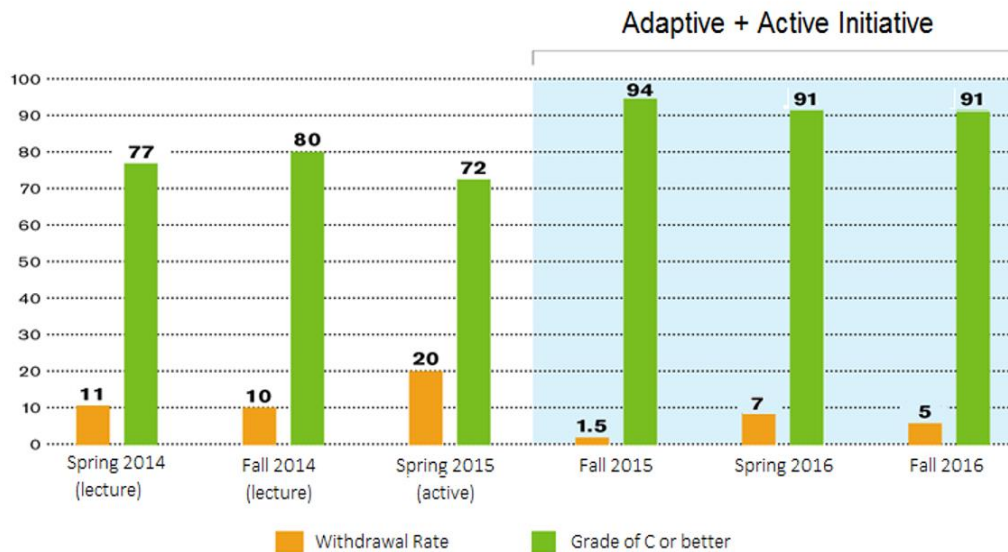
Figure 2. Student success data in *Introductory Biology*
with approx. 400 students, same instructor.

OVERVIEW OF KEY DESIGN DECISIONS:

To accomplish those transformations successfully, the ASU team closely examined the learning objectives of each course, identified matching assessments, and considered aligned instructional activities and resources. Furthermore, drawing from Ertmer and Newby's (1993) eclectic model as well as Chi's (2009) framework for interactive learning, objectives were identified, which were better suited for individual learning versus collaborative learning. As a result, learning objectives associated with lower levels of Bloom's Taxonomy (1956), such as remembering or understanding, were identified as being appropriate for individual learning, while learning objectives associated with higher levels, such as analyzing and creating were identified as being appropriate for collaborative settings.

Considering the challenge posed by large enrollment and diverse learner backgrounds, the model needed to deliver the right lesson to the right student at the right time. Here, the affordances of adaptive technology allowed each individual learner to engage with course materials matching their level of understanding. As learners interact with the adaptive courseware, key concepts and skills are being activated, demonstrated, and - at a fundamental level - applied (Merril, 2002). In addition, learners receive immediate feedback fundamental to Chickering and Gamson's *Seven Principles of Good Practice in Undergraduate Education* (1987).

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Upon mastering lower level objectives in the adaptive courseware, students engaged in active learning activities that addressed higher level objectives. These learner-centered teaching activities tend to foster reflection, enable collaboration, and increase student performance (Freeman, Eddy, McDonough, Smith, Okoroafor & Wenderoth, 2014).
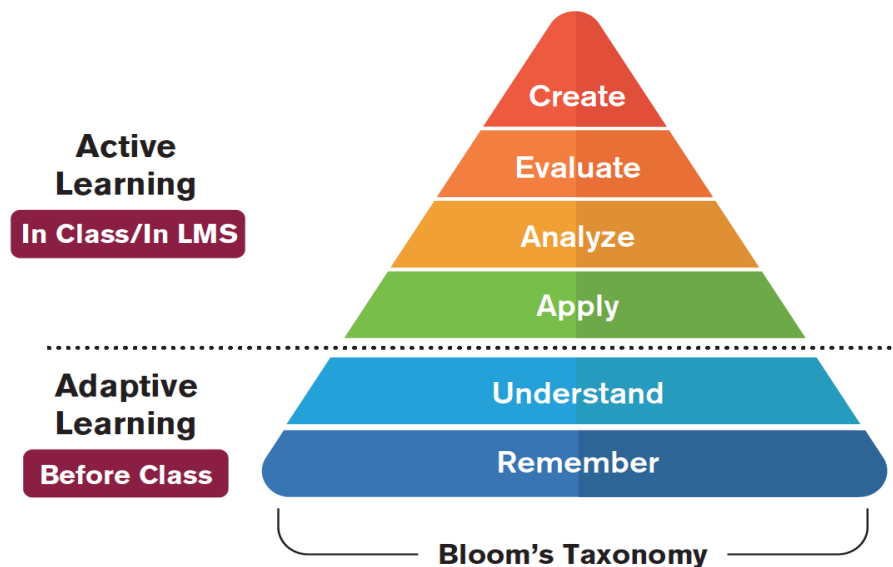

Figure 3. Adaptive+Active Learning aligned with Bloom's Taxonomy

To implement these concepts successfully, the following transformations were needed in the instructional model, course facilitation and technology:

1. Courses were designed so that the adaptive delivery of instructional resources increases learner access to the learning materials and frees up time for instructors to lead students through active learning exercises.

2. Instructional materials and activities in adaptive courseware focused on fundamental concepts and skills. Learners achieved the mastery level defined by the faculty through individualized instruction and rapid remediation.

3. Learning analytics from the adaptive courseware improved instructor insight into each learner's mastery. These insights allowed the instructor to implement a choice of instructional interventions based on individual needs.

4. Outside the adaptive courseware, active learning exercises were employed to deepen learner understanding of fundamental concepts and skills. Instructional materials and activities further addressed so-called 21st Century Skills (National Education Association, 2019) and employability skills (e.g., critical thinking, communication, collaboration, problem-solving).

5. Adaptive+active course creation was a team effort to ensure the effective design, development and facilitation of the new approach. For example, the team included at least two faculty members to lead the effort. One instructional designer provided teaching and learning support as well as coordinated the work with multimedia developers, web technologists, evaluators, and external partners. Finally, one project manager coordinated the adoption process through at least the first three iterations of the course to ensure the effective and efficient transition for learners and instructors.

It is important to note that this instruction model is flexible and applicable across modalities. On campus, this is implemented as a "flipped" model (Bergman & Sams, 2014) with the learners working in the adaptive courseware before class to prepare them to do active learning in class. Online, the same adaptive courseware is used to deliver the instruction, and the active learning is done using other digital tools, such as discussion forums and web collaboration systems.
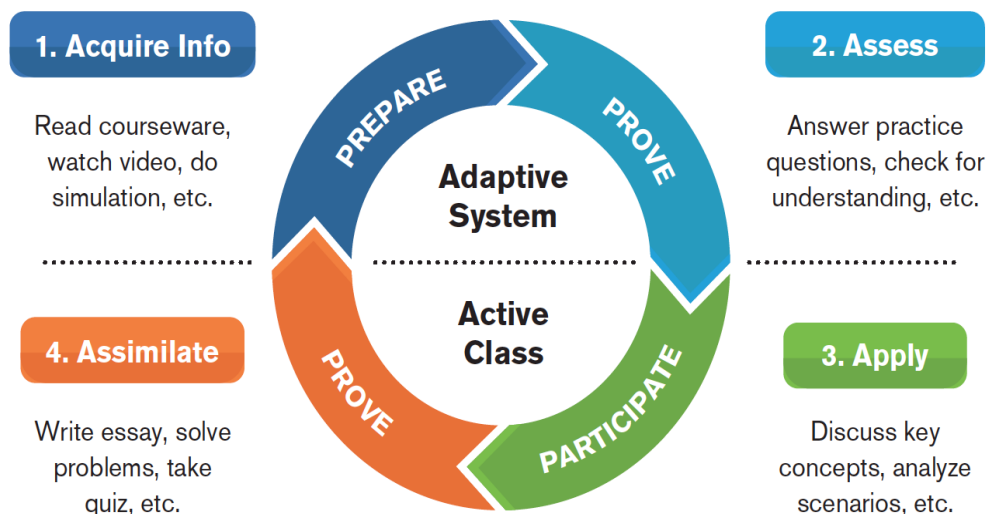

Figure 4. Roles of adaptive courseware and active learning

THE ROLE OF ADAPTIVE COURSEWARE

Adaptive courseware are technical platforms that "dynamically adjust [learning materials] to student interactions and performance levels, delivering the types of content in an appropriate sequence that individual learners need at specific points in time to make progress" (ELI, 2017, p. 1). Specifically, adaptive courseware deliver instructional resources (videos, texts, examples, exercises, etc.) and formative assessment activities (multiple choice, matching, fill in the blank, etc.) to help students master the learning objectives of each lesson. Consequently, students enrolled in the same course might have different, but more personalized experiences in a course that employs adaptive learning courseware.

Adaptive systems are nothing new; however, recent technological developments, such as a better understanding of learner behavior and knowledge through data analytics, now allow designers of these systems to develop algorithms that adapt assessments, feedback, content, and various media to individual students (ELI, 2017). The systems collect data on learner performance and progress in order to recommend lesson(s) and/or resource(s) to help each student learn as effectively and efficiently as possible. Techniques such as assessment, algorithmic analysis, agency (student feedback), and association (lesson mapping) are used to guide these recommendations.

THE ROLE OF ACTIVE LEARNING

Subsequent to engaging in individual learning activities within adaptive courseware, when in-class or online within the Learning Management System, students participated in active learning exercises that targeted higher order thinking and also helped learners develop professional skills such as critical thinking, communication, collaboration, and creativity. These exercises varied in scale and scope depending on the nature of the lesson, the amount of time available, and learning objectives of the faculty member. In general, learners were grouped into teams using various techniques (lesson progress, previous grades, random assignment, etc.) and guided through the exercises by their instructors.

Key to the development of the active learning experiences was the 5E Instructional Model by Bybee (1987). Developed as part of a Biological Sciences Curriculum Study, the 5E Model has learners collaboratively solve applied problems and investigate concepts and skills as they progress through a sequence of scaffolded learning activities. These activities are *Engage, Explore, Explain, Elaborate, and Evaluate*. Furthermore, in a more recent review, Bybee (2009) identified the model as holding the "promise as a general model for effective teaching to develop 21st century skills" (p. 11).

Summary of the BSCS 5E Instructional Model (Bybee, 2009, p. 4):

Phase Summary	Summary
Engage	The teacher or a curriculum task assesses the learners' prior knowledge and helps them become engaged in a new concept through the use of short activities that promote curiosity and elicit prior knowledge. The activity should make connections between past and present learning experiences, expose prior conceptions, and organize students' thinking toward the learning outcomes of current activities.
Explore	Exploration experiences provide students with a common base of activities within which current concepts (i.e., misconceptions), processes, and skills are identified and conceptual change is facilitated. Learners may complete lab activities that help them use prior knowledge to generate new ideas, explore questions and possibilities, and design and conduct a preliminary investigation.
Explain	The explanation phase focuses students' attention on a particular aspect of their engagement and exploration experiences and provides opportunities to demonstrate their conceptual understanding, process skills, or behaviors. This phase also provides opportunities for teachers to directly introduce a concept, process, or skill. Learners explain their understanding of the concept. An explanation from the teacher or the curriculum may guide them toward a deeper understanding, which is a critical part of this phase
Elaborate	Teachers challenge and extend students' conceptual understanding and skills. Through new experiences, the students develop deeper and broader understanding, more information, and adequate skills. Students apply their understanding of the concept by conducting additional activities.
Evaluate	The evaluation phase encourages students to assess their understanding and abilities and provides opportunities for teachers to evaluate student progress toward achieving the educational objectives.

As a final step in the design process, summative assessments had to be updated to reflect the new instructional model. The adaptive courseware and active learning offer numerous formative assessment opportunities in which learners can check their own understanding and receive feedback from various sources (e.g., machine, peers, instructor). To hold learners accountable for those activities and also provide learners an opportunity to be academically successful, the grading scheme was adjusted to reflect the importance for learners to complete all learning materials. While grading schemes differ from course to course, activities in the adaptive courseware generally account for 20% of the final grade, activities and participation in active learning for 40%, leaving another 40% to traditional summative assessments, such as exams and papers.

OVERVIEW OF KEY FACILITATION SKILLS:

The design of the adaptive+active instructional model also required to develop two key facilitation skills. The first skill was the adept use of learning analytics to identify struggling learners in large enrollment courses using adaptive courseware. Due to the digital nature of the adaptive courseware, each learner's activities and performance are tracked. Instructors need to be able to access and interpret these data quickly to ensure proper interventions. The second facilitation skill involved a change of teaching style--the transformation from lecture-style instruction to a more learner-centered, active learning approach. In particular, team efforts focused on defining the instructor role in a "classroom flip model" (Zappe, Leicht, Messner, Litzinger, & Lee, 2009). It also provided "the time and preparation needed to create and deliver [collaborative] activities" (EDUCAUSE Review, 2019, para. 1).

THE ROLE OF LEARNING ANALYTICS

Learning analytics is the practice of using data in the context of education to understand and optimize the learning experience (SOLAR, 2020). Adaptive, personalized educational approaches have been closely tied to the field of learning analytics since the early 1980s when computerized tutors taught coding and geometry using rudimentary artificial intelligence (Anderson & Corbett, 1995). In recent years, adaptive educational software platforms have used sophisticated algorithms to evaluate student background knowledge and respond as students gain mastery of educational concepts or skills (Alevan & Koedinger, 2002; Falmagne, Cosyn, Doignon, & Thiery, 2006). As learners work through course material in adaptive environments, they create unique pathways that are then recorded as data generated by the software. The data produced by learners working in these environments are especially rich because they reflect the unique characteristics of each student engaged in the learning process. This data then can be connected with

student outcomes reflected in formative and summative assessments linking each pathway with student success. These patterns of student success can be recognized through machine learning to develop predictive models.
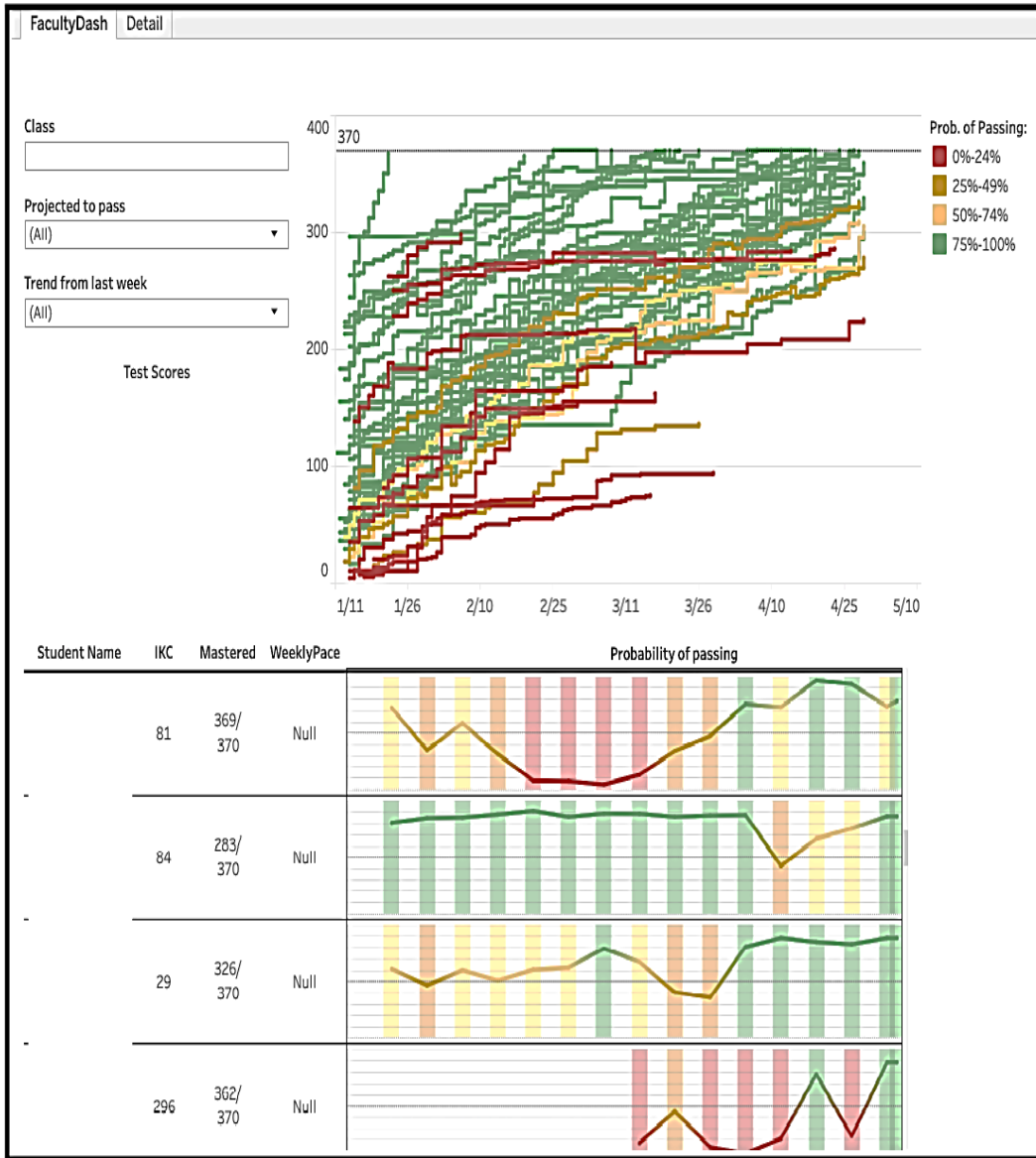

Figure 5. Example of a predictive dashboard being piloted with faculty teaching adaptive *College Algebra* classes. Colors represent varying predictions of student success.

At ASU, ongoing research is leveraging the rich data of adaptive platforms with machine learning to create predictive models of student success based on the outcomes of thousands of students. These predictions are then used to inform instructors early in the term if students are likely to be on a successful path. Because these predictions are early, interventions in the form of additional student support and scaffolding can be employed to improve student outcomes enhancing the adaptive+active instructional model. In addition to predicting student success, learning analytics are being used to evaluate the adaptive platform itself by analyzing student interactions with the software. This analysis highlights weaknesses in the course material or in the presentation of coursework that may need to be improved for greater student learning. Currently, pilot projects have been launched leveraging adaptive data; however this research is in the early stages.

THE ROLE OF THE FACILITATOR

In the adaptive+active instructional model, the facilitator is the key for a successful implementation. Foremost, the utilization of the adaptive courseware requires instructors to align in-class activities with the concepts and skills that students learn before they arrive. Hence, instructors do not need to repeat all the content that was covered in the adaptive courseware. Instead, in-class activities and assessments build upon those materials and focus on higher order thinking. By ensuring that material is not repeated, instructors hold learners accountable for the materials provided through the adaptive courseware. As Allen (1995) points out, "incorporating active learning techniques must be purposeful to carry out specific and important objectives, and must require students to use the higher order skills of analysis, synthesis, and evaluation" (p. 99).

Secondly, the shift from lecture-style instruction to more learner-centered instruction significantly impacts the role of the facilitator. In this model, the facilitator is no longer the only source of knowledge, nor are is the facilitator responsible for transferring knowledge to learners. In contrast, "successful active learning activities provide an opportunity for all students in a class to think and engage with course material and practice skills for learning, applying, synthesizing, or summarizing that material" (University of Minnesota, 2020, para. 1). This shift in classroom management is not straightforward nor can it be done individually. Mabry (1995) explains that instructors need to give up some control, so that students will learn more and retain that knowledge longer. At ASU, facilitators are supported in making this shift successfully through faculty development initiatives, peer coaching, and a continuous review and improvement approach.

CONCLUSION:

The system approach reflected in the adaptive+active instructional model has improved student success at ASU, in particular in large enrollment courses. Fundamental to this instructional model is the complementary use of adaptive courseware aligned with active learning in the classroom or Learning Management System. Beside the instructional model, teaching practices needed to reflect and match this new approach. Utilizing learning analytics effectively to inform potential interventions and implementing learner-centered teaching have been key to the overall success.

To achieve the various transformations listed in this paper, ASU stakeholders identified the need to establish a team whose members collaboratively facilitated these changes and supported faculty and departments. As subject matter experts and facilitators in most cases, faculty were fundamental to the successful design and implementation. In addition, innovative thought leaders and change agents within the institution needed to drive the transformation. Instructional designers functioned as collaborative systems thinkers who had the broad background of learning theories, teaching practices, and the technical knowledge required to design these highly complex learning experiences. Data Analysts provided the analytical mindset and skills needed to make data-informed decisions for instructional use or the evaluation of initiatives. Vendors and multimedia developers offered services that further complemented the team. Additional members, such as librarians and assessment specialists, were also considered for developing high quality learning experiences. As institutions of higher education seek to focus more and more on student success, a collaborative approach with system thinkers is at the very heart of success or failure of these transformative initiatives.

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