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## Changing the paradigm? Creating an adaptive course to improve student engagement and outcomes in introductory political science classes

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### ABSTRACT

Adaptive learning (AL) courseware holds promise for helping break down challenges students face in college. In 2016–2017 we developed an AL Political Science course, Global Issues, implemented it across 51 classes and more than 5,200 students over the next two academic years, and initiated a study to assess student perceptions and performance. In each semester, except spring 2018 when half the sections used non-AL courseware, all sections were taught using the AL courseware. Across these AL sections and on every question in a survey of student perceptions, students gave highly positive perceptive ratings of the courseware. In the spring 2018 assessment of the AL courseware versus non-AL courseware, the perceptive differences between the adaptive and non-adaptive sections were statistically significant on 12 of 14 questions (though the difference in online classes was not significant and we found significant differentiation based on instructor rank). As for student performance, the difference between AL and non-AL classes again showed overall significance, though with marked between-instructor differences and again not in online classes. It is also important to note that first-year status informed the performance results, and the average DFW rate fell significantly once the AL courseware was introduced. Our findings support the case that AL courseware can be one tool that helps provide a useful foundation for student progression, satisfaction, and performance.

### ARTICLE HISTORY

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### KEYWORDS

Adaptive learning; DFW rates; student perceptions; student performance; student success

## Introduction

In April 2016, Bill Gates told a large audience of education-technology entrepreneurs and investors that “we really haven’t changed (student) outcomes” with education technology, but he held out the promise that “we can surprise people by really making education better—both here in the United States and around the world” (Molnar 2016). This study seeks to help tackle questions surrounding the efficacy of one type of education technology, adaptive learning (AL) courseware (i.e., machine-based learning environments that adjust to a student’s abilities and prior knowledge, see below), and chip away at the puzzle pointed to not just by Gates, but also by a growing body of academic

literature (see, for example, Bailey et al. 2018; Dziuban et al. 2018; Dziuban et al. 2017; Dziuban, Moskal, and Hartman 2016; Pugliese 2016; Rashid and Asghar 2016; Yarnall, Means, and Wetzel 2016; Madaio 2015; Oxman and Wong 2014; Chen et al. 2010). As part of a grant supported by the Bill and Melinda Gates Foundation designed to implement and assess AL in large, introductory classes, we developed an adaptive-learning Political Science “Global Issues” (GI) course (i.e., we molded and enhanced an existing course using adaptive learning courseware) and implemented it across 51 classes and more than 5,200 students during the 2017–2018 and 2018–2019 academic years. At the same time, we initiated a quasi-experiment of its efficacy in addressing student performance and engagement (Georgia State University, Institutional Review Board Number: H18060, Reference Number: 345748). In the pages below, we discuss the background and challenges of the Global Issues course, review the literature and evidence to date surrounding success in the classroom, technology, and adaptive learning, and detail our process of creating the AL Global Issues class, before turning to the hypotheses, methods, results, and implications of our investigation. Our evidence suggests that adaptive courseware can help create a pathway for students to succeed in the university environment.

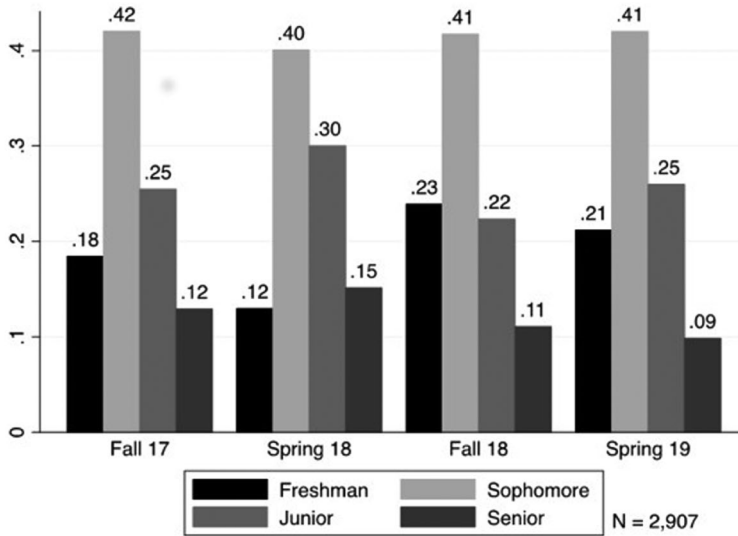
## Global issues and adaptive learning: Finding new paths to chip away at old problems?

The course we selected for this study has many large, 120-student sections, over 2,700 students annually (including summer), and generally 10–14 rotating instructors per semester (excluding summer). Almost half of the instructors are Graduate Teaching Assistants (GTAs), often teaching for the first time (see Table 1).

These courses have traditionally had broadly integrated learning goals and some shared materials—including a rotating common text and a data-literacy tool (see below)—but have also allowed for significant instructor autonomy. The undergraduate students taking these classes have significantly divergent levels of prior knowledge and overall preparedness for college. On average, almost 20 percent ( $\pm$  550 students annually) are first-year students, and over 40 percent are sophomores (see Figure 1). This landscape results in common problems found in many large, multi-section, introductory

**Table 1.** Global issues fall 2017 – spring 2019.

Semester	No. of sections		No. of students		Faculty rank		Class size	
	No. online classes	No. face-to-face classes	No. of students online	No. of students face-to-face	No. of classes taught by faculty	No. of classes taught by GTAs	Average no. of students per class	No. of classes with $\geq$ 100 students
Fall 2017	2	11	296	937	7	6	97.3	7
Spring 2018	2	8	426	668	10	0	109.4	7
Summer 2018	3	1	206	32	2	2	59.5	1
Fall 2018	1	13	389	1093	6	8	105.5	6
Spring 2019	2	8	439	728	3	7	116.7	7
Totals	10	41	1756	3458	28	23	97.68	28



The N (2,907) for Figures 1, 2, and 3 reflect the total number of students who completed the post course survey.

**Figure 1.** Global issues classes fall 2017-spring 2019 by cohort.

courses, whether in Political Science or other disciplines, including poor student preparedness for class (undermining higher level and active learning opportunities), lower-than-desired student success rates (often measured through Drop-Fail-Withdraw, or DFW, rates), weak student satisfaction and engagement, and poor student agency over their own grades and learning.

In 2016, we became part of the Gates grant with the goal of exploring and assessing the use of adaptive learning courseware in Global Issues courses. We had previously been developing tools and strategies, including digital tools and strategies, to address the challenges in these courses, and viewed AL courseware as another possible arrow in the quiver. After a systematic review of vendors through the grant's internal processes, we chose to work with the company Realizeit and create an adaptive learning course that integrated a wide variety of materials.

### ***Success in the classroom: Universal design, technology, and adaptive learning***

There is significant and diverse literature on what drives student success in the classroom. Scholars have looked at such factors as the impact of different types of instructors (Miskolczi & Márton Rakovics 2018; Chingos 2016; Silén and Uhlin 2008; Nye et al. 2004; Basow 1995), the importance of student characteristics such as socio-economic background and parental history (Dell'Angelo 2014; Misty & Tissington 2011; Epple and Romano 2011; Ermisch and Francesconi 2001), and the influence of course dynamics such as class size and mode of delivery (Miskolczi & Márton Rakovics 2018; Tobin 2017; Bolsen et al. 2016; Krueger and Whitmore 2001). With respect to curriculum development, there is an extensive literature supporting universal design (UD), with its focus on differing student needs and learning styles (Rao et al. 2014; Rao and

Tanners 2011; Roberts et al. 2011; Scott et al. 2003; Silver et al. 1998). Students can have unique propensities toward visual learning, active learning, listening, working in groups, working alone, self-pacing, creative thinking, linear thinking, and working with technology. In creating their courses, instructors need to adapt to the needs and learning inclinations of all learners so that their classes are accessible, inclusive, and transparent, and they need to have the tools to do so. While it is not the purpose here to review the literature on universal design, Rao et al. (2014) point to a range of diverse scholarly studies that support the hypothesis that universal design-based approaches lead to better student performance and engagement. However, the authors also note that because UD principles have been applied and measured in divergent ways, more work is needed to establish a “meaningful research base” on the efficacy of UD-based interventions.

Education technology is one type of intervention that could help achieve the goals of universal design, as well as other instructional needs, but as noted above there is debate as to its overall efficacy in improving student engagement and learning outcomes, even as it has become embedded in higher education. Rashid and Asghar (2016) and Chen et al. (2010) both point to the significant literature that suggests that digital tools can help improve student satisfaction and achievement, as well as to additional works which indicate that technology has had little or mixed effects, or in some cases negative effects. Their reviews suggest that it is the type of digital technology and how it is employed that is at the heart of the puzzle, and Rashid and Asghar (2016) point out that most research on education technology examines one or a few specific types of technology in seeking to better understand and address overall impact. This study follows in this line of research despite the difficulties and limitations that go with trying to unpack the layers of factors that affect student engagement and outcomes.

Adaptive learning technology is a relatively new and developing education technology with wide variations in vendors and the systems they provide (Dziuban et al. 2018; Tyton Partners 2017; Dziuban et al. 2016; Oxman and Wong 2014). Broadly, AL courseware seeks to create a machine-based, full-course learning environment that reinforces key factors that research suggests are aligned with successful learning outcomes, such as instructor creativity and engagement, universal design, and effective digital tools. Specifically, AL systems seek to:

- Use computer algorithms to dynamically adjust to a student’s abilities and prior knowledge, offer personalized (often continuous and granular) feedback, and provide guidance in determining the next steps through a flexible learning path.
- Allow students to self-pace through course modules and lessons, build competency, seek mastery, and have agency over their own grades.
- Offer real-time dashboards for students to track their progress and plan study.
- Embed a variety of learning materials that suit different student learning styles.
- Prepare students for face-to-face (F2F) class time and more active learning strategies that promote higher-level learning.
- Lead to time and cost efficacies for students, for example, if hoped-for gains in student learning and confidence lead to lower DFW rates and quicker progression through college.

- Offer real-time dashboards for instructors to track progress, reshape face-to-face class strategies toward higher-level learning, and offer personalized student interventions.
- Lead to time efficiencies for professors, as the automated systems help prepare students for class, integrate with Learning Management Systems (and grade books), allow for targeted remediation, and lessen the overall need for remediation.
- Play a role in shifting the paradigm in the higher-education learning environment by: offering new insights into how students learn; presenting new opportunities for hybrid classes and active learning; reshaping classroom functionality and class scheduling needs; and giving students at all levels more control over their own time and success.

Of course, this is the lofty promise pointed to by Gates. In reality, the evolving AL field is still sorting itself out, with often smaller and nimbler technology companies (such as Realizeit and CogBooks) competing with major publishing houses that control significant resources (such as Pearson and McGraw Hill). It is beyond the scope of this paper to survey the various AL systems and how they seek to achieve the above goals, which have been covered elsewhere (Johnson 2017; Pugliese 2016; Yarnall, Means, and Wetzel 2016; Dziuban et al. 2016). Here, we turn to academic research on the efficacy of AL courseware, also in its nascent stages.

The most comprehensive review of adaptive learning courseware is presented by Yarnall, Means, and Wetzel (2016), in a study by SRI International presented to the Gates Foundation. They synthesize evaluations, gathered between the summer 2013 and winter 2015, across nine products, roughly 19,500 students, 23 courses (including introductory courses in psychology, biology, business, economics, English, and mathematics), more than 280 instructors, and a diverse group of 14 higher education institutions (including research universities, colleges focused on undergraduate education, public community colleges, and private online colleges). Note, that each of these universities had received funding through the Gates Foundation. They also had multiple treatments and controls, looking at traditional non-adaptive lecture courses, hybrid (blended) courses, and online courses. In aggregate, their findings show adaptive learning courseware had little impact on student grades and course completion rates (whether or not students received credit for the course). Specific treatments, however, showed positive impact, including hybrid/blended AL courses over non-adaptive face-to-face courses and AL fully online courses over non-adaptive fully online courses (positive impact variously defined through posttest scores, course completion, and higher grades; note, even with such a large study, some treatments simply had too little data for comparison). Courseware products with more micro-level (individual lesson) granularity performed better than those that did not. In surveys, 74% of instructors expressed satisfaction with their adaptive courseware, and 51% of four-year college students and 77% of two-year college students said they had made positive learning gains with the AL courseware. The wide variety of products and different use cases leads Yarnall et al., to call for significantly more academic research into this shifting field, especially given the often-strong marketing claims made by the competing companies.

Other studies help fill in some of the gaps. For example, Bailey et al. (2018), in another investigation funded by the Gates Foundation, look at six diverse university cases and find some positive course-level impacts on student outcomes, defined variously through lower DFW rates, higher success rates (C or better), and higher retention and graduation rates. In one case study, they found evidence of lower DFW rates for Pell Grant-eligible students using adaptive courseware across different course types (F2F, fully online, hybrid). In another, they found retention rates for freshmen were higher for those who took at least one hybrid or fully online course. Their work also points to how adaptive learning courseware has been part of the online learning toolset that improves access for disadvantaged students, such as Pell Grant-eligible students, and leads to cost savings for universities.

Additional works focus on such areas as the stabilizing effect on learning organization and outcomes across disciplines and types of universities (Dziuban et al. 2018), and consistently positive student perceptions, again independent of university contexts, with respect to how AL courseware helps them learn material and stay engaged with a course (Dziuban et al. 2016; Dziuban et al. 2018; Dziuban et al. 2017). In seeking to add to this literature, we focused our inquiry on a large, multi-section introductory Political Science course (Global Issues), and implemented the AL courseware at scale (i.e., across almost all course sections and over 5,200 students). We then sought to gauge student perceptions of AL courseware across four consecutive fall or spring semesters, as well as more directly determine the impact of the courseware on student performance.

Our look at the performance was unique, as we sought to move past DFW, success, and course completion rates, and gauge real-time effects through common test questions administered across course types (F2F and online) in randomly selected adaptive and non-adaptive courses during a given semester (spring 2018). In addition, our study sought to hone in on the adaptiveness “black box” that comes with a specific AL system and how it is implemented, by holding other factors constant, including cost, interface, and LMS integration (see Johnson 2017 and below for more on the adaptiveness “black box”). We did not, however, seek to “unpack” our adaptive black box, which is multifaceted and unique to a specific AL platform (Realizeit) and the course content we created and/or deployed. Dziuban et al. (2018) point to how AL systems can transform the structure of learning, and how the partnerships with vendors through the adoption of AL systems make them a vital part of the learning process. This was indeed the case in our project, as it needed significant collaboration between a web of key players.

### ***Building an adaptive global issues course***

In contrast to some other introductory courses in Political Science or other disciplines, there was not an “off the shelf” adaptive Global Issues course from an outside vendor that we could choose. We knew from the beginning that we would need to fully build the course within a chosen vendor’s courseware, which would require significant time and effort, but also offer degrees of freedom in both designing the course as well as the associated academic study (note, we negotiated compensation from Realizeit for our creative work on this project). As such, our work was an innovative collaboration between two academics, an adaptive learning vendor (Realizeit), and an already extant academic



research team, amongst others. We merged a text by an outside publisher (Snarr and Snarr 1998, “Introducing Global Issues,” Lynne Rienner Publishers, 6<sup>th</sup> edition), a dynamic data literacy tool—the Robinson Country Intelligence Index, or RCII (Brown et al. 2015)—that comes with associated pedagogy, extensive open educational resources (OER), and significant original pedagogy and content into the Realizeit platform. The Snarr and Snarr text provided important background readings for many of the lessons within the Realizeit modules/learning maps, tied to key course concepts and desired learning outcomes. The RCII had previously been incorporated into most Global Issues classes to foster global, data, and digital literacy, as well as creative and critical thinking skills. Both integrated well into the Realizeit architecture (i.e., lessons and modules) through the work of IT professionals at our university and Realizeit. Graduate Research Assistants and student-interns also played an important role in researching the extensive OER built into the course (to introduce new concepts, reinforce others, and offer different avenues for content delivery, such as videos, journalistic articles, and PowerPoints) and beta testing every aspect, amongst many other supporting tasks. This team has subsequently remained engaged as the course is updated annually. Our goals were to improve overall student class preparedness and learning, allow for higher-level, more active learning in the classroom, spark student engagement while giving them some agency over their own time and grade, and provide a foundation for students as they navigate their way through college. Simultaneously, as we created the course we constructed a study to assess not just student perceptions of the courseware, but also their performance in mastering the course concepts and learning outcome goals (see [Appendix B](#) for a listing of these goals).

It is important to note that large section courses present their own challenges. We have repeatedly found that while many students perform well and are highly engaged, some do not complete class reading even if quizzed on it weekly, and sometimes they do not even purchase the book. A handful of students rarely if ever come to class, knowing it is difficult for the instructor to monitor attendance. As mentioned above, many instructors are GTAs teaching for the first time, and the undergraduate students taking these classes have significantly divergent levels of prior knowledge and overall preparedness for college. The result has been that a persistent proportion of students come poorly prepared for class, classes have lower-than-desired student performance, success, satisfaction, and engagement, students do not have enough agency over their own time and grades, and professors are less able to take classes to higher-level learning activities when applicable. We now turn to our efforts to put AL courseware to the test through the Global Issues course.

### **Putting AL to the test: Hypotheses, methods, results, and implications**

Having significant background in working to improve student engagement and performance in the large-section Global Issues class, and drawing on the broader literature on student success, education technology, and adaptive learning discussed above (Miskolczi & Márton Rakovics 2018; Bailey et al. 2018; Dziuban et al. 2018; Dziuban et al. 2018; Dziuban et al. 2017; Johnson 2017; Tobin 2017; Tyton Partners 2017; Yarnall, Means, and Wetzel 2016; Bolsen et al. 2016; Chingos 2016;



Rashid and Asghar 2016; Dziuban et al. 2016; Pugliese 2016; Yarnall, Means, and Wetzel 2016; Oxman and Wong 2014; Dell'Angelo 2014; Rao et al. 2014; Rao and Tanners 2011; Roberts et al. 2011; Misty & Tissington 2011; Epple and Romano 2011; Chen et al. 2010; Silén and Uhlin 2008; Nye et al. 2004; Scott et al. 2003; Ermisch and Francesconi 2001; Krueger and Whitmore 2001; Silver et al. 1998; Basow 1995), we approached the project with some belief that the AL courseware could help improve student perception of course materials and student performance. We were more skeptical of a positive impact on DFW rates, particularly in the short term, despite some positive results reported in previous studies (see above). Our skepticism was tied to the challenges presented by large-section courses, as well as the already ongoing and award-winning work at our university to bring these rates down (Anderson 2018; McMurtrie 2018). We also hypothesized that student and instructor characteristics could be factors in student satisfaction and success, again drawing on the extant literature discussed above. To the point, we began our work with four working hypotheses and multiple sub-hypotheses:

**Hypothesis 1:** Students will have consistent and highly positive perceptions of the AL courseware.

**Hypothesis 2:** Students will have consistent and statistically significant positive perceptions of the AL courseware as compared to non-adaptive courseware.

**Sub-hypothesis 2.1:** These results will be roughly the same in face-to-face courses and online courses.

**Sub-Hypothesis 2.2:** The strength of positive perceptions when compared to non-adaptive courseware will be stronger for Pell Grant students, first-generation students, students who showed weaker high school success (as measured through SAT scores and high school GPA), and first-year students.

**Sub-Hypothesis 2.3:** Individual instructor characteristics, such as rank, could have an impact on positive student perceptions.

**Hypothesis 3:** The AL courseware will have a statistically significant positive impact on student performance as measured through common test questions prepared for this study and as compared to non-adaptive courseware.

**Sub-Hypothesis 3.1:** These results will be roughly the same in face-to-face courses and online courses.

**Sub-Hypothesis 3.2:** The strength of positive performance improvements when compared to non-adaptive courseware will be stronger for Pell Grant students, first-generation students, students who showed weaker high school success (as measured through SAT scores and high school GPA), and first-year students.

**Sub-Hypothesis 3.2:** Individual instructor characteristics could have an impact on positive student performance.

**Hypothesis 4:** The AL courseware will not have a significant impact on student success rates as measured through DFW rates over the study's duration (though this could occur over a longer period of time).

As mentioned above, to measure the “adaptivity” of the courseware, we sought to hold certain factors constant, including cost, interface, and LMS integration. To this end, we built both our adaptive and non-adaptive courses using Realizeit. The non-adaptive course mirrored how the course had traditionally been taught, with students being given a weekly chapter to read out of an assigned textbook, and then taking a multiple-choice quiz on it at the end of the week. The only difference for our quasi-experiment was that the students using the non-adaptive courseware now completed their work in Realizeit instead of the university's LMS. In other words, we sought to trade one digital platform for another without altering functionality so as to isolate the “black box” of our adaptive courseware. Most of the rest of the design of the non-adaptive courses was left to the individual instructors, which is how the classes had previously been administered. The adaptive course, on the other hand, used the full functionality and robustness of the adaptive courseware we developed, which promised a “black box” of different methods and impacts, including:

- Students gaining more agency over their own grades and the ability to build competence and seek mastery (i.e., instead of the more traditional chapter/quiz design in non-AL courses, students could both self-pace and seek mastery)
- The mapping of required and granular lessons into modules through the Realizeit platform, all specifically tied to learning outcome goals (again, as opposed to the more traditional model)
- The integration of a rich array of OER (which was offered as additional content to instructors in non-adaptive courses to use as they saw fit)
- The Realizeit algorithm, which seeks to adjust to student's abilities, offer flexibility and suggestions for next steps, and provide feedback
- The interactive dashboards provided to students and instructors
- Possible changes in how class time was used

Clearly, what we created was unique to the different layers that made up our adaptive black box (discussed above). And indeed, these layers are embedded in the broader layers (a broader black box) associated with success in the classroom mentioned above, such as the general implementation of education technology, the rough alignment with universal design, and the importance of instructors. While our study only focuses on one layer within these different levels of analysis—adaptive v. non-adaptive courseware—and certainly has its limitations, we argue that seeking to assess our unique adaptive black box can help inform the budding research on AL courseware, and possibly success in the classroom more generally.

To assess student perceptions of the courseware, we developed an extensive survey (see [Appendix A](#)) in collaboration with other professors on the Gates grant. This survey was administered anonymously by the university's Center for Excellence in Teaching and Learning for four consecutive fall/spring semesters (fall 2017-spring 2019) to

measure the persistence of perceptions over time. [Table 1](#) (above) outlines the number of sections participating (face-to-face or online), the aggregate number of students per section type, ranks of the instructors (GRAs or faculty), and average class sizes. All sections listed used the AL courseware, except in the spring of 2018, when there were adaptive and non-adaptive sections participating in the study.

To gauge student performance, we used 36 common questions that each instructor in the spring of 2018 four group (F2F and online, with adaptive and non-adaptive sections for each) study was asked to give on one of their three tests that term (see [Appendix B](#)). Note, the instructors designed their own courses and tests and could place these questions where they thought best (i.e., there was variety in course modular flow, as well as test style and sequencing). Instructors were assigned to adaptive and non-adaptive sections by coin flip; three instructors had both an adaptive and a non-adaptive course (sections also determined by coin flip). In all, five instructors participated in spring 2018 with a total of 1094 students. Also note, by chance and unique to this semester, all these instructors were full-time faculty with comparable levels of teaching experience. Finally, it should be pointed out that after having piloted the adaptive learning course in fall 2017 in 13 sections (face-to-face and online; six taught by GRAs) and over 1,200 students, all participating spring 2018 instructors wanted to continue using the adaptive courseware.

### ***Perceptive results***

As noted above, the surveys on student feedback and student experience (found in [Appendix A](#)) were administered to students for four consecutive fall/spring semesters fall 2017-spring 2019. In each of these semesters except spring 2018, all sections of the course were taught using the AL courseware. Across these AL sections and on every question, students gave highly positive perceptive ratings of the courseware, supporting Hypothesis 1. [Figure 2](#) shows the positive/negative perception breakdown of the AL courseware by semester on the broadest question: “How would you rate the overall quality of the adaptive learning courseware tool?” [Figure 3](#) shows the aggregate responses to key survey questions across the four targeted semesters. This data gives a strong indication that students in AL sections believe they are learning the material and are setting the groundwork for future success. For example, when asked whether taking a course with the adaptive learning courseware had “influenced how they will study for future classes,” 69% of students answered positively, while only 5% answered negatively. Seventy-eight percent of students positively responded that the adaptive courseware “helped them learn the material,” while only 6% answered negatively. Eighty-one percent said the AL courseware “helped them track their progress,” while only 5% answered negatively.

For the spring 2018 term, when half the F2F and online sections used non-adaptive courseware, the perceptive differences between the adaptive and non-adaptive courseware were strongly statistically significant on 12 of the 14 questions, as seen in [Table 2](#), supporting Hypothesis 2. However, our hypothesis that students would have similar significant positive perceptive results in both face-to-face and online classes was not supported. Our findings were that while both cohorts had positive perceptions of the

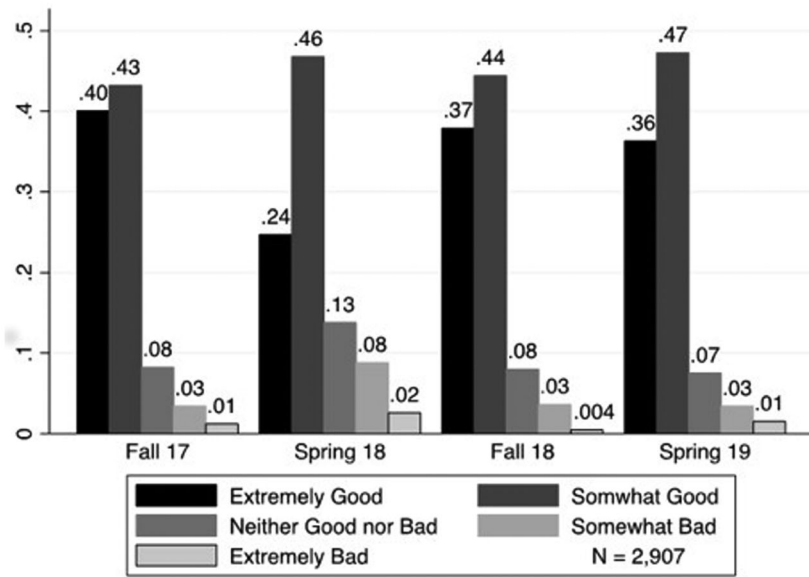


Figure 2. Student “overall” positive/negative ratings of courseware.

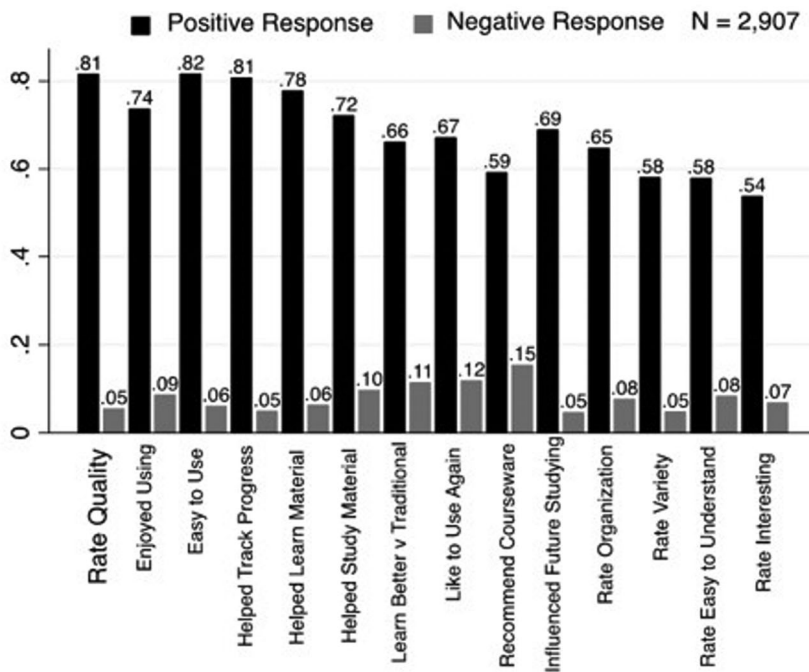


Figure 3. Aggregate survey question responses across the four semesters.

courseware across the questions, only the face-to-face students’ perceptions were statistically significant. This finding goes against the research findings of others (Yarnall, Means, and Wetzel 2016) and provides the impetus for future investigation. Possible

**Table 2.** Perceptive results of spring 2018, AL vs. non-AL classes.

Survey question	Adaptive	Non-adaptive	Diff	P-Value
Rate quality of courseware*	4.13	3.94	0.18	0.01
Enjoyed using*	4.02	3.76	0.25	<0.01
Easy to use*	4.29	4.15	0.13	0.1
Helped track progress*	4.37	4.18	0.18	0.01
Helped learn material*	4.19	4.01	0.18	0.03
Helped study material*	4.13	3.85	0.28	<0.01
Learned better v. traditional*	3.94	3.72	0.21	0.02
Like to use again*	3.95	3.67	0.28	0.01
Recommend courseware*	4.01	3.71	0.3	<0.01
Influenced studying in future*	3.81	3.42	0.38	<0.01
Rate organization+	2.88	2.53	0.02	0.72
Rate variety+	2.6	2.46	0.14	<0.01
Rate easy to understand+	2.45	2.38	0.07	0.18
Rate interesting+	2.47	2.36	0.11	0.05
N = 561				
* = 1–5 Scale, + = 1–3 Scale				

explanations include the distinctiveness of students who sign up to take online classes or the way the classes were taught by the professor teaching online GI classes in spring 2018.

In testing our other sub-hypotheses, we found that the effect of AL courseware on perception did not vary when accounting for Pell Grant eligibility, first-generation students, high school performance, or first-year students (i.e., we found no support for sub-hypothesis 2.2). This provides further evidence that the differences in student perception were driven by the AL courseware. We also explored variation in student survey responses across three classifications of instructors: graduate teaching assistant (1,338 students), regular faculty (623 students), and the instructors who created the AL course (799 students). First, we modeled the responses to each individual question across each instructor and each instructor group. We then combined all survey questions using both an additive index and a principal component factor analysis for robustness, so that each student is assigned two aggregate satisfaction scores on a 0–1 scale (see [Appendix C](#)). When evaluating the effect of instructor classification on aggregate satisfaction, we consistently find that students responded most positively to the courseware when instructed by the AL course creators, followed by GTAs, and finally the regular department faculty. The differences between these groups are statistically significant and possibly point to better adoption of the technology by younger, less seasoned instructors over those who had taught the course for multiple years and were not the AL course creators. They also point to the overall relevance of investigating instructor impact, as outlined above.

**Performance results**

As noted, in spring 2018, we asked all instructors teaching Global Issues to use 36 common questions on one of their three tests. Compliance with this request was not 100%; one professor asked all questions; one asked 34; one asked 33; one (online sections) asked 29; and one failed to correctly ask any of the requested questions. Still, 31 common questions were asked of almost all face-to-face students, 29 common questions were asked of all online students, and 24 common questions were asked of almost all

students, with large numbers of students in both the adaptive and non-adaptive pools. These different groupings made our study more complicated but left ample ground to test our performance hypotheses.

As seen in [Tables A3](#) and [A4](#) in [Appendix D](#), for face-to-face students (where there were 31 common questions), the performance difference between AL and non-AL classes was statistically significant and translated to students in adaptive sections scoring roughly four percentage points higher across these questions. In online sections (where there were 29 common questions), the students in the adaptive section scored only .73 percentage points higher than those in the non-adaptive section, and this improvement was not statistically significant. Across all sections (where there were 24 common questions), the performance difference between AL and non-AL classes was statistically significant and translated to students in adaptive sections scoring 1.88 percentage points higher across these questions. Notably, across the 24 common questions taken by all students in the study, there was not a statistically significant difference between online and F2F adaptive students, strengthening the case for overall significance. These results show support for Hypothesis 3 that AL courseware drives an increase in performance.

However, our sub-hypotheses paint a more nuanced picture. For sub-hypothesis 3.2, there was no variation in the effect of AL courseware on performance when accounting for Pell Grant-eligible students, first-generation students, or students with weaker high school performance, but we did find that the impact of AL courseware on performance was found primarily among first-year students, as opposed to sophomores, juniors, and seniors. These results are presented in [Table A5](#) in [Appendix D](#). The substantive impact of AL courseware on first-year students is presented in [Figure A3](#) in [Appendix D](#), indicating that AL courseware is associated with first-year students answering 2 more questions correctly in face-to-face classes. Note, overlapping confidence intervals indicate no significant difference between AL and non-AL courseware in online classes, reflecting findings elsewhere. This evidence offers some support to the findings of Bailey et al. (2018) that AL courseware can be part of the online learning toolset that improves access for first-year students.

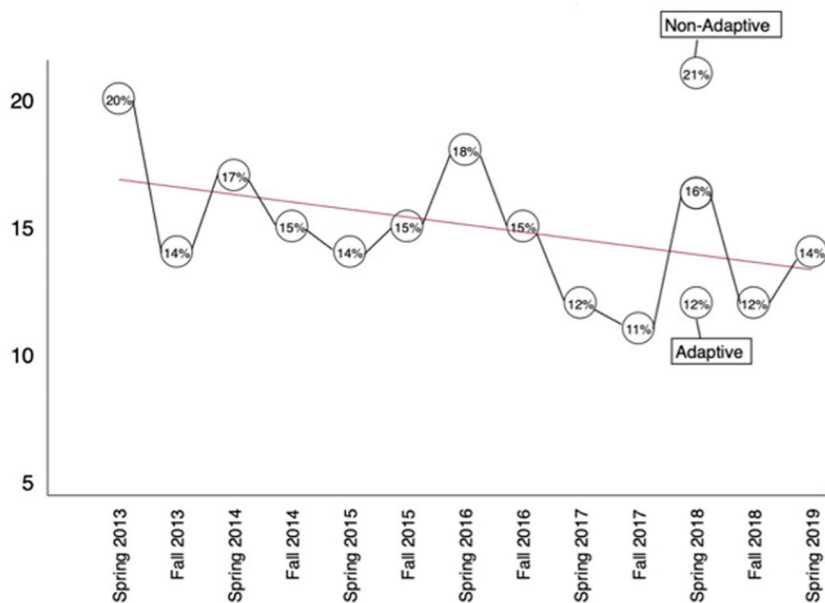
With respect to sub-hypothesis 3.3, we assessed between-instructor differences. Among the instructors who participated in the Spring 2018 experiment (all full-time faculty), *Instructor 1* and *Instructor 2* each taught two face-to-face classes, one that utilized the AL courseware and another that used the non-AL courseware. *Instructor 3* taught one course, and that one course featured the AL courseware. *Instructor 4* taught two online courses, one using AL-courseware and one featuring non-AL courseware. As seen in [Table A6](#) in [Appendix D](#), the effect of courseware on performance is highly conditional on the instructor. *Instructor 1*'s students, for example, achieved an improvement of 1.25 correct answers (5 percentage points) when using the AL courseware when compared to non-AL courseware. *Instructors 2* and *4*, however, show no statistical or substantive difference between the two groups. Confounding these results further, *Instructors 1* and *2* are the AL course creators, indicating that the instructor's relationship to the courseware is not driving its impact. As a result, we find only limited support for Hypothesis 3.0, that AL courseware improves performance in the classroom. There is some indication among first-year students and students in F2F classrooms, but improvement may be conditional on the instructor.

**DFW rates**

With respect to Drop-Fail-Withdraw (DFW) rates, [Figure 4](#) shows the significant fluctuations in these rates between 2013 and 2019 for spring and fall courses (summer courses—where there are far fewer classes, classes are in a different format given shorter durations, and class sizes tend to be smaller—generally have lower rates). Still, the average spring/fall DFW rates fell as the AL courseware was introduced. The mean DFW rate from 2013 to 2019 in non-AL courses was approximately 16%, while the mean of AL courses was 12% (see [Figure 4](#)). This difference is statistically significant. Furthermore, in the spring of 2018, in which both adaptive and non-adaptive courses were offered, the DFW rate in adaptive courses was approximately 9 percentage points lower than in non-adaptive courses (21% vs. 12%). This promising finding undermines the skepticism noted in Hypothesis 4 above and supports the case that the AL courseware can provide a useful foundation for student progression and success. However, a downward trend line from spring 2013 through spring 2019 is also evident, possibly reflecting the ongoing work by our university to provide more substantial student advising and support to bring these rates down. In other words, it is not fully clear if the introduction of AL courseware helped bring these rates down, or if our findings reflect an already extant trend.

**Implications and final thoughts**

Overall, the data provided here adds to the growing body of literature on success in the classroom and adaptive learning and lends support that AL can help improve engagement, academic confidence, and possibly performance, with some evidence that these improvements are more robust in face-to-face classes and during the first year. The reasons why online classes did not stand out in our results in comparison to other studies need further



**Figure 4.** Global issues DFW rates, 2013–2019.



examination. Despite our skepticism, evidence of lower DFW rates indicates that AL likely plays a role in increasing student retention and facilitating progression toward graduation, though this finding needs further examination given existing trends with respect to these rates. We believe our results to date with adaptive learning augur that academic leaders should consider how to continue to support building AL courses as technology continues to shift the academic playing field. However, there are many levels of analysis when trying to unpack how to improve student engagement and performance. Our evidence of an instructor's impact with respect to both student perceptions and outcomes when using AL courseware reinforces the interrelated complexity of this line of inquiry and highlights the limitations of our study. Our work is simply one additional steppingstone that points to the need to continue to develop a stronger research foundation both with respect to broader factors leading to success in the classroom, as well as narrower factors tied to specific educational technologies, such as adaptive learning courseware.

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## Appendix A: Student survey

### Student feedback

1. How would you rate the overall quality of the adaptive learning courseware tool?

- Extremely good
- Somewhat good
- Neither good nor bad
- Somewhat bad
- Extremely bad

2. How would you rate the adaptive learning courseware as compared to a traditional textbook in terms of content?

	Better	Worse	About the same	Unsure
Organization	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Variety (range of content)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Easy to understand	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Interesting/compelling	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

### Student experience

To what extent do you agree or disagree with the following statements:

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
I enjoyed using the adaptive learning courseware.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The adaptive learning courseware was easy to use.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Using adaptive learning courseware helped me track my progress.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The adaptive learning courseware helped me learn the course material.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The adaptive learning courseware helped me to study the course material.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Using adaptive learning courseware helped me to learn the course material better than I would have in a traditional non-adaptive course.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
In the future, I would like to take another course that uses adaptive learning courseware.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I would recommend that other students take a course using adaptive learning courseware.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Taking a course with adaptive learning has influenced how I will study for future classes.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

## Appendix B: Common questions

### *Global issues learning outcomes*

- A. Identify key structural features of the contemporary international system (actors, processes, institutions)
- B. Identify the UN and its main organs, recognize other major IGOs, and be able to illustrate with examples the difference between IGOs, NGOs, and MNCs
- C. Outline major security challenges (weapons proliferation, terrorism, war, etc.) and be able to assess different ways in which these challenges are being addressed
- D. Outline other major global challenges, such as those tied to human rights, economic development, and environmental sustainability, and articulate the different positions and perspectives surrounding these topics (what are they? what solutions do they offer? etc.)
- E. Identify, explain, and visualize data, and apply key indicators to global issues and challenges

### *Questions subdivided by outcome*

- A. *Identify key structural features of the contemporary international system (actors, processes, institutions), and*
- B. *Identify the UN and its main organs, recognize other major IGOs, and be able to illustrate with examples the difference between IGOs, NGOs, and MNCs*
  1. One of the main driving forces of globalization is:
    - a. The influence of cultural icons like Lebron James
    - b. Socialism
    - c. The significant increase in war between states since 1968
    - d. Information Technology
  2. Multinational Corporations (MNCs, sometimes called TNCs) are:
    - a. Non-state (non-governmental) actors, focused on profit
    - b. International Governmental Organizations (IGOs), like the IMF
    - c. Illegitimate actors on the world stage
    - d. Nonprofit organizations (NGOs), like Doctors Without Borders
  3. The benefits that all International Governmental Organizations (IGOs) offer their members include:
    - a. The establishment of regulations that limit the sovereignty
    - b. The creation of habits of cooperation between states
    - c. Guidance on setting up democratic institutions from the United States and the European Union
    - d. Direct negotiation of all disagreements between member states
  4. Which of the following is not a Non-Governmental Organizations (or NGO)?
    - a. The Red Cross
    - b. Greenpeace
    - c. The European Union
    - d. Amnesty International
  5. A “state”:
    - a. Is the same thing as a nation
    - b. Is the opposite of what we mean by a country
    - c. Is a product of 20th century “contemporary liberalism”
    - d. Is a political unit that has sovereignty over a geographic area
  6. The drawing of state borders on maps during the age of exploration and colonialism:
    - a. Led to the weakening of sovereignty and national identity in world affairs

- b. Paved the way for rulers to exert sovereignty over specific areas, as opposed to the more fluid/shifting boundaries found under feudalism
  - c. Decreased citizen participation in government in the countries that were drawn
  - d. Was a key aspect of medieval feudalism, leading to local identities tied to local nobles
- 7. Nations are best defined as:
  - a. The same now as they were under medieval feudalism
  - b. Synonymous with states
  - c. Products of the Treaty of Aix-la-Chapelle in 1748
  - d. Groups connected by a unique mix of shared ethnicity, language, religion, culture, history, and/or sense of civic community
- 8. Nationalism and religion:
  - a. Have never been mixed in the United States
  - b. Are generally considered the only illegitimate causes of social violence
  - c. Can be considered the two most powerful forms of identification in the world today
  - d. Have sparked little violence in the world outside the Middle East
- 9. State sovereignty is:
  - a. The right of states to self-government, with political leaders determining the rules, laws, and processes within their territories
  - b. Nullified by the Charter of the United Nations, which establishes global government
  - c. Seen primarily in Europe, the United States, and Japan, with former colonies now just recognizing that they have sovereign rights
  - d. Regularly undercut by the ICJ for economic reasons
- 10. The five permanent members of the UN Security Council are:
  - a. United States, India, China, Russia, Japan
  - b. United Kingdom, United States, China, Russia, France
  - c. United States, India, China, Russia, France
  - d. United Kingdom, United States, Germany, China, Japan
- 11. A founding objective of the United Nations is to:
  - a. Solve the ongoing crisis in Israel
  - b. Maintain peace and security
  - c. Militarily intervene whenever human rights are violated
  - d. Establish a world government
- 12. Which of the following is NOT an example of “hard” power?
  - a. A cyberattack on a country to shut down its power grid
  - b. The capacity to work within multilateral coalitions and attract other countries to your view
  - c. The size of nuclear arms stockpiles within a particular state
  - d. Economic power, such as with the use of economic sanctions by a particular state
- C. *Outline major security challenges (weapons proliferation, terrorism, war, etc.) and be able to assess different ways in which these challenges are being addressed*
- 13. *Which of the following is an example of horizontal weapons proliferation?*
  - a. When North Korea produces plutonium for use in its nuclear weapons program.
  - b. When the United States sells Patriot missiles to Saudi Arabia.
  - c. When Russia modernizes its nuclear weapons and delivery systems.
  - d. When China increases the number of nuclear bombs and missiles in its stockpiles.

14. What is the difference between intra-state conflict and traditional war?
  - a. Intra-state conflicts claim fewer than 1,000 deaths whereas traditional wars claim more than 1,000 deaths
  - b. Intra-state conflict is subject to UN Security Council oversight, whereas traditional war is outside the reach of the UN
  - c. Intra-state conflicts are fought in less developed countries, whereas traditional war is fought in more developed countries
  - d. Intra-state conflict involves at least two groups within a state, whereas traditional war involves conflict between states
15. Under the traditional concept of security, policymakers:
  - a. focus on protecting the state from foreign military attacks
  - b. look to traditions to provide security for the state
  - c. assess the impact of environmental, social, and other interconnected threats to determine how to promote security
  - d. leave security policy to intelligence analysts
16. Which of the following is NOT a required part of a definition of terrorism?
  - a. The violence is premeditated and political
  - b. Attacks are intended to influence an audience
  - c. Attacks are concentrated against civilians and noncombatants
  - d. Attackers must follow a specific religion
17. Weapons of mass destruction (WMD) seem to strengthen deterrence because they:
  - a. Increase the damage that can be inflicted on an attacker
  - b. Are useful under any war situation
  - c. Are cheap and easy to use
  - d. Even the playing field because every state has WMDs
- D. *Outline other major global challenges, such as those tied to human rights, economic development, and environmental sustainability, and articulate the different positions and perspectives surrounding these topics (what are they? what solutions do they offer? etc.)*
18. European colonial economic policies can be described as:
  - a. Neoliberalism
  - b. Mercantilism
  - c. Socialism
  - d. Contemporary Liberal
19. For people and countries to develop and prosper, they need:
  - a. Less Foreign Direct Investment (FDI) and fully protected domestic economies
  - b. Free market systems without any government involvement in the economy
  - c. Capital (goods, services, and money)
  - d. More people than in other countries
20. The World Bank and the IMF are part of what post-World War II system?
  - a. G-77
  - b. Bretton Woods system
  - c. Cold War system
  - d. European Union
21. In a socialist system:
  - a. Countries try to become dependent on primary products
  - b. Capitalism is found only in urban areas and import-substituting zones
  - c. The state owns and controls key means of production
  - d. Most of the economy is privately held



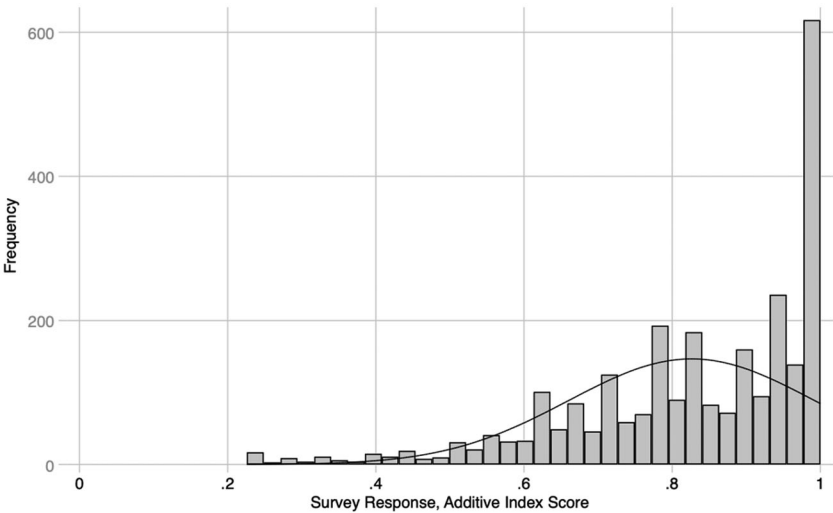
22. The primary role of IMF loans is to:
  - a. Provide financial assistance to the Security Council in matters of peacekeeping
  - b. Provide loans for democratization in developed countries
  - c. Help stabilize a country's economy when the country has severe budgetary imbalances
  - d. Assist countries pursuing export promotion through high tariff promotion
23. Classic liberal trade theory holds the view that:
  - a. Free trade without governmental interference will eventually benefit all economies in the international system by ensuring efficiency in the production and distribution of goods and services
  - b. Too much dependence on trade should be discouraged because it leads to dependence on foreign economies and governments and therefore a loss of sovereignty
  - c. Governments should not hesitate to intervene in controlling international trade if it is necessary to protect domestic jobs and industries
  - d. Governments should continually protect their infant industries with trade barriers so that they can become competitive in the international arena
24. Those who caution against free trade generally argue:
  - a. Countries can be forced to significantly strengthen (raise) their environmental and labor standards in order to compete with countries where these standards are lower
  - b. Free trade can lead to functionalism, neo-functionalism, and war
  - c. Countries should try to become dependent on a few agricultural products
  - d. Free trade leads to dislocations which can cost people their jobs
25. Losing a case through the WTO disputes settlement mechanism could lead a country to face:
  - a. Economic sanctions or a withdrawal of trade concessions by the winning state
  - b. A total trade embargo by the United States
  - c. Being forced to rewrite laws declared unconstitutional by the WTO
  - d. Military force
26. What is the definition of "relative poverty"?
  - a. Relative poverty is estimated at \$32,250 per family of four
  - b. Relative poverty is based on a comparison with a defined group within a particular country
  - c. Relative poverty is estimated at \$2.10 per capita
  - d. Relative poverty is the number of poor people in a country
27. South Korea and other East Asian states have pursued strategies that have included:
  - a. Withdrawing from APEC and ASEAN because of the 1997 East Asian economic crisis
  - b. Strong investments in education and efforts to allow the poor to share in rapid growth
  - c. Closing their markets to MNCs, particularly from the U.S.
  - d. Ending the government's role in industrialization
28. Which of the following is INCORRECT concerning trends in global population growth?
  - a. The world's population continues to grow but the rate of population growth is decreasing
  - b. Fertility rates in the least developed countries are declining but are still very high
  - c. More than 80% of the world's population is located in the less-developed world
  - d. Women in developed regions of the world have higher fertility rates than women in less developed regions

29. The demographic transition model suggests that as societies industrialize and urbanize:
  - a. Death rates will fall, and when values shift from large to small families, fertility rates will decline
  - b. Fertility rates will play an unimportant role compared to death rates
  - c. Populations will grow at almost identical rates in states with emerging economies
  - d. The decline in fertility rate occurs at the same time as the decline in the mortality rate
30. The majority of the world's refugees and internally displaced people are:
  - a. Men (women and children generally get left behind)
  - b. Women and children
  - c. Latin American (mostly Mexican and South American)
  - d. In the United States
31. Which of the following is an example of a civil and political right (or first-generation right)?
  - a. Everyone has the right to education.
  - b. Everyone has the right to rest and leisure.
  - c. Everyone has the right to freedom of thought, conscience and religion.
  - d. Everyone has the right to work.
32. Which of the following is an example of an economic and social right (or second-generation right)?
  - a. No one shall be subjected to torture or to cruel, inhuman or degrading treatment or punishment.
  - b. Everyone has the right to a nationality.
  - c. No one shall be subjected to arbitrary arrest, detention or exile.
  - d. Everyone, without any discrimination, has the right to equal pay for equal work.
33. When was the Universal Declaration of Human Rights adopted?
  - a. 1948
  - b. 1945
  - c. 1966
  - d. 1992
34. While \_\_\_\_\_ is a term that refers to the concern that increased greenhouse gases increase the earth's temperature, \_\_\_\_\_ is the term that includes reference to changes in extremes of temperatures and precipitation.
  - a. Gaseous warming process/weather change
  - b. Ozone layer depletion/natural disasters
  - c. Climate change/global warming
  - d. Global warming/climate change
35. The model used to explain why communities might overexploit shared environmental resources even when they know that it could be against their long-term interests is known as:
  - a. resource overexploitation
  - b. privatization
  - c. the "tragedy of the commons"
  - d. "exploit and move on"
36. Sustainable development involves:
  - a. Reducing consumption, increasing efficiency, and using renewable energies
  - b. Constructing larger buildings using stronger design and materials
  - c. Developing better transportation by building more roads
  - d. Searching for more deposits of fossil fuels to accommodate current demands

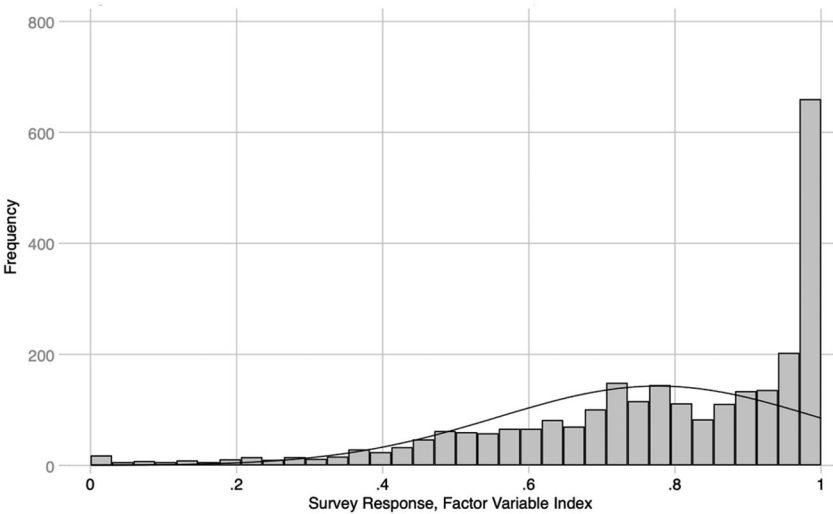
**Appendix C: Calculation of aggregate perceptions**

To generate overall scores for student perceptions of the courseware, we employed a normalized additive index and a normalized factor score. To calculate the additive index, we summed the total response scores of all questions, then divided them by the sum of the highest possible response values for all questions, similar to generating a batting average in baseball. For example, if a student responded with the highest possible mark for all survey questions except “*I enjoyed using the adaptive learning courseware,*” in which the student responded, “somewhat agree,” the student’s additive index score would equate to 61/62, or 0.983. [Figure A1](#) presents the distribution of the additive index scores across all responses.

For robustness, we also generated a principal factor score for the 14 questions included in the survey. We have normalized this factor score for comparison’s sake on a scale from 0 to 1. The eigenvalue of the factor is 8.02. The distribution of this factor variable is presented in [Figure A2](#).



**Figure A1.** Distribution of additive index.



**Figure A2.** Distribution of factor variable.

The pairwise correlation of the two indices is 0.9979, with descriptive statistics of each index presented in Table A1. Table A2 provides the mean scores for each instructor classification group with associated standard errors.

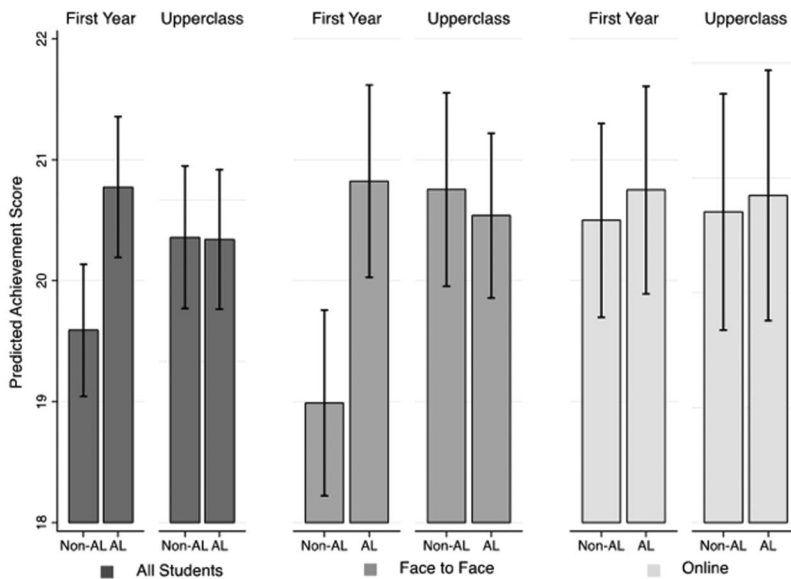
**Table A1.** Descriptive statistics.

	<i>N</i>	Mean	Standard deviation	Min	Max
Additive Index	2,679	0.826	0.165	0.225	1
Factor Index	2,679	0.776	0.219	>0.0	1

**Table A2.** Effect of instructor classification on aggregate evaluation.

	Aggregate evaluation:		Aggregate evaluation:	
	Additive index		Factor score	
	Score	Std. Error	Score	Std. Error
Faculty	0.78	0.006	0.72	0.009
Graduate Teaching Assistant	0.83	0.004	0.78	0.006
Course Designer	0.86	0.005	0.82	0.008

## Appendix D: Measuring student performance, tables and figures



Note: Predicted achievement score conditional on first year status and AL courseware with 95% confidence intervals.

**Figure A3.** AL courseware and first year students.

**Table A3.** Performance results, F2F, online, and all – difference of means.

Difference in means – total correct – students missing 5 questions or less					
	Adaptive	Non-adaptive	Difference	One tailed P	P Value
All students – F2F and online – 24 common questions					
Total Correct	20.63	20.18	+ 0.45	0.01	0.03
N	685				
F2F students only – 31 common questions					
Total Correct	25.9	24.67	+ 1.23	<0.001	<0.001
N	366				
Online students only – 29 common questions					
Total Correct	24.98	24.75	+ 0.23	0.25	0.51
N	319				

**Table A4.** Performance results, F2F, online and all – scores.

	Adaptive	Non-adaptive	
All students	85.98%	84.10%	$P = 0.03$
Face to face	83.55%	79.58%	$P = <0.001$
Online	86.16%	85.34%	$P = 0.51$

**Table A5.** Effect of AL courseware & first year student status on achievement.

	All students Coef. (S.E.)	Face to face Coef. (S.E.)	Online Coef. (S.E.)
Adaptive	0.36* (0.23)	0.67** (0.34)	0.1 (0.3)
First year	-1.93*** (0.56)	-1.72** (0.7)	-1.82* (0.99)
Adaptive * first year	1.23 (0.78)	1.28 (1.01)	0.89 (1.3)
Constant	20.43*** (20.43)	20.04 (0.23)	20.82*** (0.21)
N	525	271	254
R <sup>2</sup>	0.03	0.05	0.02

OLS standard errors in parentheses. \*\*\* $p < 0.01$ , \*\* $p < 0.05$ , \* $p < 0.1$ .

**Table A6.** Effect of AL courseware on achievement by instructor.

		Est. Score	Difference	95% Lower bound	95% Upper bound	N
Instructor 1	Adaptive	20.025	0.27	19.25	20.79	41
	Non-adaptive	18.75		18.13	19.36	69
Instructor 2	Adaptive	20.73	-0.02	20.13	32.31	73
	Non-adaptive	20.75		20.19	32.32	85
Instructor 4	Adaptive	20.87	0.13	20.42	21.31	137
	Non-adaptive	20.74		20.31	21.16	139