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Work-in-Progress: A Review of the Type, Breadth, and Limitations of Publicly Available Educational Technology Products in 2022

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Introduction and Motivation

One of the major changes in the higher education ecosystem over the last decade has been a rise in the availability of education-based software products, including education-based web-pages and web-services. Globally the investment in education-based startups in 2017 was $9.5B which surged to $18.7B in 2019 [1]. The COVID-19 pandemic further fueled record investment in this sector, with the US seeing $2.2B invested in 130 startups in 2020, up from $1.7B in 2019 and $1.4B in 2018 (see [2] and [3]). Early indicators show that 2021 will again see further increases [4]. While the majority (92%) of these investments are aimed at consumer and corporate sectors, there is potential for the innovations developed to diffuse into both the P-12 and higher education spaces [5]. What is evident from the investment numbers is that an integration of learning technologies specifically into higher education is progressing at a relatively slower pace [5]. It is the goal of this work-in-progress to identify some of the reasons for this slower progress. Our hypothesis is that, while some of these reasons may be obvious, there are also more subtle and/or counterintuitive reasons for the reduced interest in higher education.

The motivation and need for the proposed study grew out of an ongoing NSF RED project where we endeavor to fuse the concept of convergence, loosely defined as "deep integration," into our undergraduate engineering curriculum. Increasingly software and data systems at colleges and universities, and the affordances they do and do not offer, are integral to university structures. If the respective software systems do not support certain activities and functions then the programs are simply not useful to the faculty [6]. Additionally, any subset of systems needs to seamlessly integrate to form a coherent and usable learning support system that faculty, students, and staff can use without issue and/or barrier. The goal of the proposed activity within our grant is, thus, to build structures to collect, analyze, and display data in support of developing skills in addressing convergent problems.

Methodology

To study the subject we are compiling a database with a large number of education-based software products, web-pages, and web-services, with a commensurate analysis of the type, breadth, and respective strengths and limitations of the products. In our study, we are limiting ourselves to employing publicly-accessible descriptions of each product (including descriptions provided by the software provider as well as third parties). This excludes products that are still in the development stage. Additionally, we do not endeavor to explicitly test the products ourselves, which would not be feasible given the large number and variety of available products. The intent is not to comprehensively describe each product in detail, but to instead develop an ontology of the types of available products and services including their potential strengths and limitations. We see value in this ontological framework as an aid to navigating and understanding the vast set of available tools as it continues to grow. A detailed description of the current state of the framework is provided in the *EdTech Overview* section.

To evaluate the ontology, we presented the preliminary findings to engineering faculty and solicited their feedback regarding (i) what type(s) of product they may already be using and why, (ii) what other type(s) of product may be of interest to them, and (iii) what type(s) of product is/are currently not of interest to them and why. Data were collected through one-hour-long faculty interviews in which the use of the educational-technology tools was discussed among other topics. Using this feedback, the resulting database of products continues to be refined, including respective type labels for each product to allow for fast searching and browsing, and wider dissemination. The process of searching for a suitable tool for a particular task is typically quite time-consuming for a faculty member, and oftentimes it is not even clear if the desired tool even exists. In this paper, we present the database with our current classifications in the *EdTech Overview* section and a brief summary of our results from the faculty interviews in the *Discussion* section. We are hoping that the paper and the database provide a useful alternative to aid faculty in finding an existing tool more quickly to support their teaching with technology.

EdTech Overview

The work on our educational technology database is still ongoing. It currently encompasses close to 100 products across 15 categories. In order to provide context for our *Discussion* section we briefly introduce 10 of the 15 categories and provide a selection of example products with their respective web-links. Here, we omit 5 of the 15 categories, namely *Digital Textbooks*, *P-12 Tools*, *Circuit Design Tools*, *Chatbots*, and *Optical Character Recognition (OCR) Tools*, due to space limitations. A complete snapshot of the current state of the database, including detailed summaries of each product are publicly available at the following web-link:

Educational Technology Database Web-Link

Please note that the provided list is by no means comprehensive. We are neither endorsing any of the products that are listed here, nor are we having reservations about particular products that do not appear in the list. The provided selections are merely intended to serve as examples. We, nevertheless, hope that the list and categorical organization may be used as a starting point for faculty who wish to consider any of the provided product categories in their teaching. It should be noted that many products provide functionality that would fit under multiple categories.

1. Learning Management Systems (LMS)

Perhaps the most well-known category is Learning Management Systems as these are ubiquitous at Colleges and Universities, both nationally and internationally. At its core, an LMS is a software or online-tool that bundles standard “housekeeping” chores for instructors. The LMS typically provides access to functions and services such as document sharing, assessment, communication with students, student tracking, gradebooks, course structuring etc. Most LMS attempt to be a universal tool (i.e., attempt to do *everything* instruction-related), but many options/modules are not as capable or feature-rich as dedicated tools found in other parts of this ontology.

LMS Product Web-Links

Classter	Canvas	TalentLMS	BlackBoard
Edmodo	LearnUpon	Neo LMS	Chamilo LMS
Sakai	Tovuti LMS	Engrade	Alma
Moodle			

2. Grading Tools

Grading tools assist instructors in creating (electronic or paper) quizzes, exams, or assignments. Students can complete the exams either in person or remotely. The work of the students is submitted through the software for grading. Some tools support automatic grading (e.g. via scanned bubble sheets), others require (electronically supported) manual grading by the instructor. The tools usually produce not only a grade or score for each student but also a visualization and/or statistical analysis of multiple scores. Many grading tools integrate with an LMS.

Grading Tool Web-Links

Socrative	GradeScope	Edulastic	Quizalize
GoFormative	Engrade	TurnItIn	

3. Feedback Tools

Feedback tools are separate from *Grading Tools* and specifically focus on helping to provide written or spoken feedback to students on assignments, quizzes, and exams. Some tools can be used to also produce a letter or number grade, others can only be used for feedback. The feedback is intended to support learning and help students understand how to improve their work, what is going well, and what may require further attention on their part. Interesting in this category is the variety of modalities for which feedback can be created and with which feedback can be provided, including text, audio, images, and video.

Feedback Tool Web-Links

GoReact	Kaizena	CrowdMark	GoFormative
Quizalize	GradeScope	Floop	Quizizz
Peergrade	The Criterion: Online Grading Tool		

4. Discussion Tools

Discussion tools are designed to enable and foster critical engagement between students, in and outside of the classroom. These tools often seek to go beyond the basics of a traditional discussion board. Students can upload videos, comment on class readings, or respond to questions via these tools. Instructors can pose a variety of questions for students to respond to as well as allow for students to respond to one another to guide class discussion. Discussion tools can also be used for peer feedback. Some tools provide automatically generated analytics of the discourse for the instructor.

Discussion Tool Web-Links			
Flipgrid	Piazza	NowComment	Perusall
Learning Catalytics			

5. Reading Tools

Instructors can use these tools to assign readings and ask students questions throughout the readings. Students can annotate as they read and also see what other students say about the reading and respond to them. Faculty, especially in the STEM disciplines, often find difficulty in motivating their students to critically engage with written text. Reading tools provide a means to directly assess the level of engagement for each student on a reading assignment.

Reading Tool Web-Links			
Hypothes.is	InsertLearning	NowComment	Perusall

6. In-Class Tools

The majority of products in the educational technology realm are focused on providing functions and services to teachers and students outside of the classroom. There are a few products, however, that are specifically geared towards use inside of a classroom. These tools help fostering engagement and participation, and provide a low-stakes way of gauging and tracking understanding.

In-Class Tool Web-Links			
EdPuzzle	TurnItIn	NearPod	GoSoapBox
Padlet	Kahoot	TedEd	FreshGrade
MarkBook	Descript	Top Hat Lecture	
Google Classroom			ProjectPals

7. Communication and Task Managemenet Tools

Educational technology can also be used for effective and time-critical communication between peers, students & teachers, as well as for task and project management. Some tools offer schedules to track events, to-do lists, and track progress on activities. These tools can be a fast way to keep everyone updated on what is going on in a class or project, as well as send or post helpful information, photos, videos or links to sources.

Communication and Task Management Tool Web-Links			
BaseCamp	ClickUp	Padlet	Trello

8. External Resources

The tools in this category are used by students outside of class time for studying, projects, homework, and lab assignments. The key difference to other tools is that the instructor does generally not provide the available materials, yet data shows that students are using and valuing these tools [7], [8]. Instead the materials are typically provided externally, i.e. from people other than the instructor. For some platforms the instructor has very little, if any, control over the content available to their student.

External Resources			
ThingLink	Khan Academy	Chegg	Quizlet
Course Hero			

9. Dashboard Programs

For instructors it is not only important to deliver course-content to students and/or provide students with computer assisted functionality and services, but also to track student performance, aggregate scores, and generate informative graphical representations of student progress in various categories. Graphical dashboard tools can provide such services. Some LMS-like systems provide basic dashboards as a built-in feature, however, much more powerful tools are available; albeit they are predominantly designed and targeted for the business sector and less so for the educational sector.

Dashboard Programs			
Domo	Cumul.io	Tableau	iDashboards
Grow	Ubiq		

10. Autograding Tools

The automatic grading of multiple choice and numeric answer questions in quizzes and exams are a common feature of many of the previously mentioned platforms. Very few platforms, however, provide more sophisticated types of autograded questions. An advanced algorithm is needed when answers are provided in terms of a mathematical expression, a piece of programming code, or an essay for example. The platforms listed below provide some of these more sophisticated types of analysis for autograding. In our ontology, we have explicitly separated this category from both *Grading Tools*—which focuses on the generation and submission of assessments with some automated grading features—and *Feedback Tools*—which support richer feedback to students—as this category seeks more sophisticated grading automation and has a large growth potential as demand for AI-assisted tools continues to grow [9]–[12].

Autograding Tool Web-Links			
Webwork	Bakpax	Copyleaks	Repl.it
web-CAT	GitHub Classroom		TeacherMade

Discussion

This database was built in conjunction with discussions and interviews with faculty. Recognizing that *faculty time* is perhaps the most precious resource, we sought to understand *What faculty want to do* in their classrooms with regard to student learning and *What is holding faculty back* from these goals. While systemic structures (such as the rigid course structure of the university) dictated what is ultimately available, often the conversation came back to: time and technology. Seeing the vast array of available technology/tools and knowing that it is not possible to ever learn all these for oneself, we began work on this database and ontology to help guide would-be adopters of educational technology.

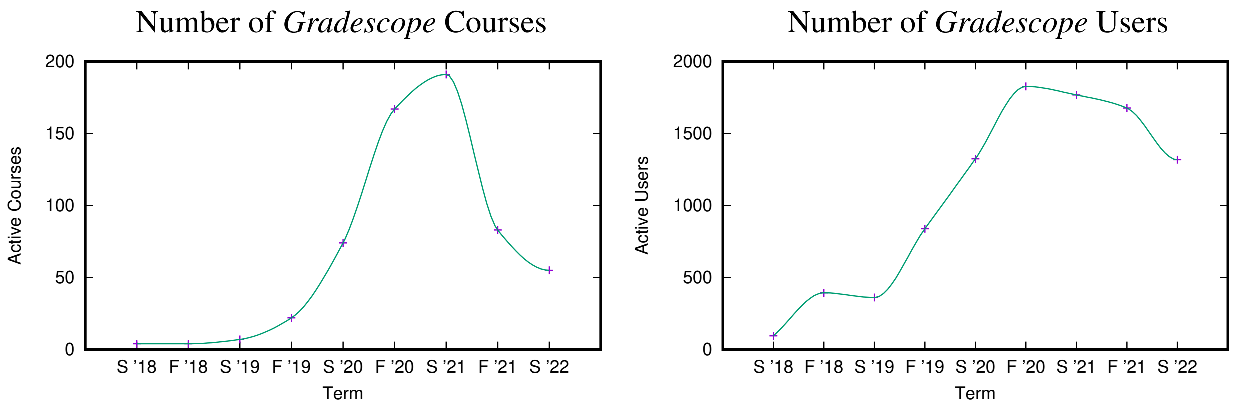

Figure 1: Active number of courses and users of the online grading tool *Gradescope* on a small, liberal arts campus over time.

In the one hour-long faculty interviews, example questions included:

1. How do you want students to have changed at the end of your class, in terms of knowledge and skills, as well as attitudes and beliefs?
2. How do you measure/assess the effectiveness of the activities you do in class? What are the advantages and disadvantages of the chosen types of assessment?
3. How do you get from what you are doing now to your *ideal* course/class structure? What is stopping you?
4. What are the best technologies you have used in the classroom that help you meet your goals? What have been your most problematic experiences with technology?

Based on these interviews, we find that critical in the evaluation of educational technology is: (1) what functions/services are included, (2) how well these functions/services are integrated, and (3) how well the respective user interface supports the maintenance of the functions/services. Without these factors, technology can counter-intuitively hamper and even interfere with faculty achieving their instructional goals due to frustration, time-consuming manual integration, and a sunk-time-cost. Regarding the last point, it is important to recognize the tension that it requires significant time to learn and adopt new technology and that often the available functions/services are not fully-known until after an initial time investment. It can be particularly frustrating to only realize a misalignment between the hopes/expectations of a technology's functions with its actual capabilities after spending this time. Thus, we arrive at a primary problem of faculty not having sufficient time to research technologies which further exacerbates "faculty blindspots" regarding what technologies are available.

Often time-investment alone (and disregarding the factors previously mentioned) is claimed as a reason to not adopt new technology. The thought follows that an initial time-barrier required to adopt a tool is high, yet once a user knows how to use the technology, they will continue using it. A contradiction to this reasoning can be seen in Fig. 1 showing faculty adopting the *Gradescope* tool on a small liberal arts university's campus. Here the major increase can be explained due to the pandemic as the University switched into a remote/hybrid teaching mode. However, it is also noticeable that many users dropped *GradeScope* again when the University went back to an in-person teaching mode in the fall of 2021, suggesting that the initial barrier is not sufficient to fully explain why educational technology is not that widely used in higher education.

Thus, we see a need for faculty to be able to learn about the available technologies and the specific problems they solve, as well as an understanding of how these systems can operate within a larger ecosystem. As another example, many faculty in our interviews expressed frustration with the LMS system. The usefulness of this tool was greatly minimized by what one interviewee termed "death by one thousand clicks." While the LMS attempted to integrate with external tools provided by other platforms or modules, this integration was sometimes awkwardly organized and required non-trivial maintenance to keep scores and other data synchronized. Faculty seek technology to support their overall instructional goals and many tools claim to support goals, yet there remains a large disconnect in between. This disconnect manifests itself often prominently in a *lack of integration* between different platforms, functions, and services. As shown in the *EdTech Overview* section, the industry has developed a multitude of powerful software solutions to support instructors. Some tools are already well integrated. Many functions and services, however, are still too cumbersome or even impossible to connect, students need to have too many accounts with too many platforms and too many different interfaces, and the creation of course materials and functions is bound to a fixed platform and difficult to port to other platforms. It is not surprising that instructors choose to dramatically limit their use of educational technology, even if they are aware of what is available and how to use it.

At this stage in our study it is too early to provide a comprehensive analysis of the mechanisms that lead to the slow adoption of educational technology in higher education. A lack of knowledge about the technology and barriers associated with learning how to use the technology may be one reason. A deeper reason, however, may also be that currently available software is *just not good enough yet* to compel faculty to adopt it. This may be mirroring the lack of interest people had in using automatic speech recognition software, for example, in the early 2000's. The quality of the software had dramatically improved in the decades before, but it was just not good enough for people to want to use it. The eventual adoption in products such as Apple's Siri and Amazon's Alexa, for example, didn't happen until after the introduction of deep neural networks in the past decade. With educational software we may see a similar situation in which the currently provided level of support and automation has not yet surpassed the necessary critical threshold.

Conclusion and Outlook

In this paper, we have introduced a basic ontology of the available educational technology and introduced a basic database seeking to track this ever-growing area. Faculty tend to not have sufficient time to understand and explore the technology that is currently available which results in "blinders" as to what either is currently available or even as to what is possible with technology. We hope that the basic ontological framework provided in this paper, to categorize and understand the broader ecosystem of educational technology, can help instructors seeking tools to better navigate what is available.

Furthermore, at many schools, it is generally the respective IT divisions that drive decisions for software adoption *for* the faculty and not vice versa. We feel, however, that it should be the other way around, i.e. that faculty should drive these decisions. For that to happen, though, it would require new faculty adopters to receive information and support from seasoned users, potentially via some type of online community. This paper could serve as a step towards that development.

In summary, what drives faculty to adopt one technology over another or even no-technology is not yet fully understood, yet will play a key role in future educational practices as technology continues to evolve. In future work, we hope to better understand the factors that are important to adoption of new technology and better understand how technology is being used.

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