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How and Why Higher Education Institutions Use Technology in Developmental Education Programming

A CAPR Working Paper

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Abstract

As postsecondary institutions increasingly integrate technology into developmental education, it becomes important to understand how technology is used in these programs, what challenges institutions have encountered relating to the technology, and what considerations institutional leaders take into account when deciding whether and how to integrate technology in developmental education. This study explores these questions drawing from semi-structured interviews with key personnel from 31 open-access two-year public colleges, 11 broad-access four-year public colleges, and 41 state-level organizations overseeing such colleges. We find that institutions are integrating a variety of instructional, course management, and student support technologies into developmental education. In doing so, institutions have encountered a number of challenges, particularly with regard to end-user difficulties with technology.

We also find that evidence of effectiveness of technology for improving educational outcomes was considered by a number of organizations in our sample when making decisions about technology use in developmental education; however, other considerations — particularly those based on costs and resources — were also quite influential. Indeed, such economic considerations were described to us more often than evidence of effectiveness by respondents discussing reasons for using technology in developmental education.

Contents

1. Introduction

As institutions of higher education look for innovative and more effective ways to deliver course content and to connect more broadly with students, campus decision makers are increasingly turning to a variety of technology-based options. These options range from new computer labs, to software-based homework, to courses or degrees offered entirely online (Bell & Federman, 2013; Epper & Baker, 2009; Jacobson, 2006; Twigg, 2003; Zachry & Schneider, 2010). Developmental education programs — designed for individuals who begin postsecondary education demonstrating a lack of college-level skills in subjects such as English or mathematics — similarly make use of technology to help students transition into college-level coursework. For example, math and reading instructional software products have been used in developmental education programs to assess students' individual academic weaknesses and to provide targeted instruction and testing to help students master those skills (Epper & Baker, 2009). However, analyses show mixed results regarding the relationship between content-driven software and student outcomes (see, e.g., Raines & Clark, 2016), and little is known about how higher education leaders make decisions about what technology to use in developmental education. Understanding how leaders make these decisions is important for determining whether considerations of effectiveness for student learning are being prioritized, as well as for developing strategies for the implementation of educational technologies.

Using semi-structured interviews conducted by the Center for the Analysis of Postsecondary Readiness (CAPR), this study explores the ways in which technology has been used in developmental education, the challenges that using such technology has presented for institutions, and the considerations underlying decisions about how and why to use technology. We find that institutions are integrating technology into developmental education in a variety of ways, which can be categorized into instructional, course management, and student support technologies. Institutions have encountered a number of challenges while implementing technology in developmental education programs, particularly with regard to end-user difficulties with technology. We also find that evidence of effectiveness of technology for improving educational outcomes was considered by a number of organizations in our sample when making decisions about technology use in developmental education; however, other considerations — particularly those based on costs and resources — were also quite influential. Indeed, such economic considerations were described to us more often than considerations of effectiveness by respondents discussing reasons for using technology in developmental education. The results of this analysis illuminate institutions' experiences with technology in developmental education as well as the extent to which considerations of

effectiveness for improving educational outcomes is prioritized when colleges make decisions about instructional and student support technologies.

2. Background: Developmental Education and Technology-Centered Reforms

Developmental education programs provide instruction and academic support for students who enter college lacking assessed college-readiness skills in at least one academic area (typically mathematics, reading, or writing), for the purpose of enabling students to develop the skills needed to meet requirements for college-level coursework (Bailey & Cho, 2010; Boylan & Bonham, 2007; Jaggars, Edgecombe, & Stacey, 2014). Students are typically referred to a single course or to a sequence of two or three developmental courses in a single academic area. While nearly 60 percent of new community college students place into developmental education (Bailey, 2009; Bailey & Cho, 2010; MDRC, 2013), these students often struggle to succeed. Approximately 30 percent of students in developmental reading and in developmental writing do not pass all their developmental courses in these areas, and about 70 percent of students do not pass all their developmental mathematics courses (Attewell, Lavin, Domina, & Levey, 2006, as cited in Bailey, 2009). Meanwhile, recent estimated annual costs for providing postsecondary developmental education in the United States total more than $3.5 billion (Bettinger, Boatman, & Long, 2013).

It is within this context that calls for developmental education reform have been made by policymakers and other leaders in the field (see, e.g., Fain, 2012; MDRC, 2013). Some of these reforms have involved technology. The Tennessee Board of Regents, for example, provided grants to institutions "to support technology-supported active learning strategies aimed at improving student learning outcomes, accelerating time to credit-bearing courses, and reducing instructional costs" as part of the state's Developmental Studies Redesign initiative (Crandall & Soares, 2015, p. 11). Legislation in Texas that mandated developmental education redesign instructed the state's Higher Education Coordinating Board to make provisions "for using technology, to the greatest extent practicable consistent with best practices, to provide developmental education to students" (Texas S. B. No. 162, 2011, as quoted in Texas Higher Education Coordinating Board, 2012, p. 28). Recommendations to use technology in developmental education reforms have arisen at a time when technology-centered reforms are occurring in a number of other policy areas as well, such policing (Spivak, McGough, & Rodriguez, 2016), physician education (Han, Resch, & Kovach, 2013), voter registration reform (Corley & Palmer, 2015), and K-12 education (National Conference of State Legislatures, 2017).

However, evidence of the effectiveness of technology to improve educational outcomes is mixed. While some studies indicate that technology may enhance student

achievement (Testone, 2005), other experiences with technology have resulted in no such improvement (Jacobson, 2006). Initial research indicates that students tend to complete online courses at lower rates and earn lower grades than their peers in face-to-face courses (Bailey, Jaggars, & Jenkins, 2015). Other studies demonstrate that underprepared college students tend to struggle in entirely online classes (Smart & Saxon, 2016; Xu & Jaggars, 2014), and that greater structure and classroom practices help students to complete computer-mediated courses (Fay, 2017).

In light of the mixed evidence regarding the effectiveness of technology to improve developmental education, it is important to consider how institutional actors make decisions about using technology in these programs, and currently, little is known about this. Some argue that decisions about technology use in educational settings should be made carefully and, ideally, based on evidence that such technologies will enhance student learning (Ashford-Rowe & Holt, 2011; Fuhrman, 2017). Indeed, some studies have found that evidence-supported education reforms are related to increased student achievement (see, e.g., Carlson, Borman, & Robinson, 2011; Van Geel, Keuning, Visscher, & Fox, 2016). Evidence that organizations rely upon when making decisions may range from the findings of rigorous, systematic studies used in "data-driven decision-making" (Swan, 2009) to information gleaned from decision makers' own past experiences. Hollands and Escueta (2017) report that higher education leaders often rely on local knowledge and information, while relatively few such decision makers cite academic research. Moreover, factors unrelated to best practices or evidence of effectiveness sometimes drive decisions about educational technology (Ribeiro, 2016). Given the financial investments and infrastructure requirements that new technologies often involve (Carbonell, Daley-Hebert, & Gijselaers, 2013; Porter, Graham, Spring, & Welch, 2014), as well as the need to improve academic success for developmental education students, it is important to know whether effectiveness of technology is a driving factor for institutional decision makers when innovating with instructional and student support technologies. Also, in light of calls by policymakers for increased use of technology in developmental education, it is useful for institutional leaders to understand the challenges associated with implementing educational technologies.

3. Methodology

This research is part of a larger descriptive study, conducted through CAPR, whose purpose is to develop a better understanding of the practices and techniques that higher education institutions use to provide developmental education. In light of calls to reform developmental education using technology, an important component of this study is to analyze how institutions use technology to provide developmental education and to foster student success in such programs. The research questions addressed in this paper are:

1. What have been the experiences of higher education organizations with the use of technology in developmental education programming? Specifically:
   a. What types of technology are used to provide developmental education instruction and other student support?
   b. What challenges have institutions faced with regard to the use of technology in developmental education?

2. What considerations have influenced decisions regarding technology use in developmental education?

Data Sources and Data Collection

Data pertaining to the issue of technology used in developmental education are drawn from the qualitative component of the CAPR descriptive study.[1] We conducted telephone interviews with key institutional personnel at public open-access two-year and broad-access[2] four-year institutions across the United States ("institutional sample"), as well as with individuals working in higher education systems, state departments of education, statewide associations representing higher education institutions, and organizations whose work involves overseeing, administering, or organizing multiple two-year and/or broad-access four-year campuses within a state or jurisdiction ("state-level sample"). About one quarter of the organizations from which we interviewed were

[1] Another component of the CAPR descriptive study involves a nationwide survey about developmental education practices. The survey results are not part of the analysis presented in this paper.

[2] For purposes of this study, a "broad-access" institution is one that has admitted at least 70 percent of applicants according to the Integrated Postsecondary Education Data System (IPEDS) database. All public two-year colleges are therefore broad-access institutions. Indeed, two-year public colleges, or community colleges, are typically referred to as "open-access" institutions as they enroll virtually any student who wants to attend. We also note that some community colleges in our sample confer bachelor's degrees as well associate degrees and various certificates. For simplicity's sake, we refer to such institutions as two-year public colleges or community colleges, terms we use interchangeably.

purposefully sampled from institutions and state-level organizations in five particular states — California, Florida, New York, Tennessee, and Texas. Four of these states (Florida, New York, Tennessee, and Texas) were selected for particular attention because they have been engaged in developmental education reform and/or analysis (see, e.g., Dougherty et al., 2016; Lehr & McColskey, 2013; Tennessee Higher Education Commission, 2011), and California was selected because it possesses more public institutions of higher education than any other state (see Digest of Education Statistics, 2016). The remainder of the organizations in our sample were selected from a random national sample of broad-access public institutions and state-level organizations representing or overseeing at least one broad-access institution.[3]

Table 1 presents the number of individuals and organizations represented in each of our samples. As shown, we interviewed a total of 127 individuals across 83 organizations.[4] Organizations located in 36 states and one additional U.S. jurisdiction are represented in our sample. Respondents were faculty or administrators who had some responsibility for developmental education within their institution or system. During the interviews, we asked respondents about of variety of topics relating to developmental education, including assessment and placement practices, instructional practices, faculty engagement in developmental education reforms, and technology use in developmental education programming. With regard to technology, we asked whether the respondent's organization required or encouraged faculty to integrate technology into developmental instruction, and if so, what type of technology is typically used. Respondents also occasionally discussed technology in response to other questions, such as when describing accelerated or modularized developmental education programs. When respondents' statements were vague or the researchers sought to supplement respondents' statements with additional information, we also reviewed relevant documents, such as information posted on the websites of state- or system-level entities, higher education institutions, or other organizations, as well as relevant published literature.

[3] These institutions were drawn from a list of broad-access institutions surveyed for the CAPR descriptive study's national survey, which asked institutions around the country about their developmental education assessment and instructional practices. A total of one hundred public institutions were drawn, including 71 two-year public institutions and 29 four-year public institutions. (The relative numbers of institutions drawn matched the proportions of two- and four-year public institutions in the overall survey population.) Among these institutions, 26 two-year and 6 four-year institutions participated in the interviews. The state-level organizations in our sample came from a list developed by the research team of state-level organizations overseeing, representing, or coordinating at least one broad-access higher education institution.

[4] When multiple individuals within a single organization were interviewed, they were sometimes interviewed together and sometimes interviewed separately.

Table 1

Institutional and State-Level Samples, by Organizational Type

	Institutional Sample		State-Level Sample		
Sample Type	Open-Access Two-Year Public Colleges	Broad-Access Four-Year Public Colleges	Open-Access Two-Year Public Colleges Only	Broad-Access Four-Year Public Colleges Only	Both
Purposeful	5 organizations, 6 respondents	5 organizations, 6 respondents	1 organization, 2 respondents	4 organizations, 6 respondents	5 organizations, 6 respondents
Random	26 organizations, 43 respondents	6 organizations, 9 respondents	11 organizations, 18 respondents	8 organizations, 16 respondents	12 organizations, 15 respondents
Total by organization type	31 organizations, 49 respondents	11 organizations, 15 respondents	12 organizations, 20 respondents	12 organizations, 22 respondents	17 organizations, 21 respondents
Total by sample	42 organizations, 64 respondents		41 organizations, 63 respondents		
Total	83 organizations, 127 respondents				

Data Analysis

With interviewees' consent, we audio recorded all but six respondents' interviews. These audio recordings were transcribed, and the transcripts were uploaded to our database within the Dedoose qualitative data analysis platform. In the few instances in which interviews were not recorded, interviewers' notes were used in place of verbatim transcripts. Members of the research team then used a standard coding scheme to code each transcript. The coding scheme was developed by the CAPR descriptive study research team based on the study's research questions, a review of relevant literature, and themes and patterns that emerged from an initial review of interviews. Some emergent patterns (see, e.g., Merriam & Tisdell, 2016) included issues relating to decision-making and challenges related to technology use. Data analysis revealed that respondents representing more than 90 percent of the organizations in our sample discussed technology use in developmental education. Respondents representing just over half of the organizations in our sample discussed some aspect of the reasoning behind organizational decisions, and respondents representing just under half of the organizations in our sample discussed challenges regarding technology use in developmental education.

After all interview data were coded, we exported the transcript data identified as relating to technology use into a spreadsheet that identified respondents' position (e.g., English faculty, mathematics faculty, administrator) and organizational type (e.g., two-year institution, four-year institution, state-level organization) for each piece of coded data. We then reviewed the coded data to identify emerging patterns and themes (Merriam & Tisdell, 2016). Regarding issues about decision-making and challenges associated with technology use in developmental education, we conducted an inter-rater reliability exercise (Armstrong, Gosling, Weinman, & Marteau, 1997), in which two researchers independently coded the data and compared application and consistency of codes. This exercise resulted in a small number of minor coding disagreements, which the raters discussed with a third researcher in order to arrive at a coding consensus. From there, broader themes were identified in coded data and categories representing these themes were consolidated in data reduction tables.

4. Results

Technology Use in Developmental Education

Types of Technology Used

Institutional and state-level respondents described uses of technology in developmental education that can be divided into three categories based on the technology's function: instructional technology, course management technology, and student support technology. Table 2 depicts this typology of technology use and describes how each type of technology has been used in developmental education. Most of our findings focus on instructional technologies.

Table 2

Types of Technology Used in Postsecondary Developmental Education

	Type of Technology		
	Instructional Technology	Course Management Technology	Student Support Technology
Definition	Technology that provides instructional content to students (e.g., reading, writing, or mathematics)	Technology that organizes course materials and makes them electronically available to students	Technology that provides extracurricular assistance to students through electronic methods
Examples of brands	ALEKS, Cengage, Hawkes Learning, Pearson "Labs," Weaver, Khan Academy	Blackboard, Canvas, Moodle, WebCT, Desire2Learn	Pearson Smarthinking, Starfish
Examples of use in developmental education	• Provides subject matter information, assessments, and assignments • Online video lectures • Open educational resources and other electronic course materials	• Provides electronic storage of and access to course materials, online assessments, student grades, class-wide communications, instructional videos, course evaluations, and discussion boards • Primary course delivery system for online courses	• Asynchronous online tutoring/remote access to tutors • Electronic early warning systems

Instructional technology, with regard to developmental education, refers to software and other technologies that provide the instructional content of the course — be it reading, writing, or mathematics — to students. Frequently reported examples of such technology include Pearson "Lab" software packages and other similar products, such as Hawkes Learning or ALEKS (for math) or Weaver (for reading). Pearson's MyMathLab, for example, provides "multimedia e-text, video lectures, computational examples, animations, interactive tutorials, practice exercises, and sample quizzes and tests" (Raines & Clark, 2016, pp. 24–25). Instructional technology also includes other electronic methods of providing subject matter information to students, such as online video lectures or electronic textbooks (see EDUCAUSE, 2010; Thompson, 2011). This type of technology can be used across different types of course formats. Such technologies have been used in a variety of ways by institutions in our sample, both before students enroll in classes and after enrollment. During the pre-enrollment period, instructional technologies have been used to prepare prospective students for assessments of their college-readiness skills. These programs were sometimes offered as online courses. Other times, instructional software programs such as Pearson "Labs" were provided to pre-college students (for example, through local high schools), to provide students with developmental instruction before they reach the postsecondary level. Instructional software has also been used in pre-enrollment bridge programs or "boot camps," often taking place over the summer, before students begin the academic semester. These technologies are used in such programming to improve students' English, reading, or mathematics skills with the goal of enabling them to improve their scores on readiness assessments and enroll in college-level work by the time the semester begins (Edgecombe, Cormier, Bickerstaff, & Barragan, 2013).

Once students had enrolled in developmental courses, instructional technology was used across different kinds of course delivery methods. For example, respondents told us of students using instructional software to complete assignments as part of their coursework, which occurred in both lecture-based classes and emporium-style courses, in which class takes place in a computer lab and instructors provide assistance as students work on individualized computerized lessons (see Twigg, 2003). Additionally, some institutions in our sample have offered mathematics computer labs that employ instructional software applications to provide additional assistance to students outside of class time. Instructional technology also includes the use of open educational resources, which are teaching and learning resources such as books or other course materials that are free or low-cost and available electronically (EDUCAUSE, 2010). Other electronic textbooks, such as those produced by Cengage, were also described by our respondents. Online video lectures also fall into the instructional technology category. These include

online videos produced by Khan Academy, a web-based provider of short instructional videos in a variety of subject areas (Thompson, 2011).[5]

Course management technology (sometimes referred to as a "learning management system" or LMS) involves using technology to organize and present course structure and materials. Some specific uses for course management technologies are electronic storage of and access to important course materials (such as the syllabus, required reading materials, and lecture presentations), online quizzes and other assessments, student grades, class-wide communications (such as emails or electronic announcements), a course calendar (often providing deadlines for assignments), links to instructional videos, electronic course evaluations, and online discussion boards (see Dalsgaard, 2006; Qutab, Shafi-Ullah, Safdar, & Khan, 2016; Wernet, Olliges, & Delicath, 2000). Some brands of learning management systems include Blackboard, Canvas, Moodle, WebCT, and Desire2Learn (authors' interviews; Dalsgaard, 2006; Qutab et al., 2016; Wernet et al., 2000). Like instructional technology, course management technology can be used across different course formats. Such technology would conceivably be more critical in courses that provide all or part of their delivery online, but our respondents also discussed instructors in traditional, face-to-face classes using these systems to make course materials electronically available. Some respondents indicated that their organizations provide a learning management system for all courses. The scheduling aspect of course management technology might be particularly useful to students in developmental education, who may lack self-regulation skills (as some of our respondents suggested) and therefore stand to benefit from the structure and notice of deadlines that course management technology provides.[6]

Student support technology is the use of technology to support students' academic performance either by providing individualized assistance with academic tasks or by monitoring students' academic behavior (such as course attendance and performance) to ensure they are staying on track to complete their courses. These electronic services

[5] We also note that instructional technology appears to be more widely employed in developmental mathematics than in developmental reading and writing among the organizations in our sample. While emporium-style classes, extracurricular academic support for mathematics in computer labs, and entirely online courses have been used to teach developmental math, respondents mentioned fewer instances of such extensive technology use in the teaching or tutoring specifically of developmental English. This does not imply that technology is not widely used in some fashion in developmental English instruction. To the contrary, many of our respondents identified various ways that technology has been used in teaching developmental English, as described in the sections above. The use of technology to teach mathematics, however, was more central to course delivery and reported more frequently among the organizations in our sample.

[6] Wernet et al. (2000) found that older-than-traditional students identified the "course calendar" aspects of a learning management system as instrumental to their involvement and enhanced performance in a course (p. 500). Additional research is needed to determine if the same applies to underprepared students.

include online access to remote tutors to assist students with academics and learning (authors' interviews; Britto & Rush, 2013; Price, Richardson, & Jelfs, 2007). A brand of online tutoring that was mentioned multiple times by our respondents was Smarthinking, a Pearson product. Online tutoring provides as much as 24-hour remote academic assistance via the Internet from tutors in a variety of subject areas. One respondent described electronic tutoring as being "asynchronous," meaning that students and tutors need not be online at the exact same time.

Respondents also described the use of electronic "early alert" systems to identify students who are in danger of failing and targeting those students for extra advising or other assistance (authors' interviews; Britto & Rush, 2013; Faulconer, Geissler, Majewski, & Trifilo, 2014). These products track students by monitoring their academic behaviors and activity on learning management systems, and then notifying advisors if a student is not fulfilling course requirements. Such software can trigger an intervention by an advisor or other individual at the college to help prevent students from failing classes or dropping out of their programs (Britto & Rush, 2013; Faulconer et al., 2014).

Challenges Encountered When Using Technology in Developmental Education

When describing various types of technology used in developmental education, just under half of our respondents also described challenges they or their institutions experienced when implementing those technologies.[7] These challenges can be categorized as follows (in order of reported frequency): end-user difficulties, cost-related challenges, product limitations, and unavailability of technology. Although many of these challenges may not be particular to developmental education (cost-related challenges, for example, are issues for all of higher education), end-user difficulties that pertain to students and product limitations may be particularly relevant in the developmental education context.

End-User Difficulties

The challenge that was described by our respondents more frequently than any other (described at just under 45 percent of organizations whose representatives discussed challenges) related to the difficulty that end users, including both students and faculty,

[7] Issues relating to challenges with technology use was a finding that emerged in the process of data collection; therefore, not all of our respondents discussed it. In this section, when we describe the proportion of "respondents who discussed challenges," this refers to the proportion of only those respondents who described technological challenges in their interviews, which was respondents representing a little less than one half of the organizations in our total interview sample.

have experienced with technology. A community college system-level respondent stated, "Some students will do all right with online education for … developmental subject material. Others are not going to thrive in that environment." Statements indicating that students experienced difficulty using instructional technology were made by respondents representing just under a quarter of organizations in our sample for which technological challenges were described. Some institutional personnel believed that students sometimes lack sufficient skills to use technology in an effective manner. For example, one respondent at a community college heard reports of students lacking keyboarding skills, which are important for using a personal computer. Additionally, some faculty, like students, do not possess the requisite skills to use technology effectively. As one administrator at a community college stated, "There are some faculty members who don't have the technology skills themselves necessarily to really feel successful in [technology use]."

More than one sixth of organizations in our sample whose representatives discussed challenges noted that end users sometimes had a difficult time with the reduction (and in some cases outright removal) of in-person interactions as a result of using technology in instruction. These respondents viewed face-to-face interaction as beneficial to the learning process and noted that the implementation of computer-mediated instruction diminishes the opportunity for in-person interactions. For example, a two-year college administrator complained that instructional software had changed the in-class dynamic, saying, "rather than being a supplement, it kind of turned into the course," and that "the instructor is still willing to answer questions and help out, but I think that students were more hesitant … to ask for that help." Other respondents echoed the perspective that the removal of in-person interaction was detrimental to the educational process and posed difficulty for at least some students at their institutions.

Insufficient Resources

Respondents at about one fourth of the organizations in our sample for which challenges were discussed indicated that costs or a lack of sufficient resources at their organizations created challenges when it came to implementing technology in developmental education. Challenges related to costs sometimes meant that an institution would choose one option over another, or decide to forgo a particular kind of technology that was deemed too expensive. Other times, respondents explained that a technology was expensive, but the institution chose to use it anyway because it was a superior product or met a particular organizational need. Respondents also discussed the fact that institutions incur ancillary costs linked to the increased demand for technology in instruction, such as costs associated with the use of computer labs or additional training for faculty. As an administrator at a community college system said:

> I think our biggest challenge is the professional development that we need to make available for our faculty. Because when you talk about resources and you include funding in that conversation, if funding is shrinking … typically one of the areas that gets hit is the professional development funding.

Product-Specific Limitations

About a fifth of the organizations in our sample whose representatives discussed technological challenges reported that particular products were limited in what they could do. Some respondents complained that certain instructional software products did not provide a useful tool for integrated reading and writing classes, when both of these subjects are taught in the same course (see Bickerstaff & Raufman, 2017, and Perin, Raufman, & Kalamkarian, 2015, regarding integrated reading and writing). Also reported was the perspective that a software vendor may have an excellent product for developmental math but not a similarly useful tool for developmental English. Other respondents made general statements about software products' limitations — saying that a product "hasn't been without its hiccups" or that it is "not a perfect software by any means" — but also indicated that these limitations were not preventing the institution from using the software in developmental education programming.

Unavailability of Technology

Another challenge reported multiple times (discussed by respondents representing about 15 percent of the organizations for which challenges relating to technology were discussed) was that crucial technology is not always available, particularly for low-income students and students or institutions located in rural areas. One community college student services administrator told us that "very few of our students actually have Internet outside of class" and noted that the instructional software product being discussed "just wasn't effective for those students." Technology availability is also a problem when institutions or students experience technical difficulties, Internet outages, or loss of access codes, all of which result in the unavailability (even if only temporarily) of educational technologies.

These Challenges Align With the Literature

Our findings about challenges associated with technology use in developmental education largely align with challenges related to technology use in education more broadly as described in the literature. Resource and cost concerns, availability of technology (including technical difficulties and software problems as well as Internet

unavailability for low-income students), and end-user problems (such as the need for end users to develop new skills and the lack of technical skills among some students) have all been documented in the literature as challenges to using technology in education (see, e.g., Bell & Federman, 2013; Butler & Sellbom, 2002; Groff & Mouza, 2008; Harrington, 2010).[8] Groff and Mouza (2008) also identify "lack of human support and infrastructure" as a school-level challenge with educational technology use (p. 24), which echoes our finding about the removal of in-person interaction posing a challenge for some end users.

[8] From a different perspective, Karp and Fletcher (2014) note that factors such as the provision of training for end users, the selection of appropriate technologies, and the development of sufficient infrastructure can facilitate successful implementation of student services technology in higher education institutions. These steps could be taken to prevent or address challenges using technology such as the ones revealed by our research.

Reasons for Organizational Decision-Making About Using Technology

Decisions about the use of technology in developmental education have been based on a variety of considerations. According to our respondents who discussed their reasoning, some decisions were based on economic considerations, while others were motivated by a desire for the personalized educational experience that technology is perceived to offer. Although expectations about technology's effectiveness for improving student outcomes was among the reasons given (reported at a little over a quarter of the organizations for which decision-making factors were discussed), product-specific characteristics (reported at just under a quarter of these organizations) and state government influence (reported at about a quarter of these organizations) were each cited as reasons for technology use almost as frequently. Further, respondents representing just over two fifths of the organizations for which decision-making factors were discussed cited economic considerations as an influence on technology decisions — more than any other single influence. Some respondents discussed making decisions about whether to use technology at all, while others discussed reasons for selecting one particular technology rather than others. Moreover, some decision-making factors are related to others, and some decisions are made based on multiple considerations instead of just one. Nonetheless, this section separately considers the reasons given by our respondents, so that we can examine each decision-making factor individually. The considerations underlying decisions regarding technology use in developmental education uncovered by this study are summarized in Table 3 and are discussed in more detail in the subsections that follow, which are presented in the order of frequency with which each consideration was reported to us.

Table 3

Considerations Underlying Decision-Making Regarding Technology Use in Developmental Education

Decision-Making Consideration	Examples
Economic considerations	• Choosing a technology because it is low-cost or forgoing a technology because it is expensive • Adopting technology to save money • Receiving grant funding or state appropriations to implement a particular technology
Effectiveness of technology for educational outcomes	• Awareness of evidence demonstrating technology's effectiveness or ineffectiveness for improving educational outcomes • Decision maker's previous experience with a technology's demonstrated effectiveness or ineffectiveness in improving educational outcomes
State- or system-level influence	• Policy mandate • State- or system-wide license to use particular technology • State or system demonstrates its prioritization of educational technology
Product or vendor characteristics	• Customer service or training provided • Sales pitch • Feature of the technology meets an organizational need • Technology lacks characteristics that the organization needs
Personalized educational experience	• Technology more easily allows for more instruction to be tailored to individual student needs • Modularized technology allows students to complete coursework at their own pace
Ubiquity of technology	• Technology is increasingly pervasive in society, which raises expectations that it will be used in higher education • Organizational culture favors technology

Economic Considerations

Participants identified considerations relating to costs, resources, and economics more than any other reason for technology decisions (reported at just over two fifths of organizations for which decision-making about technology was described). Some decision makers selected a particular technology because it cost less than alternatives or chose to forgo a particular technology if it cost too much. A system-level administrator's statement indicated that a factor behind the selection of a particular brand of technology was this: "It's a dollar a student based on [full-time equivalency]. … I don't know about any other technology that is that inexpensive for a campus — a dollar a student — oh my gosh. That's incredible!" In another case, an English faculty member explained that a particular brand of instructional software was piloted for developmental education, but "was too expensive, so we did not use [it] again." One community college faculty member informed us of a situation in which an institution chose to implement an entirely technology-based instructional method because the college lacked sufficient resources *not* to do so. This respondent said that small colleges in the state transitioned to a technology-based modular approach to developmental math following a statewide requirement to reform developmental education, but did not retain elements of face-to-face instruction alongside the online modules because the colleges "didn't have the resources to continue with the traditional lecture for students who might benefit from that."

Institutions also considered costs for students when making decisions about technology. For example, one community college mathematics professor explained that his college allows students to access online textbooks rather than purchase physical copies in order "to save students money." Another respondent, who spoke on behalf of a university system, told us that electronic open educational resources are being used "to mitigate costs for students with regard to the $200 textbook." A different system-level respondent reported "a real push" for institutions to use open educational resources — particularly in the community college sector — because "the cost of course materials is a constant issue."

The receipt of grant funding was cited as at least one of the reasons behind using technology in several cases. A couple of institutions reported receiving grants pursuant to Title III of the Higher Education Act, which they used to fund technology initiatives relating to developmental education. Title III grants award discretionary funding to eligible colleges and universities for the purpose of enhancing certain aspects of their operations, including faculty training, developmental education, and other activities that "improve and strengthen [their] academic quality, institutional management, and fiscal stability" (U.S. Department of Education, n.d.). Institutions in our sample used Title III

funding to provide (among other things) faculty professional development with online technology and tutoring in computer labs for developmental math students. Other institutions received funding from private foundations or from state legislatures or systems for purposes of developing technological innovations related to developmental education.

Effectiveness of Technology

A number of our respondents (representing a little over a quarter of organizations that reported decision-making factors) indicated that decision makers' understanding about a given technology's effectiveness (or lack thereof) to improve educational outcomes played a role in the organization's reasoning for technology use in developmental education. Often, perceptions of effectiveness were expressed by our respondents in somewhat vague terms, with some citing general "evidence" or what they "believe" to be effective for developmental education students. Despite the fact that these decisions were not necessarily based on specific systematic research, effectiveness considerations played a role in these organizations' decisions about whether and how to use technology. For example, a community college representative expressed a general awareness that students "struggle" with entirely online classes, and because of this, the institution was looking into how to assess new students' "qualifications" to ensure that they are "really ready to take that distance [education] course." This illustrates how institutional decision makers may have a basic impression about technology's effectiveness, even if they do not have strong evidence of it.

We were also told of instances in which decision makers' own previous experiences with technology provided evidence of effectiveness and therefore influenced future decision-making. In one example, a community college administrator spoke about the college's plan to expand a digital textbook initiative that began with developmental education:

> We've done some pilots and we've focused those specifically with our developmental courses. … That was really, I would say, one main impetus in moving forward with the [initiative], because the retention rates as well as the success rates for those students were significant, so we really wanted to move that college-wide.

A combination of previous experience and knowledge of relevant research may also inform organizational decisions about the use of technology in developmental education. This combination of factors was illustrated by a university administrator

discussing the fact that the institution had instructional technology "available" but that it was "not utilized that much" for developmental education students:

> I have found that developmental students … don't function well with [computer programs]. … Research has shown that developmental students in general do not respond that well to computer online programs. … And I've seen it for about the 20 years that I've been teaching developmental education.

State- or System-Level Influence

A similar number of respondents who reported effectiveness as a decision-making consideration also reported state- or system-level influence in decisions to adopt technology in developmental education (about one quarter of the organizations for which decision-making about technology was discussed). Sometimes, a statewide mandate to redesign or to integrate technology in developmental education led institutions to adopt instructional technologies. For example, a system-level administrator explained that under that state's policy mandate, "one of the required components of developmental [education] programs is the integration of technology with an emphasis on instructional support programs."

State-level actors can also influence decisions about technology in less direct ways. The existence of a statewide license to use a particular product or brand of technology has led decision makers to employ that particular technology at institutions within the state. Additionally, states can influence institutional technology decisions by demonstrating that the state prioritizes technology and by providing resources to campuses for adopting new technologies. One system-level respondent said that a state higher education board had created an office dedicated to educational technologies and provided online faculty training somewhat frequently, and that these actions have "really helped to push out the innovation around technology." A different system-level respondent said that some high-ranking academic officers were "asking what technology they are currently using and looking to see if there is a way to … share best practices across the system." This respondent viewed such activities as sending a system-wide "message … that the use of technology in a variety of ways can really help students be successful."

Product or Vendor Characteristics

Sometimes organizations selected a particular product or brand of technology because of characteristics unique to the product or vendor. Such considerations were

reported at just under a quarter of the organizations in our sample for which decision-making about technology was discussed, slightly less frequently than either effectiveness or state/system-level influence. Multiple respondents cited a particular vendor's customer service or "sales pitch" as a reason for choosing a type of technology. A relatively unique feature of one type of technology was cited as a reason for deciding to use it when that unique feature met an institutional need. An example of this is an institution selecting a software product that provides integrated reading and writing material — something that, as of the time of our interviews, not a lot of software vendors provided. Relatedly, a few respondents identified particular shortcomings with technology products as reasons they were not being used. As noted when discussing challenges associated with technology adoption, a system-level administrator said that a certain software vendor's exclusive focus on mathematics and not on English was a reason that the product was not used more frequently at institutions within the system.

Personalized Education

Respondents at about one fifth of the organizations whose representatives discussed decision-making identified the desire for personalization in instruction as a motivation for employing technology in developmental education. These respondents seemed to believe that technology can be used to tailor the curriculum to a student's individual educational needs, and that this personalization would enhance the educational experience. One way that technology can personalize education involves the use of diagnostic components of certain instructional software products (such as ALEKS or Pearson "Lab" products) to inform instruction. In the words of one community college administrator, these assessments help educators "to see where the students are, where the gains have happened, and where gaps [in student mastery] still exist." Instruction that takes place in computer labs (as with emporium classes or "math learning labs") was also thought to provide an individualized approach. A representative of a community college system explained that students "go into the lab and it's individualized supplemental instruction. … Lab students are there doing individualized work [and the] faculty member is going around and helping them throughout the time they're there."

Personalized education also includes using technology to modularize course content and allow students to complete each module at their own pace. A community college faculty member, discussing a decision made at the system about modular math, noted that the modules were "technology-based, for the most part" and stated:

> [It] didn't feel like students needed that entire course, so they created different exit points for different programs of study. … There is now a

> four-week interval course which allows students to finish their requirements a lot sooner.

Similar perspectives were discussed by other respondents with regard to computer-mediated self-paced developmental education modules. It should be noted that while self-paced courses theoretically enable students to complete requirements at a faster pace, this does not always occur in practice. For example, Bickerstaff, Fay, and Trimble (2016) found that in some self-paced courses, students have made "less progress than intended by the design of the course" (p. 24). Nonetheless, the personalized nature of self-pacing was discussed by multiple respondents as reasoning for the use of computer-mediated self-paced courses in their curricula.

Ubiquity of Technology

Although reported less frequently than the previously described considerations, several respondents (representing just under one sixth of organizations for which decision-making was described) made statements indicating that ubiquity of technology influenced decision-making about whether and how to use technology in developmental education. These statements suggested that because technology is so pervasive in contemporary society, it is expected that higher education institutions will use technology in some way, and therefore organizations feel they must accommodate and use technology in — among other things — developmental education. One administrator at a university system said that technology integration in developmental instruction was not "required" at institutions within the system, but that "because of the way curricula [have] developed over the years and the way faculty approach their courses … certainly technology is playing a bigger and bigger role." A community college administrator discussed reasoning for using technology to teach developmental writing, which illustrates how increased ubiquity of technology can influence decision-making about using technology in instruction: "When I first came here in the early 90s, I computerized our writing courses on the theory that nobody is writing without a computer."

Technology may also be so commonly used across a campus or system that it becomes part of the organizational culture, or at least prioritized in the minds of decision makers. As explained by a student services administrator at a "mostly online" community college, "We're … a very technology-heavy college normally, so it's just part of our culture. … We're always looking for innovative ways to offer online instruction." An administrator at another community college indicated that the institution had invested in technology "many years ago," and that the institution "certainly encourage[s]" technology use in developmental education. Statements such as these indicate that the ubiquity of technology across an organization as well as across society can influence

decision-making about the use of technology in instruction. Such statements also suggest that some organizations are (or hope to be viewed as) innovative, and that technology-based instruction is one method to help achieve this objective. Moreover, as discussed above, state- or system-level mandates influence campus decisions about technology in developmental education, and one way that a particular technology can become ubiquitous across a state or system is through the imposition of such a mandate.[9]

[9] This latter point is an example of multiple or combined influences on decision-making about technology use in developmental education.

5. Discussion and Conclusion

This study explores the experiences that institutions of higher education have had with technology in the provision of developmental education, including the various types of technology used and the challenges faced by institutions when implementing technology. Our respondents described technologies that fall under three categories. The first is *instructional technology*, which is content-driven and used to provide reading, writing, or mathematics instruction to students either before or after they enroll at an institution. The second category is *course management technology*, which electronically organizes and provides online access to course materials, such as syllabi or required reading materials, and allows certain course functions such as quizzes and discussions to take place online. The third category, *student support technology*, uses technology to assist students with academics or to encourage them to remain on track to complete their courses and programs. End users, such as students and faculty, have experienced difficulties with using technology, which has presented a challenge for institutions that implement technology in developmental education. Other challenges include finding funding to cover the costs of technology, lack of availability of technology, and limitations of particular products.

Our analysis of decision-making considerations regarding the use of technology in developmental education demonstrates how issues related to costs and resources weigh on institutions as they implement new technologies. Among the organizations we studied, economic and cost considerations were reported more frequently than any other decision-making factor. Expectations about the effectiveness of technology for enhancing educational outcomes were also considered, but these were reported to us less frequently than costs and other economic considerations, and about as frequently as the influence of state- or system-level policies and practices. In the field of education, there has been a growing focus on the use of data to inform decisions about educational practices (see, e.g., Swan, 2009). Data and evidence, however, are not always readily available, and other factors — especially costs — may play an outsized role in decisions about technology use in developmental education. Moreover, institutional leaders do not always have or rely upon strong evidence regarding the effectiveness of technology to improve student outcomes; many times, decision makers described somewhat vague perceptions of effectiveness when explaining why technology has been used.

We must also note that the use of educational technology interacts with other phenomena at the state and institutional levels, with stakeholders engaged in numerous conversations concerning improvements to developmental education as they are making decisions about implementing technology-based solutions and reforms. Beyond resource

availability, the use of a particular technology depends, at least in part, on whether the technology possesses some feature that will meet an organizational need. Furthermore, organizational culture with regard to technology, as well as the perception (or reality) that such technology is increasingly used and becoming ubiquitous, may also play a role in the decision to use technology.[10] Considerations such as these may determine whether, how, and in what form technology will be used in an institution's developmental education programming. Technology vendors who persuade decision makers that a given product is effective, cost-efficient, and able to meet an organizational need (or some combination of these features) may experience greater success in persuading an institution to use a particular technology. Indeed, our findings show that a vendor's "sales pitch" has played at least some role in certain organizations' decisions to use a particular technology.

This study contributes to the literature on developmental education and educational technology in meaningful ways. First, we identify the various types of technology used in the provision of postsecondary developmental education, and we categorize these by their function as instructional, course management, or student support technology. Moreover, our findings shed light on some of the factors underlying decisions about the use of technology in postsecondary developmental education, illustrating that many of these considerations are unrelated to effectiveness in improving educational outcomes.

This study also provides information about challenges faced by those institutions implementing technology in developmental education, so that campuses considering a new technology may anticipate these challenges and take preliminary steps to prepare for them. End-user difficulties with technology — particularly with regard to developmental education students, but also faculty — were frequently discussed challenges among our sample. This is important because students and faculty should be able to use technology appropriately and effectively. Institutions and systems may anticipate this challenge and attempt to address it by providing additional training on how to use the technology. Our study also provides information to policymakers, institutional leaders, and system-level officials on how decisions are made with respect to technology use in developmental education. Institutional and state-level leaders who want to encourage evidence-based decision-making regarding the effectiveness of educational technology can make efforts to identify such evidence, share it with campus stakeholders, and employ it themselves when considering the purchase of organization-wide licenses or acquisitions. Leaders may also, to the extent possible, provide additional funding for the implementation of

[10] For more about organizational culture and technology use in higher education institutions, see Karp and Fletcher (2014).

new technologies, so that a potentially effective technology will not be disregarded solely based on its cost.

Underprepared college students require support that will set them up for success in their college-level courses and ultimately guide them toward college graduation. Student success rates in developmental education are relatively low (Bailey, 2009), and the goal of integrating technology in developmental instruction should be to help place more students on the path to academic success. This paper has provided information for policymakers and higher education leaders to consider when looking for effective ways to use technology in developmental education.

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