UNIVERSITY INNOVATION ALLIANCE RESEARCH REPORT

Student Success through Digital Representation and Digital Mediation

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The UIA Doctoral Research Fellows Program is supported by the Carnegie Corporation of NY

INTRODUCTION

Today's higher education institutions use digital technologies that provide "combinations of information, communication, computing, and connectivity" (Bharadwaj et al., 2013, p. 471) to transform "sociotechnical structures that were previously mediated by non-digital artifacts or relationships" (Yoo et al., 2010, p. 6). While such digital innovations generally challenge organizations to cope with dynamic landscapes to improve their competitive positions (Kohli & Melville, 2019), they provide higher education institutions new means to improve their student success.

Digital innovations transform sociotechnical structures through combinations of material agency—the capacity of digital technologies to act on their own apart from human intervention—and human agency—the capacity of people to form and realize their goals (Leonardi, 2011). In some combinations, people use digital technology to monitor and produce a particular work space through digital representation of that workspace (Jonsson et al., 2018). In other combinations, people use digital technology to share and enact a particular work arrangement through digital mediation among the people involved (Jonsson et al., 2018). While some, if not all, digital technologies support both representation and mediation, some technologies, such as database systems and data analytics technologies, predominantly support representation—defined as representation-dominant technologies—while others, such as mobile devices and collaboration technologies, predominantly support mediation—defined as mediation-dominant technologies.

Although there is substantial research on digital innovation, research on how higher education institutions can improve student success through digital innovations is limited. Moreover, although representation-dominant technologies and mediation-dominant technologies each have been studied separately from a variety of perspectives, there is a lack of understanding on how these two types of technologies come together and complement each other in enabling higher education institutions to improve student success. Against that backdrop, we present a case study of Georgia State University's (GSU) Student Success Program asking: "How can digital representation and digital mediation be combined to support student success?"

As a pioneer of innovation in higher education, GSU has undertaken many digital innovation initiatives over the past two decades to improve student success, significantly transforming itself in the process. In these efforts, GSU faced unique challenges from its socio-economic context in Georgia, the highly competitive higher education context in the US, and the evolving technological context around the world. Due to Georgia's diverse demography, the undergraduate student body at GSU comprises 67% non-white and 58% Pell-eligible students with a majority of first-generation college-bound students who are challenged socially, economically, and pedagogically. Nationally, students from low-income and underrepresented backgrounds earn bachelor's degrees at lower rates (Stewart, 2020), due to factors such as preparation in under-resourced K-12 schools and unfamiliarity navigating the college environment. In response to such formidable challenges to improve the 6-year graduation rate of its undergraduate students, GSU has since 1999 effectively implemented digital innovations to support students' educational journey in four key areas—teaching, monitoring, engaging, and financing (Fuad et al., 2021). Through a combined effect of these digital innovation initiatives, GSU gradually improved its 6-year graduation rate from 32% in 2003 to 55% in 2018. In 2020, GSU was recognized as the number one public university for teaching in the US and the number two most innovative university in the US (US News & World Report, 2020).

Representation-Dominant Technologies

Representation-dominant technologies create approximate digital rendition of the real world to monitor the behavior of or to predict the outcome of real-world objects and processes by analyzing data in digital format. These technologies can monitor and produce work spaces using synthetic abstract models of real-world phenomena, imitating reality as closely as possible (Bailey et al., 2012). Such representational capacity is the fundamental characteristic of these technologies in which "activities, events, and objects are translated into and made visible by information" (Zuboff, 1988, pp. 10–11). Using representation-dominant technologies, people can access, manipulate, and make sense of requisite information (Zammuto et al., 2007). Although representing the real world with data is the primary focus of these technologies, they can also help people communicate to achieve shared understandings through mediation (Carlile, 2002). Regardless of its affordances, at the core of a representation-dominant technology is abstraction of the real world using data in digital format.

Considering representation-dominant technologies, GSU has implemented the Graduation Progression System (GPS) and complementary advising technologies to monitor and advise students. GPS predicts problems students may face and directs them to academic advisers who help students avoid or overcome these problems. GSU has also opened the Student Financial Management Center (SFMC), which uses predictive analytics to predict students' financial problems early and to help students address them proactively through counseling.

Innovation in Monitoring Students

Since the majority of students at GSU come from low-income or underrepresented backgrounds, GSU needs to closely monitor and frequently advise students. Starting in 2011, GSU gradually developed a Graduation Progression System (GPS) that monitors and detects problems students may face and complementary advising technologies that help students avoid or overcome these problems. GPS uses predictive analytics and a system of more than 800 alerts to track all undergraduate students daily, identify at-risk behaviors, and have advisers respond to alerts by intervening in a timely manner to get students back on track. The high impact of such data-driven monitoring systems on improving student success is echoed in previous research (Devlin & Bushey, 2019). Academic advisers at GSU's University Advisement Center (UAC) monitor the alerts and respond with timely, proactive advice to students, providing students the information they need when they need it to make decisions that lead to increased retention, progression, and graduation. UAC is continually helping students with individualized education planning, proactive risk targeting, and personalized interventions.

The GPS system went live in August 2012. Based on 10 years of 144,000 student records and 2.5 million grades, the system offers analytical models that predict potential problems for any student and refer them to an academic adviser at UAC for consultation. In the 2019-2020 academic year, GPS generated more than 55,000 individual meetings between students and advisers to discuss specific alerts and get students back on track toward graduation. Before GPS, many students were confused on which major to choose and which courses to take. Since GSU initiated GPS advising, the number of students in majors that fit their academic abilities increased by 13 percentage points, progression rates increased by 16 percentage points, and changes of major in the sophomore, junior, and senior years decreased by 32%. Also, freshman fall-to-spring retention rates increased by 5 percentage points and seniors are taking fewer excess courses toward graduation. As the SVP of student success commented "we are engaging with students and really changing their trajectory." With data-driven predictive analytics and student-centric proactive advising, GSU continues to improve the performance of its students.

Innovation in Financing Students

Predicated on the premise that more students will persist if their financial problems are identified early and addressed proactively, GSU opened the Student Financial Management Center (SFMC) in late fall 2016. SFMC deploys predictive analytics parallel to GPS academic advising system. In the case of SFMC, ten years of financial data were analyzed to identify early warning signs of students' financial problems. The analyses revealed that some financial decisions made before the students first set foot on campus may determine whether a student ever graduates, such as choosing a single dorm rather than living at home or with roommate in the summer before the freshman year. Through SFMC, certified financial counselors now track students daily and reach out to offer support and advice when problems are identified.

With 93% of undergraduates receiving federal aid, a major challenge for GSU is getting students to take the necessary steps to address outstanding financial-aid obligations and to resolve their balances. In the first year of SFMC operation, 56,833 students visited the center and received financial advice. Students were also given information on managing credit and budgeting. These efforts had a significant positive impact on students, as SFMC achieved more than 94% FAFSA completion rate for students re-enrolled in the spring semester compared to a 74% FAFSA completion rate in general student population. For the Fall 2017 semester, students who visited the SFMC were 6 percentage points more likely to complete all financial-aid requirements and bring their balances down to zero than the rest of the student body. With a campus of 52,000 students, this translates into more than 3,000 students being financially able and ready to start the semester than would have been true without the assistance of SFMC.

Mediation-Dominant Technologies

Organizational practices require participation and interventions from humans who communicate, collaborate, and coordinate through mediation-dominant technologies. As modern organizations innovate new forms of work arrangements, such as virtual teams and global outsourcing, they face challenges of discontinuities—stemming from physical locations, time zones, organizational affiliations, and national or professional culture—threatening cohesion of work (Chudoba et al., 2005). Mediation-dominant technologies bridge geographical, temporal, and cultural boundaries in distributed work arrangements that allow the involved actors to share information from the work space for joint problem solving and decision making (Jonsson et al., 2018). While mediation-dominant technologies can provide digital representations of the real-world, their main purpose is to help organizations interact internally and with the environment (Kallinikos, 2009). As such, mediation-dominant technologies transform organizations into complex sociotechnical systems with meta-human or human-in-the-loop (Rai et al., 2019) work arrangements that are co-created by the features of these technologies and the knowledge and experience of the people involved.

Considering mediation-dominant technologies, GSU adopted Adaptive Learning Technologies (ALT) that use computer algorithms to support learning by selecting and adapting the presentation of materials and activities based on each student's responses to previous questions, tasks, and experiences. Also, GSU implemented an artificial intelligence (AI) chatbot, named Pounce, that sends reminders, conducts guided tutorials, takes surveys, and provides targeted student support on various topics.

Innovation in Teaching Students

To improve student learning, GSU faced unique challenges from the socio-economic context in Georgia, where the majority of students is African-American, Hispanic, and

immigrants. Moreover, most students are first-generation college students from low-income families. To improve the performance of this student body and as a pioneer in applying digital technologies in teaching, GSU implemented adaptive learning technologies (ALT) that use computer algorithms to support learning by selecting and adapting course contents based on each student's previous performance. GSU initiated ALT in 2006 through its Mathematics Interactive Learning Environment (MILE). Mathematics has been a challenging subject for students from low-income backgrounds, and they are less likely to succeed in introductory gateway mathematics courses. To break this pedagogical barrier, GSU redesigned these mathematics courses using MILE. Before the redesign, drop, fail and withdrawal (DFW) rates regularly topped 40% in these courses. After failing once, students had to retake the course, often picking up another D or F. As a result, each semester hundreds of students lost their scholarships and dropped out.

GSU now offers these courses only through MILE. Students attend MILE lab sessions in large groups with dedicated instructors. In each lab session, students sit at individual terminals working on the same material using ALT and receiving support from teaching assistants and instructors. Using MILE, GSU was able to drop DFW rates across the introductory mathematics courses from an average of 31% in 2007 to 23% in 2014, helping hundreds of additional students pass the course in their first attempt each semester. Encouraged by this success, in 2017 GSU deployed ALT in five gateway courses in economics, political science, and psychology. The involved professors praised ALT, emphasizing that they help students manage enormous amounts of information in a structured way that is tailored to their evolving knowledge and capabilities.

Innovation in Engaging Students

Many students, especially first-generation, low-income students, become victims of "summer melt" by accepting offers of admission during summer but not showing up in fall. In 2015, 19% of GSU's incoming freshmen were victims of summer melt. From National Student Clearinghouse data, GSU found that, one year later, 274 of them (74% of whom were low-income) never attended any college. To successfully begin their college education, students need answers to questions about financial aid, FAFSA, registration, immunization, housing, admissions, and academic advising. Hence, GSU became more proactive and personal in interacting with students, between high-school graduation and the first day of college, by deploying an artificial intelligence (AI) chatbot to reduce summer melt. In summer 2016, GSU deployed its first chatbot—a texting system named after the school mascot "Pounce"—that allowed students to text any question 24/7. GSU built a knowledge base of 2,000 answers to commonly asked questions and in the three months leading up to the Fall 2016 classes, Pounce had 185,000 exchanges with students, with an average response time of 6 seconds. Similar usage was tracked in 2017 and 2018. With Pounce, in 2016, GSU lowered summer melt by 324 students (22%). In 2017 and 2018, summer melt declined by an additional 4 percentage points.

Students asked Pounce questions on a broad range of topics—about FAFSA, the difference between a grant and a loan, immunization records, and so on. After receiving a question from a student, the AI integrated in Pounce determines if there is an appropriate answer in the knowledge base or whether the student's question needs to be directed to a staff member to write an answer and add that to the knowledge base. As such, the knowledge base continues to grow and the AI learns to derive the meaning of more questions over time. With Pounce, access to information for all has been achieved. As the project director of the chatbot stated, "this technology lets us touch students faster and more effectively." After Pounce's success in admission, GSU expanded its knowledge base to help students in retention. Today the chatbot sends reminders, conducts guided tutorials, takes surveys, and provides targeted human support on topics including academics, financing, student life, student organizations, housing, meal plans, sports, and more. Critical to Pounce's success was building an adequate and reliable knowledge base, which currently includes 3,000 answers and the chatbot continues to learn.

Improving Student Success through Digital Innovations

Improving student success through digital innovations requires diversification of efforts across different areas of higher education. GSU improved student success through digital innovations in four key areas—teaching, monitoring, engaging, and financing. Innovation in teaching helped students pedagogically in retention and progression and ultimately in graduation. While innovation in teaching was an obvious and traditional choice, GSU pioneered innovation in monitoring students using predictive analytics. Such massive undertaking to monitor every undergraduate student daily using predictive analytics on 800 different indicators was unprecedented. GPS enabled GSU to oversee the activities and behaviors of students and guide them toward graduation through advising when necessary. GSU's efforts did not stop at simply teaching and monitoring students, rather GSU proactively innovated in engaging students through personalized communication using a chatbot. The labyrinth of higher education is difficult to maneuver for any student, let alone for a first-generation college student. Pounce provided access to information to all students at their fingertips and made their college life much easier. Finally, a significant challenge for GSU was the financial hardship of its students. The majority of students at GSU being in financial need required guidance in terms of how to manage their finances throughout college life. SFMC through its predictive analytics monitored student finances and provided professional counseling when necessary. GSU's success demonstrates the need to address different aspects of student success, starting from pedagogy to supervision, communication, and finances. Hence, we suggest a first principle:

Principle 1: *Improving student success through digital innovations requires diversified programs across areas such as teaching, monitoring, engaging, and financing.*

Digital innovations realize student success through two different means—representation and mediation. Representation-dominant and mediation-dominant technologies influence student success differently. On one hand, representation-dominant technologies create digital abstractions of the real-world, enabling analysis of real-world processes and systems, and prediction of outcomes. At GSU, GPS provides an abstraction of student activities and behaviors, imitating their academic status as closely as possible. Through such abstraction, GSU can predict undesirable outcomes for students and take action to avoid such outcomes. Specifically, GPS helps in monitoring students throughout their academic journey through a representation of the real-world. Similarly, SFMC creates abstraction of the financial status of students and helps in predicting potential pitfalls through a representation of the real-world. Such representation is key in achieving student success through digital innovations across diversified initiatives. Hence, we put forth a second principle:

Principle 2: *Digital representations improve student success through abstraction and analysis of data about student behaviors.*

On the other hand, mediation-dominant technologies provide the means of communication and dissemination of information in higher education institutions. While representation-dominant technologies imitate real-world through abstractions, mediation-dominant technologies convey aspects of such abstractions to facilitate collective sense-making and coordination. Abstractions created by representation-dominant technologies are codified and difficult to comprehend by humans and hence require collective interpretation and coordination through mediation-dominant technologies. GSU implemented an AI chatbot, Pounce, that acts as a medium to convey necessary information to students regarding various aspects of academic life. While the chatbot does create abstract models connecting possible questions to appropriate answers, such answers only become meaningful after it is conveyed to a student. Such mediation helps to engage students in college life and to keep them informed and updated. Similarly, adaptive learning technologies not only disseminate knowledge but also select and present knowledge according to the experience and skill-level of each student. Hence, we suggest a third principle:

Principle 3: *Digital mediations improve student success through dissemination of information and coordination amongst people involved.*

Finally, while some improvements in student success might be completely attributed to digital representations and others completely to digital mediations, to realize and sustain student success higher education institutions need both representation and mediation. Student success is effectuated by a combination of work spaces enabled by representation and work arrangements enabled by mediation. On one hand, representation-dominant technologies reduce uncertainties through abstraction and analysis of data; on the other hand, mediation-dominant technologies improve awareness through dissemination of information and coordination amongst people involved. In combination, representation-dominant and mediation-dominant technologies create synergies with greater effect on student success than the sum of their individual effects. Moreover, through complementing their individual effects across different areas of student success, representation-dominant and mediation-dominant technologies not only realize improvements in student success but also help sustain such improvements. Hence, we suggest a fourth and final principle for student success through digital innovation:

Principle 4: *Synergistic effects created by combining digital representation and digital mediation help realize and sustain improvements in student success.*

Together with our previous reporting of GSU's approach to change management (Fuad et al., 2021), these principles for leveraging digital representation and digital mediation can hopefully inspire and help other higher education institutions advance their student success programs.

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