DIGITAL TECHNOLOGY DESIGN FOR PROMOTING SELF-REGULATING LEARNING IN STUDENTS WITH LEARNING DISABILITIES

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By

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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As they progress into later grades, many students with learning disabilities struggle to keep up with academic standards; “88 percent of secondary students with learning disabilities (LD) performed below average or very below average in passage comprehension on the Woodcock-Johnson III” (Berkeley & Larsen, 2018, p. 75). Not only are students with learning disabilities poorly prepared for meeting the educational standards of higher grades due to their conditions, but they are also likely to develop behavioral and motivational problems that further impede their learning (Berkeley & Larsen, 2018, p. 75). A common experience of students with learning disabilities involves academic failure and the inability to reach academic requirements, which impedes their development of self-regulating learning behaviors and lowers their efficacy to reach their goals (Lichtinger & Kaplan, 2015, p. 124). Furthermore, Butler and De La Paz note the possibility of promoting self-regulating learning behaviors by targeting students’ academic performance, stating that “interventions that improve students’ academic performance are likely to improve their self-efficacy, goal setting, and attributions; therefore, given the reciprocal relationship between learning and motivation, it seems likely that interventions with self-regulatory elements may also have positive effects on struggling learners’ motivation” (2021, p. 354).

Since the COVID-19 pandemic, the educational technology field has experienced a massive growth; “Venture and equity financing for education technology start-ups has more than doubled, surging to $12.58 billion worldwide last year from $4.81 billion in 2019” (Singer, 2021, para. 2). Evmenova et al. noted that technology-based interventions improved the writing abilities of students with learning disabilities, including their proficiency in transitioning ideas and structuring ideas in essays (2020, p. 41). However, the push for educational technology during the COVID-19 pandemic has also provided “an opportunity to ed-tech businesses to sell

untested solutions which sometimes have little to do with proper teaching and learning philosophies" (Teräs et al., 2020, p. 870). This results in the abrupt adoption and subsequent abandonment of technology when the services it provides do not match the educational curriculum or teachers' understanding of how it could aid students (Boyle & Kennedy, 2019, p. 68).

The technical project was a capstone design project overseen by Professor Harry Powell, a professor in the Electrical and Computer Engineering department at the University of Virginia, and it aimed to address the implementation of educational technology into teaching curriculums by proof of concept. It involved prototyping a digital educational tool designed to teach students how to spell simple English words. Using feedback from professors in the Department of Education at the University of Virginia, the technical project combined a software-controlled spelling game with a physical interface using letter blocks. The intent was for students to learn new words while also exercising motor functions at the same time. The other team members on this project were Noah Beamon, Rachel Lew, Catlinh Nguyen, and Shymbolat Tnaliyev, who are all fourth-year students in the Electrical and Computer Engineering department.

In conjunction with the technical project, the STS project analyzes the efficacy of educational technology in promoting self-regulated learning in students with learning disabilities as well as the factors that affect its implementation into classroom curriculum practice. It examines the relationship of relevant social groups, including teachers, students, administration, industry, safety commissions, and education standards, using the Social Construction of Technology framework (Pinch & Bijker, 1984, p. 416). The framework is used to highlight the methods by which educational technology is applied into educational practice, the effectiveness

of methodologies towards developing self-regulating learning behaviors in students, and how educational technologies change with feedback from relevant social groups.

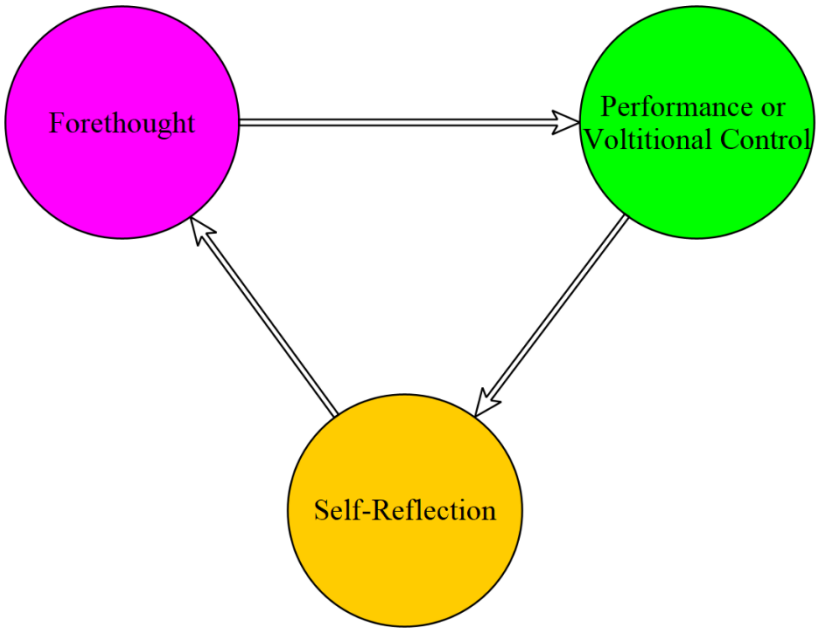

Figure 1: Self-regulated learning model. Students set goals in the forethought step, take action in the performance step, and reflect on their actions in the final step. (Adapted by Guo (2022) from Harwood & Koyama, 2020)

The two projects both attempt to detail the features that make educational technology feasible as a means to teach in the classroom. The STS project focuses more on considerations and limitations of using technology in practice to create a design methodology for digital tools to promote self-regulating learning in children with learning disabilities. The technical project provides insight into the technical and design challenges that impede the integration of digital technology into educational practice.

DIGITAL TECHNOLOGY IN EDUCATIONAL PRACTICE

SELF-REGULATED LEARNING IN STUDENTS WITH LEARNING DISABILITIES

Self-regulated learning can be described as the process of formulating plans to achieve a goal and then evaluating those plans to optimize them in the future (Lichtinger & Kaplan, 2015, p. 120). Harwood and Koyama (2020) describe self-regulated learning as a three-step cycle, depicted in Figure 1, showing how self-regulation leads to feedback cycles of attempting

different strategies to reach a goal. A common experience of students with learning disabilities, categorized as students who have characteristics that hinder their academic progress, is of academic failure and low expectations for success, which prevents them from developing positive self-regulating learning techniques and ultimately lowers their efficacy to reach their goals and finish assignments (Lichtinger & Kaplan, 2015, p. 124). The continual experience of academic failures in students with learning disabilities are "associated with a sense of alienation from school, avoidance of challenging tasks, and self-handicapping strategies", making academic progress even more difficult to achieve (Lichtinger & Kaplan, 2015, p. 124).

By eighth-grade, students with learning disabilities greatly lag behind other students in their educational progress; "seventy one percent of eighth-grade students with learning disabilities (LD) score below basic in reading, compared to 18% of students without disabilities, making it difficult for them to gain content knowledge from texts" (Lauterbach et al., 2020, p. 227). Despite this, secondary content teachers often do not align their instruction with these students' needs. Lauterbach et al. (2020) note that teachers often "felt they were not responsible for students' inability to read texts … traditional methods (e.g., lecturing) could circumvent reading difficulties, and that students could learn content without learning to read text … they chose not to teach literacy skills even when they were aware students needed them", indicating that students with learning disabilities fall further behind due to the teacher's perspective on their role in educating their students (p. 228). This further reinforces the idea that without an established strong set of self-regulated learning techniques, students with learning disabilities struggle to develop self-efficacy in academic settings.

The STS project analyzes the introduction of digital tools into educational use using the Social Construction of Technology framework (Pinch & Bijker, 1984, p. 416). The paper

examines the relationships of relevant social groups on digital tools, and it uses the Social Construction of Technology framework to identify the influence these social groups have on the design of digital tools. The social groups analyzed in this paper are teachers, students, educational standards boards, school management, investors and digital tool manufacturers, and

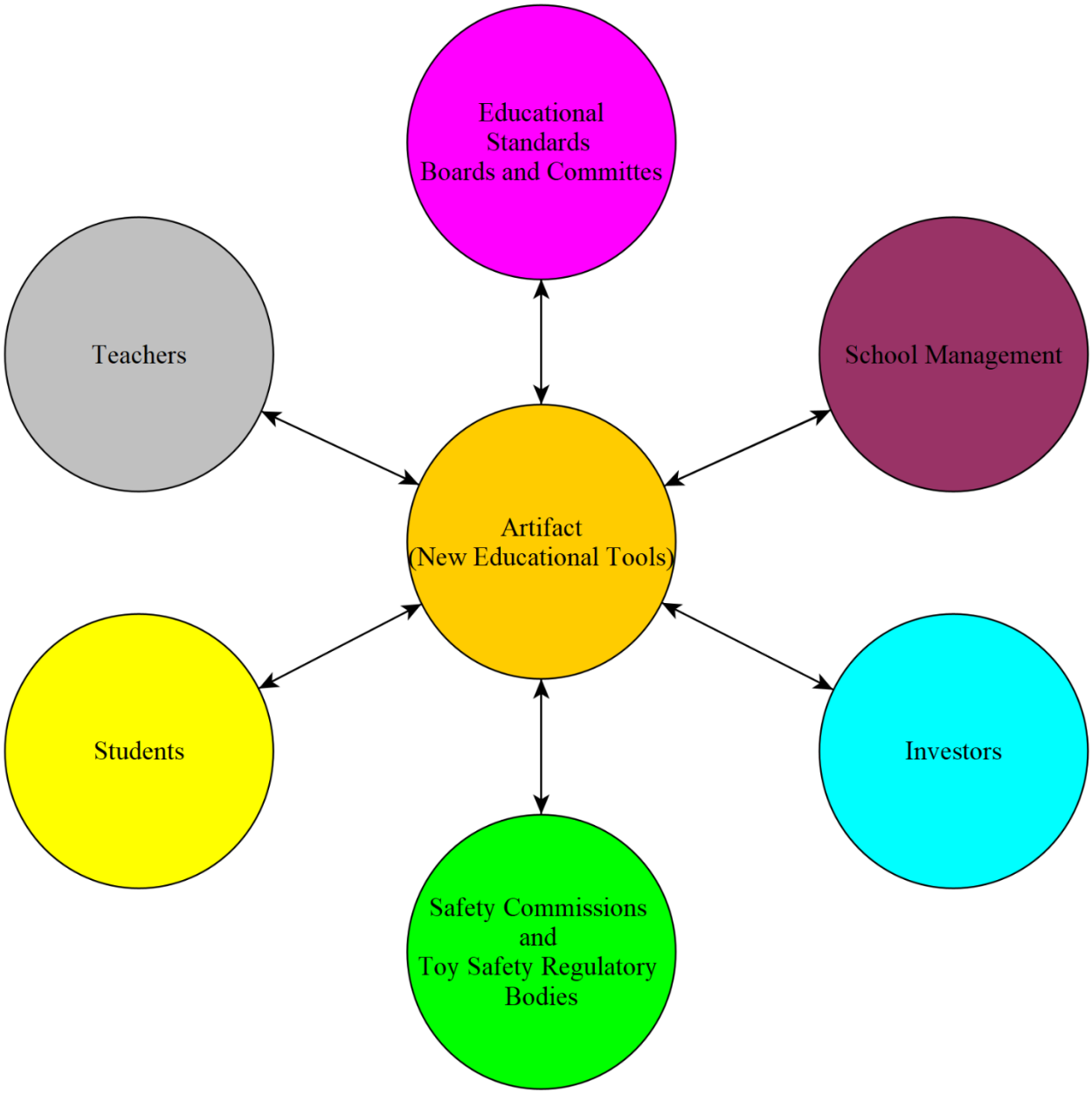

Figure 2: Social Construction of Technology framework for new placing digital tools in context of educational settings. Each social group has a different interpretation of what an educational digital tool is, creating conflicts in the implementation of the artifact. (Adapted by Guo (2022) from Pinch & Bijker, 1984)

safety commissions. Figure 2 shows the relationship diagram using the framework with the presented social groups.

IMPLEMENTATION OF TECHNOLOGY INCENTIVIES AND BIAS

Teachers often strongly influence if digital tools enter educational practice. Kale and Akcaoglu note in their analysis of preservice teachers' perceptions on the usage of technology that future programs should "focus on having them recognize technologies' educational utility values (e.g., how a technology can benefit them in their future teaching in specific ways) rather than assuming or appealing to temporary interest with technologies", implying that part of the reason technological integration is difficult is not only due to the failure of technical solutions, but also because teachers themselves do not see the value presented from the technology (2017, p. 303). Thus, the teacher's pedagogical views may impede the implementation of technology, as "evidence suggests that teachers with more teacher-centered beliefs do not perceive technology as being essential to the teaching and learning process" (Tondeur et al., 2017, p. 569). This idea supports the concept of programs to make student-centered teaching a higher valued pedagogy in teachers. Additionally, this also supports the idea that technology should be introduced in a way that connects with the teacher's existing teaching methods instead.

Teachers' ability to understand, use, and access new technologies presented to them also plays a role in technological integrations. Kucirkova and Flewitt (2020) writes that "that there are five principal external barriers that impede technology integration: lack of teacher confidence and skills; lack of time; lack of effective training; lack of well-organized access to resources; and technical problems", noting that accessibility to technology and the resources necessary to set up new systems up are considerations that digital technologies must design for (p. 136). Furthermore, Alelaimat et al. (2020) note that "most of the teachers interviewed … indicated that

integrating technology into education did not seem to be a priority in their study plan … technology-related courses were not adequate, as these courses neither improved their technological skills nor increased their awareness about how to integrate technology into education" (p. 308). The level of digital literacy in teachers plays a role in determining what technologies will be used or dropped, implying that the lack of expertise prevents teachers from connecting the intended purpose of educational digital tools to their own pedagogical views.

Investors and school boards may have different incentives to integrate technology, as "for many current platforms, datafication, or leveraging user generated data for profit-making, has become the business model" (Teräs et al., 2020, p. 873). The education sector has become increasingly data-driven, with students being required to consent to data collection practices before they can even use proprietary applications and software by businesses (Teräs et al., 2020, p. 867). "Robust anti-regulation approaches to Internet privacy (led by Internet companies like Google) in the US advocate for a utilitarian or "business friendly" approach to data protection", implying that businesses in the educational technology field should be allowed to harvest data from digital devices in order to provide a better service (Parsons, 2021, p. 337). Teräs et al. note that "technology and datafication of education are typically synonymized with progress and economic growth" with the underlying assumption that data gathered can be used to improve education by leading the development of technologies to solve current problems in education (2020, p. 867). Marketers for educational tools often promote the "Silicon Valley Narrative", which specifies that the current education system is broken and can only be fixed by technological intervention (Teräs et al., 2020, p. 869). Teras et al. note that the narrative creates a culture of fake solutionism; technology is presented to solve a problem despite the technology's inability to solve or even mitigate current societal challenges (2020, p. 870). As a result, the

focus tends to shift to financial investments, with a side effect being that "ed-tech solutions may reinforce problems rather than fix them" (Teräs et al., 2020, p. 870). The monetary incentive provided by data collection can drive investors to make arguments for promoting such capabilities in spite of ethical or privacy violations regarding the continuous collection of student and teacher data. Additionally, the increasing acceptance of conformity with the idea that technological integration symbolizes solving problems in educational practices may also push school management to advocate for technology advancement.

The Children's Online Privacy Protection Act (COPPA) is a set of regulations from the Federal Trade Commission aimed to address the implications of data collection from commercial services (Schifferle, 2020, para. 2). COPPA "requires companies that collect personal information online from children under age 13 to provide notice of their data collection and use practices and obtain verifiable parental consent" as a means of getting voluntary consent from the parents or guardians of students (Schifferle, 2020, para. 3). However, the Federal Trade Commission does note that COPPA is targeted towards corporations instead of school systems, and school districts still have the responsibility to vet the data collection practices of commercial services they are potentially using (Schifferle, 2020, para. 4). As a result, the requirements of regulation commissions influence the design of educational tools with its usage and application, but not necessarily with the tool's intended purpose.

DIGITAL TECHNOLOGY AS A MEANS OF LEARNING

The efficacy of digital tools also depends on the students using them. For one, the significance of the services provided by digital tools must first be made known to the students, as "simply providing access to technology does not necessarily translate into its effective integration … it is important to ensure that students receive explicit instruction that includes

modeling of how to use the technology effectively" (Evmenova et al., 2020, p. 29). The actual process of introducing technology to students is important because it influences the way they use digital devices as well as their interpretations on the value digital devices give to them.

There are previous examples of using technology to help students with learning disabilities practice and master core subjects like reading and mathematics. Evmenova et al. suggests the use of technology-based supporting tools to add to instruction, such as technology-based graphical organizers, to help structure students' thoughts (2020, p. 28). One consideration to take is that these technologies will often cater to the issues that are prevalent in students with learning disabilities; Hughes et al. note that their method of using a computer-based graphical organizer included technological feature specific to students' needs, and that "students with LD often struggle with transcription skills such as handwriting and therefore require external supports to manage this skill" (2019, p. 15). Kong et al. also covers the effects of word problem solving interventions in the educational curriculums of elementary students with learning disabilities, concluding that evidence exists to suggest that social activity with their peers can improve learning if provided alongside explicit and structured teaching (2021, p. 258). These findings support the idea that technology can be used as an intervention method to reinforce early education, preventing students with learning disabilities fall behind in their academic studies.

Bartolomé and Steffens write in their analysis that in order for technologically enhanced learning environments to foster self-regulated learning, learners should "be encouraged to plan their learning activities", "receive appropriate feedback so they can monitor their feedback", and "be given criteria so they can evaluate their own learning outcomes" (2011, pp. 23-24). One of the technologies the authors identify are personal learning environments, which consists of a

collection of educational tools and services built by the students themselves (2011, p. 25). By collecting the various services and piecing them together, “Students have to define their own learning goals, assemble the required resources and organize them in a personal web environment” (Bartolomé and Steffens, 2011, p. 25). While the responsibility of providing feedback then falls onto the teachers, personal learning environments challenge students into setting goals and performing their own analyses to construct an efficient environment. Compared to intervention methods, technology plays a different role in personal learning environments; educational services are not used for reinforcing academic foundations but rather for their capability to fulfill part of a student’s information network.

Forty-one states and multiple U.S. territories have adopted the Common Core State Standards, a set of guidelines for educational practice (Common Core State Standards Initiative, 2013). The standards recognize the different potential of digital technologies in classroom use, stating that while digital technologies could streamline new ways to deliver information, the design of digital technologies should empower user flexibility and control to avoid losing the focus on educational criteria (Common Core State Standards Initiative, 2013, p. 6). As such, the Common Core State Standards object on the use of digital tools should “they break down the Standards in such a way as to detract from focus, coherence, or rigor” (Common Core State Standards Initiative, 2013, p. 12).

One important distinction to make about the Common Core standards is that it attempts to encompass the needs of students with learning disabilities by including an over-arching criterion to accommodate all students (Common Core State Standards Initiative, 2013, p. 6). This not only shifts responsibility onto digital tool developers for meeting this criterion, but it also blurs the requirements in educational standards for students with learning disabilities. The Common

Core State Standards provide school boards a set of expectations for them to consider when purchasing or implementing new educational tools (Common Core State Standards Initiative, 2013, p. 5). The lack of specific recognition for students with specialized needs may bias the digital tools chosen by administrators because they target a smaller subset of students.

CONSIDERATIONS FOR NEW DIGITAL TECHNOLOGIES IN EDUCATIONAL PRACTICE

Spector proposes a framework that contains values, principles, people, context, and technology as an interconnected web (2016, p. 1009). From this perspective, it is easier to analyze the previous relationships made using the Social Construction of Technology framework (Pinch & Bijker, 1984, p. 416).

In context, students with learning disabilities often struggle to develop self-regulation learning behaviors and reach the same academic level as their peers. Technological devices and tools are presented as potential solutions to provide a meaningful learning experience. For students with learning disabilities, technological solutions show promise in helping them develop social relationships and early academic foundations, preventing them from lagging behind in school (Kong et al., 2021, p. 258). While educational technology does show to support building self-regulated learning behaviors in students with learning disabilities, through reinforcing academic basis and building personal learning environments, it is also important to consider both how technologies are presented to students and how students access educational technologies. Digital tool manufacturers, investors, teachers, and school administrations all have differently weighted values that affect the designs of educational technologies that end up reaching students. The intended purpose of digital tools is lost on teachers who are not sufficiently literate in digital technologies and teachers who do not view the technology as useful tools. Bias exists in digital

tool manufacturers and school management when implementing new technologies due to monetary incentives and societal pressure to “change the system”. The efficacy of using digital technology to aid students with learning disabilities build self-regulating behaviors is hindered by factors that inhibit technological integration with teaching pedagogies.

This analysis is limited in scope in several areas. First, the paper classifies students with learning disabilities into one group and uses generalizations of students with learning disabilities to form conclusions. As learning disabilities can vary widely from student to student, the paper does not discuss the implications of different types of disabilities on self-regulated learning behaviors or academic achievement. Similarly, the paper classifies educational technologies to be broadly accepting of digital technologies or tools potentially used for educational purposes. Part of the goal of this paper is to identify the perceptions and potential biases that affect the integration of educational technologies, which is why even if different types of tools produce different results the paper does not go into depth on them.

Further research should go in depth on the types of technologies best suited for self-regulated learning behaviors for students with learning disabilities, such as graphical organizers or puzzle solving games. The design of new technologies is often critical to the understand of students and teachers’ perspective on its intended use. Additionally, further research should also focus on regional differences and teaching practices. This paper does not cover culturally influenced teaching, which may affect the perception of new educational tools in a localized area.

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