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An Operationalized Understanding of Personalized Learning

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Abstract

As referenced in the Every Student Succeeds Act and the National Educational Technology Plan, personalized learning is the new focus in many K–12 learning environments. Nonetheless, few people understand what personalized learning really means and even fewer can design and implement a personalized learning environment appropriate for all learners, especially learners with disabilities. This 18-month descriptive research study focused on identifying the design characteristics of personalized learning environments and the initial results of these environments. Findings indicate that personalized learning environments require more than technology, that the technology itself is simply a tool to support implementation. These personalized learning environments were highly learner self-regulated, had transparent and actionable near-real-time data, provided various structures for student voice and feedback, and integrated purposeful supports for embedding the principles of Universal Design for Learning at the cornerstone of practice. Personalized learning requires a shift in instructional practice on behalf of both the teacher and the learners. Implications for further research and practice are discussed.

Keywords

personalized learning, educational perspectives, Universal Design for Learning, instructional/policy perspectives, blended learning, K–12 online learning

In the last 5 years, various innovations have taken place in the technology sector, triggering trends and shifts in the practice of education. Five years ago, during the early inceptions of the Center on Online Learning and Students with Disabilities (Center), virtual school or fully online enrollment was skyrocketing (Waston, Murin, Vashaw, Gemin, & Rapp, 2011). Now K–12 fully online education is still growing, but this growth has been outpaced by the expansion of blended learning environments and the emergence of what has been termed "personalized learning" (Watson, 2008). In blended settings, students may engage with online curriculum resources and activities within the context of a brick-and-mortar classroom setting as well as with an "in-person" classroom teacher. Additionally, in the blended classroom, teachers and students frequently have access to real-time academic progress data to help individualize their learning.

In the most ideal sense, online and blended learning trends emerge as the education system, and the technology sector learn from one another about how to design and implement more effective environments. On a practical level, monitoring and analyzing trends or practices in education, especially those prompted by the rapid evolution of technology, is difficult at best. As a Center, we have been funded to identify trends and to measure and design promising practices for supporting the education system's most varied learners: those with disabilities.

At the time the Center grant proposal was written in 2011, members of the technology industry showed some excitement about the ability to design education systems capable of individualizing, and personalizing, educational materials based on the needs of each learner. Although the idea of personalizing education had been studied and reported in academic literature, especially in computer science (Lin, Yeh, Hung, & Chang 2013), there was limited known application of personalized learning in the education system, especially in K–12 education (Watson, Murin, Vashaw, Gemin, & Rapp, 2011). Nonetheless, with the Center's focus on learners with disabilities, the ability to personalize, based on learner needs, offered great potential. Nearly 5 years later, the education system is on personalization overdrive, with systems claiming and attempting to personalize learning for all students (Enyedey, 2014). In fact, the passage of the Every Student Succeeds Act (2015) as well as the recent National Education Technology Plan (2016) call for more

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personalized learning intermixed with the Universal Design for Learning (UDL) framework (http://www.udlcenter.org/).

The reality of personalized learning is that although it sounds like an excellent proposition for education, there is not consistent understanding on what it truly means and little understanding on how to actually design and implement a personalized learning environment appropriate for all learners (Patrick, Kennedy, & Powell, 2013; Penuel & Johnson, 2016). As researchers who conduct research on identifying, designing, or supporting the implementation of better learning environments, within this article, we will share understandings, findings, and lessons learned within personalized learning. Through the research conducted within the Center, it has become evident that well-designed personalized learning environments can transform both teacher and student behavior and encourage students' academic growth in ways that might not be possible without these advances (see Findings presented in this article).

A personalized environment is both active and complex, and it emphasizes individual learner growth, often in the context of skill based and cooperative student grouping. If designed and implemented correctly, personalized learning is extremely disruptive to the traditional education system. For instance, a personalized system places very little to no emphasis on whole group measures or on measuring academic growth based on single assessments. Further, personalization is less concerned with measuring performance compared to a hypothetical "average" student across an average curriculum and more focused on each student's skill growth as an individual learner. Specifically, if an education system accepted the idea that each learner had variability and that each learner would progress at a different pace, based on a wide number of variables, then the notion of an average student or learner is not overly useful (Rose, 2016). Personalization essentially does away with the factory model of education. In his book on establishing a new vision for how society should think about averages as compared to individuals, Rose (2016) provides a clear rationale for how the traditional notions of the average have provided society an outdated and misunderstood emphasis on planning and educating the average student when no one is truly average. In actuality, each individual has wide learning variability, and personalized educational environments should consider these differences in the instructional process.

Personalized learning has the potential to revolutionize the education system (Duncan, 2013). Nonetheless, without guidance or research-based understanding, personalized learning will be haphazardly referenced, partially implemented, eventually demonized, and then viewed as an unrealistic fad in education. The purpose of this article is to provide an operationalized understanding of personalized learning. This understanding is derived from the perspective of researchers who have both investigated and supported implementation of personalized learning on the ground with schools and teachers. This research includes observations of numerous personalized learning environments and interviews with teachers, students, and education leaders. Researchers have investigated promising practices, and designed, as well as tested implementation strategies. This article will highlight some of this work. For more information, visit the Center website: http://centerononlinelearning.org/.

General Terminology

Blended learning. As defined by Christensen, Horn, and Staker (2013), blended learning is a formal education program where students learn, in part, through online learning with some learner control over time, path, pace, or place. At least some of the learning takes place in a school-based, brick-and-mortar setting, away from the home.

Competency/proficiency-based learning. In this curricular structure, students progress based on mastery of successive goals. Students are often grouped by age and/or proficiency levels not grades, and movement through a course of study is based on evidence-based skills or knowledge achievement not seat time.[1]

Digital delivery systems. Content management or learning management system (LMS) that displays provides access to digital materials and learning interactions for student use. Most of these systems require an individual student log-in via username/password or unique student identification number and record and display student usage and achievement data.[1]

Digital learning. Use of digital technology to support learning. This term is context free to specific digital technology, environment, pedagogy, instructional design, and learner interaction with the material or environment.

Personalized learning. According to Patrick, Kennedy, and Powell (2013), personalized learning means tailoring learning for each learner's interest, strengths, and needs. This approach encourages flexibility to support mastery and enables learners to influence how, what, when, and where they learn .[1]

UDL. A scientifically based framework focused on supporting the variability of every learner through proactive and iterative design that integrates multiple means of engagement, representation of information, and action and expression of understanding.[1]

A Brief Understanding of Personalized Learning

The use of technology to personalize learning in education is not new. Skinner (1958) successfully demonstrated how "teaching machines" could be used to support increased learner independence, allowing students to complete tasks independently and at their own pace. This work established one vision for how technology could be used to support the instructional learning environment. Since that time, Computer-assisted instruction (CAI) has been studied and supported by a number of researchers for how it can provide learners with a more fluid digitally based learning experience (Pennington, Ault, Schuster, & Sanders, 2011) when compared to traditional teacher-centered classrooms. Recent work in this area has focused on adaptive and dynamic implementations, sometimes referred to as personalized learning systems. Essentially an updated version of CAI, these personalized learning systems generally guide learners down an array of learning pathways based on performance (Coleman-Martin, Heller, Cihak, & Irvine, 2005).

The Challenge of Digital Decision-Making

Many completely digital personalized environments rely heavily on machine-based, stimulus–response analytics rather than on contextualized, learner-centered growth patterns to make learning pathway decisions for students. Many of these models simply replace the teacher with digitally generated oversight (Shute & Zapata-Rivera, 2012) and fail to take into account learner strengths and weaknesses, the learning context, and the affordances of the instructional system. Beyond being driven by narrowly developed algorithms (often created from statistical models of the hypothetical average student referenced previously), these completely digital environments also neglect other important knowledge and skills such as social–emotional development and hands-on problem-solving (Basham, Stahl, Ortiz, Rice, & Smith, 2015; Stodel, Thompson, & MacDonald, 2006). This is not to suggest that fully digital environments are ineffective in supporting the K–12 student population but rather to assert that more research is necessary.

Student Self-Regulation and Learning Online

According to McLoughlin and Lee (2010), while the ability to use digital technology to personalize learning for each student hold promise, the process of personalization puts enormous pedagogical and procedural burden on the students—as well as teachers—to make critical instructional decisions. From a design perspective, because of the various interactions that must take place among the student and the technology as well as the student and the teacher, it could be hypothesized that personalized learning environments rely heavily on student self-regulation. System-level design scaffolds, and tools for developing self-regulated learning are critical to personalization efforts (Dabbagh & Kitsantas, 2005). For instance, design elements in successful environments include the explicit teaching of self-regulatory behavior and embed supports for the use of these skills (Dembo & Eaton, 2000). Moreover, the various design elements that support student self-regulated learning have shown meaningful impact across academic areas (Dignath, Buettner, & Langfeldt, 2008). Yet, although self-regulation likely plays a role, in reality, there is little known about the active design elements and practices within personalized learning environments and even less is known regarding the impact of these environments on student outcomes, especially for those with disabilities and other diverse learning needs. In fact, a search of academic journal databases returns no articles related to design elements, classroom practices, and outcomes associated with personalized learning.

Moving Beyond the Fully Digital

In 2013, the company IBM predicted that within 5 years, classrooms would support personalized learning by continually gathering data and supporting personalized pathways for success (IBM, 2013). In 2014, a National Summit on Technology Enabled Personalized Learning (National Summit) was held to identify both pioneering work and barriers in the area of personalized learning (Abbott et al., 2015). Interestingly, both the IBM report and the findings from the National Summit focused on the need for various types of models for supporting personalized learning. In the final report of the National Summit, Abbott et al. highlighted blended learning as a feature within personalized environments. Abbott et al. also highlighted UDL as a foundational framework for building when considering the adoption of personalized learning environments. According to the National Summit report, the research associated with the National Summit identified five organizing themes for advancing the practice of personalized learning: data, technology architecture, human capacity, content and curriculum, and research and development. These themes were interconnected with considerations of instructional design and practices, technology standards focused on development of new technology (e.g., system interoperability, resource tagging), and regulations that govern both business and education practices.

While K–12 education systems are advancing the adoption of personalized learning, very little research has looked at personalized learning in ‘‘real-world’’ blended K–12 education settings. Conceptual indications support the idea that personalized learning is comprised of various moving and intermingled human–machine interactions and system design features. Nevertheless, a search for refereed research literature based on personalized learning finds the largest number of articles are written on building machine-driven systems (e.g., Chen, 2008; Hwang, Kuo, Yin, & Chuang, 2010; Lin et al., 2013; O’Keeffe, Brady, Conlan, & Wade, 2006) and only one study that examined both system design dynamics and learner outcomes of personalized learning (e.g., Chiu-Jung & Pei-Lin, 2007). No studies found investigated the design features, the operational human interactions, and initial outcomes for K–12 students, especially those with disabilities.

Students with disabilities have conditions that coexist. For example, students with physical or sensory disabilities may present with associated learning, attentional, and executive function challenges. These conditions overlap and interlock, creating complex profiles. These complex learning difficulties require personalized learning pathways that recognize children’s and adolescents’ unique and changing learning patterns (Carpenter et al., 2011). Although personalized learning for students with disabilities is important, it is still an emerging practice. Achieving true personalization requires schools to understand data that are high volume, high velocity, and high density and to disaggregate these data to support learning profiles at the individual student level (McDermott & Turk, 2015). Since students with disabilities are usually a small population within a school and data about them are subject to privacy protections, frameworks need to be developed that truly account for student learning. These frameworks need to be developed as part of well-designed and well-funded research projects. An example of such a project was developed within the Now the Schools network (http://complexld.ssatrust.org.uk). This project focused on developing engagement frameworks that focused on learner profiles and concomitant scale development, providing information to schools about students with complex learning needs and alerting them to what types of data patterns will emerge for students with various needs, an inquiry framework for curriculum supported by staff development materials, and ongoing support from the Now the Schools network. More projects like this should be developed in both the United States and abroad.

To advance initial understanding in the ability to operationalize K–12 personalized learning settings, there is need to conduct both exploratory and descriptive research on associated design features, human and role interactions within these systems, and initial outcomes within these designs. To support this need, the Center initiated a longer term research project in a widely recognized K–12 personalized learning environment. For this project, the team was interested in answering the following questions:

- How are personalized learning environments operationalized?
- What levels of success do students with disabilities demonstrate in personalized learning environments?

Method

The Center conducts work across the nation on various research partnerships, and this project was conducted in a northern central state. The district was an urban reform district (URD) with roughly 6,500 students in Grades K–12. The district operated 12 schools across this large, urban area. The URD was a state takeover district, designed to reinvigorate chronically low-performing schools. At the initial point of takeover, the district's student population included about 20% students with disabilities (this diminished over time to more normalized levels of around 12%). By design, the URD used technology, data, and human practices to support a personalized learning environment. The district had an extended school day (7.5 hr) and extended school year (210 days).

The URD learning architects designed a personalized and proficiency-based district where students established and maintained their own learning pathways. Within these environments, each student had their own personalized learning plan, and students with disabilities also had federally mandated Individualized Education Program (IEP). Using a personalized setting that was blended with machine–human interaction, these active environments demonstrated an inherent alignment to UDL. Moreover, rather than being grouped by grade levels, students were grouped by age, supporting an environment that was fully inclusive and accepting of learning differences. The system mandated that a series of transparent, academic, self-regulatory protocols be present and actively employed in each classroom. Students were encouraged and provided with the tools and scaffolds to take ownership of their individual learning. The primary focus of this district's partnership with the Center was to develop an understanding of what was working compared to what was not working within these environments and to support the design of environments and practices that worked throughout the district.

Data Collection

Researchers conducted 50 observations (over an 18-month window). Observations took place monthly, within a 2- to 3-day window, in agreement with the district. The researchers had the ability to move throughout the district, conduct observations, watch day-to-day operations, talk with district staff, and (with necessary permissions) talk with students and parents. Single observations lasted from 20 min to multiple hours. For this study, researchers conducted observations and then developed initial themes from the emergent observations. After developing some common themes, researchers then conducted observations and interviews to support an operationalized understanding of the principles and practices. Researchers also used an instrument designed to measure UDL alignment. During the later observations, the researchers used the UDL Instructional Observation Instrument (Basham, Gardner, & Smith, 2013) to align practices to the UDL framework. In the process of identifying design principles and practices, researchers also interviewed both instructional staff and students to confirm how these principles and practices were operationalized on a day-to-day basis within the environment. To investigate the factors associated with student outcomes, researchers gained access to 2012–2013 school year data. These data included all student and school-wide data associated with academic performance, behavioral incidences, and enrollment. These data also included student demographic information, including—but not limited to—disability status.

Analysis

To identify design principles and practices, the researchers conducted numerous long- and short-form observations over an 18-month window, across multiple classrooms and other learning environments within URD. To identify design principles and associated practices, researchers used a multilevel coding process. During initial observations, researchers used an open observation technique to identify common principles and practices across settings. Initial themes and common language among researchers were then developed by reviewing data, developing initial coding, and then cataloging associated observation data. After developing initial themes, researchers conducted targeted observations and interviews to confirm and support the findings from the open observations. Data from observations and interviews were all then coded in alignment with the common themes that emerged through the open observations.

Factors associated with students who met different levels of anticipated growth were demonstrated in terms of demographic characteristics such as gender, ethnicity, and disability (yes/no). χ^2 Test was performed to examine the associations between these demographic variables and each of six levels of anticipated growth (yes/no). Effect sizes (ϕ, Cramer's V) were also reported. In addition, those percentages were visually inspected for a pattern of change over a range of students' ages. Given the clustered nature of the data (i.e., students nested within schools), generalized linear mixed modeling (GLMM) was then used to identify the variables that significantly contribute to meeting at least 1-year growth (yes/no), accounting for dependency of observations. Specifically, the models included the fixed effects of age, days from enrollment to start, gender, ethnicity, citizenship (U.S./non-U.S. citizen), limited English proficiency, disability, IEP (yes/no), and their potential interactions. The random effects included were students and schools (i.e., intercept variances). The model parameters were estimated via restricted pseudolikelihood estimation (Wolfinger & O'Connell, 1993) implemented in SAS PROC GLIMMIX (SAS Institute Inc. (2010). SAS [Software, version 9.2.] Cary, NC. SAS Institute Inc., 2002–2010). The descriptive statistics and preliminary GLMM results indicated similar, but not identical, growth patterns over age between math and English, and thus GLMM analysis was conducted separately for math and English.

Findings

This section highlights the findings from the observations, interviews, and data obtained from URD.

How Are Personalized Learning Environments Operationalized?

From an observational stance, there was a visible, omnipresent role of student self-regulation designed, built into, and consistently used throughout the personalized learning environments. Related to self-regulation, during the time of this study, all observed environments had a consistent use of classroom/system-level data; these data were transparent indicators of learner self-rated progress and effort. The overriding integration of UDL with a heavily identifiable focus on the use of multiple means of action and expression was apparent within the environments. There was also a continual development and use of various protocols and strategies to help support both teacher and student decision-making in established personalized pathways in the learning process.

In the URD personalized schools, students became active participants, assuming responsibility for their learning, unlike in traditional classrooms where teachers assume primary responsibility for instruction. Within these personalized environments, the teachers took on the role of designing learning environments, wherein students had the appropriate resources, engagement, and scaffolds to be successful. Teachers were in charge of designing and maintaining an environment that supported student self-regulation, providing the learners with necessary tools, strategies, and scaffolds for success. Teachers would often discuss how designing for learning and engineering learning was important to working within the environment. Teachers also discussed using student data and student voices in planning pathways for student learning. School administration and staff communicated a "can-do" attitude: During interviews, teachers often discussed solving problems as well as developing and testing solutions based on the needs of their environment or their students.

URD learners participated in planning, establishing goals, and producing evidence of what they have mastered based on projects, performance tasks, and common assessments. Learners gained understanding of information through a variety of forms, including instruction from teachers, various forms of technology, expert peers, traditional reading materials, and, if needed, learning coaches. By the middle of the school year, more than 25% of students across the 12 URD schools had already achieved 1 or more years' growth in reading and in math. Both students and teachers discussed how feedback on learning progress was important to the process. For instance, during one interview, a middle school student indicated that weekly meetings to discuss his "learning data" were critical for him to stay on pace and helped him take ownership of his learning.

Technology was a critical component within URD. Teachers used technology to support individualized, small group, and, occasionally, large group instruction and data collection. The district was established as a nearly 1:1 district, yet often learners were seen working in pairs or groups, collaboratively working on projects or demonstrations of understanding. When students were working individually on computers, they were often learning a new skill in an online system, completing an individual project, or taking a quiz. Beyond modern technology, learners would often be seen drawing, writing, or doing some other type of low-tech projects.

The district purchased various technology systems for supporting both learners and teachers. According to conversations with the district administration, these systems were adopted with a focus on designing personalized learning environments for all learners or based on specific learner or teacher needs. Beyond centrally adopted systems, teachers were encouraged to innovatively problem solve and test solutions around learner needs. During one visit to a high school, a team of teachers were discussing an issue they were having with students not completing out-of-school activities and homework, trying to prepare students to transition to postsecondary life, the need to provide the learners with useful solutions, and then described the need for learners to keep to-do lists while also being facilitated by adults (allowing teachers and parents the opportunity set reminders, etc.). The teachers devised a solution, wherein the learners could use a free Google calendaring system. In another example, a team of middle school teachers discussed the desire to communicate with learners and parents during off-school hours. From their experience, parents were not eager to e-mail, but text messaging was useful. The teachers also did not want learners and parents to have 24-7 access to their personal mobile phone numbers, so they found a system that allows them to text parents (occasionally scheduling reminder texts to have student complete work) without giving the parents the teachers' mobile phone numbers. Teachers then took turns monitoring the system, or being on-call, during off-school hours, to respond to questions.

The district partnered with a nationally known educational technology vendor to customize a cornerstone, personalized LMS, Agilix Buzz (Agilix Labs, (2016). See: Agilix Buzz. http://agilix.com/). This system supported individualized learning pathways and gathered support data (including student self-report data). Within the LMS, teachers would upload digital learning objects or assets to support student learning of specific competencies. The compiled objects or learning sequences could be shared between teachers and used with various learners in the district. This system also allowed learners to self-identify and report comfort level with content, level of engagement, and level of effort put into learning a competency or task. These data could be used for identifying barriers to learning (e.g., was not engaged, did not give much effort). The system also allowed learners to find and seek assistance from their peers who were identified in the system as master learners for a given competency.

In an effort to build in redundancy, the district also required progress trackers to be posted in each classroom. These trackers showed learner movement or growth through individual competencies and not the actual pace of learning. Thus, each learner, regardless of level, could demonstrate growth on their individual competencies. The combined interaction across the teachers, learners, technology, and data in the environment was clearly observed and discussed. The systems allowed the learners and teachers to access daily updates on academic progress. These daily progress data were combined into a weekly profile used in learner–teacher conferences to review progress, identify mastery levels, or isolate academic challenges that might require increased attention. The availability and regular use of student progress data provided teachers and learners with the information they required to effectively personalize instruction for URD learners.

In one-on-one conversations, learners would often talk with researchers about their data. For example, on an initial visit to a middle school classroom, a learner was explaining the data system to a researcher and said, "No one in this class is average." During a visit to an elementary classroom of 5- to 6-year olds, one learner took a researcher by the finger to show him the "buzz" score she had earned in English language arts (ELA) and math and said, "My Buzz score is ... they are different, but that's okay, everyone is different." Older students would often simply refer to their scores or levels, without reference to the system, then talk about their progress and their plans for academic growth. Students in upper elementary or middle school would often discuss their scores relative to the competencies or through academic "I Can" statements.

While some classrooms represented a more traditional classroom seating setup (these were generally in older grades), most learning environments in URD were designed for open flow, wherein learners could work in small groups or individually at both desk style or other, comfortable seating arrangements. Some classrooms provided a means to pull together larger groups of students or even entire classes. Entire classes were observed only when learners were explicitly learning a new learning strategy or when a teacher had decided that all learners needed to learn or meet about something as a group. Across all of the observations conducted, only two larger group instructional experiences were observed, and others were discussed by teachers. One larger group experience took place when a larger group of students was pulled into a room to learn how to use a new graphic organizing tool in studying and expressing understanding. During another observation in a middle school classroom, learners were pulled together to learn how the group was going to help support a community event that was taking place at the school. Teachers also discussed pulling entire groups of students together to learn and discuss concepts such as self-regulation and grit. During all other observations, there were various pockets of students working independently or in small groups. During one observation of an elementary classroom, two learners were viewing a video from YouTube, three learners were working in a digital learning systems, two learners were working on worksheets, two other small groups of learners were working on two separate paper-based projects, and the teacher was facilitating a small group at the interactive whiteboard. Visiting the classroom, one could very quickly imagine the planning, time, and coordination of resources (including data) that went into making this single classroom operational.

Reflecting the district's view on technology, teachers were encouraged to think about, design, and test new learning spaces. Teachers were inspired to test new space configurations and could propose ideas and receive small amounts of funding for purchasing items such as furniture or mats. For example, for a period of time, a group of elementary teachers decided to combine their rooms to provide a "learning village." Within the village, one room was an open creative space that provided students with an opportunity to spread out, sit on a large carpet, sit in beanbags, or even sit on a table. This space was also used for larger groups to participate in a lesson or story time. Another classroom was established as an individual or very small group workspace, and it was generally a quiet space. The third classroom was set up as small group space, wherein learners worked small groups (generally around tables) and could also be seen sitting on the floor in groups. Teachers and learners would move about these three rooms within the learning village based on need.

What Levels of Success Do Students With Disabilities Demonstrate in These Personalized Environments?

Student growth. Figure 1 shows the percentages of students who met at least 1 year's growth (age 6–18 years). The percentage

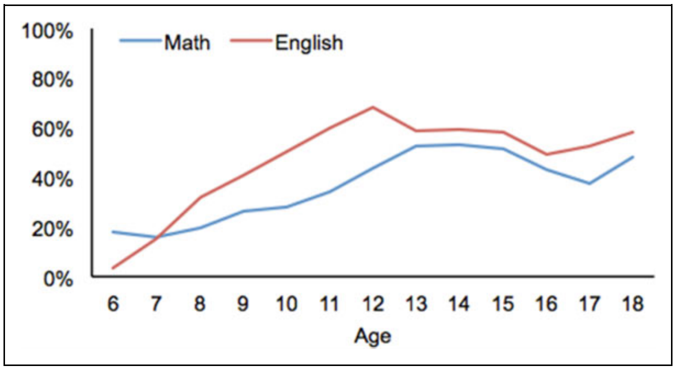

Figure 1. Percentages of students who made at least 1-year growth.

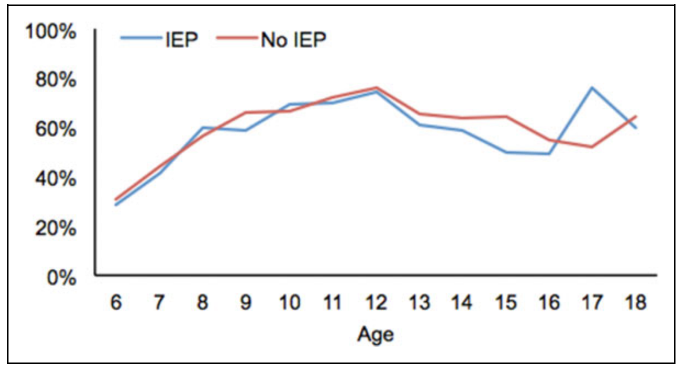

Figure 2. Students with and without disabilities meeting at least 1-year growth in math.

Table 1. Met At Least 1-Year Growth in Math.

Effect	Estimate	*SE*	*p*	*OR*
Intercept	−1.25	.36	.004	
Age	0.37	.06	<.001	–
Age × Age	−0.02	.00	<.001	–
Age × IEP	−0.07	.03	.013	.89

Note. Odds ratio (*OR*) was estimated at mean age (11.88 years). IEP = individualized education program.

of students meeting at least 1-year growth in math slowly changed (increased then decreased) in a quadratic pattern. This percentage changed also in a quadratic pattern in English, but it rapidly increased by the age of 12 years then slowly decreased after that age (Table 1).

Mathematics. Of the data on 6,180 students, 6.2% met ½-year growth; 6.8% met ¾-year growth; 13.9% met 1-year growth; 12.7% met 1½-year growth; and 38.5% met 2-year growth in math. 65.1% met at least 1-year growth in math. Male students showed lower percentages of meeting ½-year growth in math, but higher percentages of meeting 2-year growth and at least 1-year growth than did female students.

When the data were disaggregated for students with disabilities, these students showed lower percentages of meeting ¾-year growth, 1-year growth, and 1½-year growth in math, but higher percentages of meeting 2-year growth and at least 1-year growth than students without disabilities (SWOD). However, the estimated effect sizes suggested that all the differences were minimal.

There was a quadratic change pattern observed and confirmed by significant Age × Age interaction (see Table 1). In addition, days from enrollment to start and gender had significant effects. The chance of meeting at least 1-year growth increased by 5% (odds ratio [*OR*] = 1.05) with each 100 more days from enrollment to start. Male students were 17% (*OR* = 1–.83) more likely to meet at least 1-year growth than female students. Finally, there was significant Age × IEP interaction (see Figure 2). The likelihood of meeting at least 1-year growth was similar between students with and without an IEP by the age of 12 years, but the gap in the likelihood becomes greater after this age. There was no significant interaction between age and gender and between gender and IEP.

ELA. Of the data on 6,035 students, 3.6% met ½-year growth; 3.4% met ¾-year growth; 6.0% met 1-year growth; 5.2% met 1½-year growth, and 50.0% met 2-year growth in English (see Figure 2). This demonstrated that 61.3% met at least 1-year growth. Overall, male students showed lower percentages of meeting 1-year growth in English, compared to female students. Students with disabilities showed lower percentages of meeting ½-year growth, ¾-growth, and 1-year growth, 1½-year growth in English than SWOD. However, the effect size estimates were small for all differences. Similar to the results for math, days from enrollment to start had significant effect. The chance of meeting at least 1-year growth increased by 5% (*OR* = 1.05) with each 100 more days from enrollment to start. The Age × IEP interaction was not significant.

Discussion

This study sought to develop a better understanding of K–12 personalized learning environments and the potential of these environments to support students with disabilities. Specifically, the researchers conducted observations and interviews, engaged in conversations and communication with district staff, and entrenched themselves in the month-to-month operations of the district at various levels (district leadership, building leadership, and teachers) for an 18-month period. The overarching purpose of the study was to identify the foundational principles of operation with the hopes of supporting further research and development in the area of personalized learning. Overall, the research found that there are specific design elements apparent within these settings that can be replicated and researched in other settings. Generally, the research also found indication that both learners with and without disabilities can be successful in these personalized settings. In fact, there is some indication that learners with disabilities cannot only be successful but thrive in personalized learning environments.

Foundational Components of Personalized Learning

While the intricacy of architecting personalized learning systems should not be lost on the simplicity of a single research project, over the 18-month period, various design components became apparent as the research unfolded. From the onset, the chief learning architect of the system told the researchers that the vision for the district was simple to completely redesign schools to be solely focused on one thing: the individual learners. This vision was constantly communicated to district personnel and drove how the district operated. From signs on the walls to the district's Wi-Fi passwords, the vision was clear: focus on the learners. Within URD, supporting and taking ownership in individual learner betterment, regardless of learner variability, was the primary job of each staff member. This vision established a culture of equity and cooperation with a can-do attitude. Everyone worked individually and in teams to problem solve and overcome barriers to support each individual learner regardless of the learners' variability. In a school, toward the end of the day, or while teachers were on break, researchers would often observe teachers collaborating on how to solve an issue for a learner or group of learners. Whether it was identifying and testing a new learning strategy, looking for a new pathway for success, finding a new technology, and/or thinking about the learning space, teachers were given the authority and directive to be innovative and engineer solutions that worked for each learner.

Another foundational element that became apparent is that the UDL framework served as a primary driver of implementation within these personalized learning settings. Learners were provided with multiple ways to engage within the environment with self-regulation serving as a basis for how the personalized environments operated. Learners were empowered to continually make choices for how to gain new information and instruction using available multiple media resources, thus there were multiple means of representation. Learners were able to take action and express their understanding of content in multiple ways.

Beyond the integration across the three UDL principles, these environments had alignment to the four UDL critical elements (UDL-Implementation and Research Network [UDL-IRN] [2011]). Each learner approached activities with clear intention and goals—for example, learners could talk about their learning through their I Can statements. The design of instructional environments was intentional and considerate of learner variability. This planning for variability was evident in the multiple pathways provided within the competencies; the instructional tools that could be used; how students could use various supports, including teachers; a number of strategies, technology, and peers; and how many environments were designed to support the needs of students working independently, in teams, or in larger groups. Throughout instructional periods, there was continual use of flexible methods and materials used to support learning. Finally, there was ongoing and transparent use of data to support timely progress monitoring for both learners and teachers to make instructional decisions.

Operationalizing Personalized Learning

Within these environments, these design components were intermixed with elements operationalized in the day-to-day practices of establishing and operating a personalized environment. From this initial study, the Center has established a research project with another district that is in the early stages of personalized learning implementation. The project at URD, combined with this new partnership, has provided an opportunity to study the various design components and elements of implementation in more detail. Beyond the aforementioned foundation design components, the findings of the research projects have pointed to the following specific elements of operation.

Highly self-regulated environments. While self-regulation is actually a guideline under providing multiple means of engagement within UDL, it is important to specifically discuss the need for self-regulation in personalized learning environments. For perspective, the Center's current research (highlighted in forthcoming articles) begins establishing personalized learning environments through self-regulated data collection systems. Thus, it is critical that culture, design, tools, strategies, and interactions within the learning environment support a self-regulated learning process. This process requires designing environments, systems, and a learning culture that supports self-regulation, as well as teaching learners the necessary strategies and systems, and the importance of self-regulation. Specifically, the design of these environments has focused on the integration of a three-phase process of self-regulation: (1) forethought, (2) performance, and (3) self-reflection (Zimmerman, 1998). For example, learners often establish weekly and daily learning goals and define their desired accomplishments. Learners learn strategies for persisting, or, as necessary, reengaging. Finally, learners take time to self-reflect: After an instructional period, a student may take time use a self-reflection tool and/or simply complete a exit ticket where they rate their ability to accomplish the desired tasks.

Transparent, continual, and actionable data. Both teachers and learners in personalized learning environments rely heavily on data that are transparent, continual, and actionable. These data are used to make decisions relative to a learner's progress, path, and point of instruction within an individual instructional sequence. Importantly, these must be actionable, therefore it must be meaningful, available, and usable. It is useful to have these data readily visible for both the learner and the teacher—in URD environments, it was often in the LMS as well as displayed in the room. The two types of data that have most relevant have been transparent indicators of student progress and student effort. Both types of indicators support the ability for both the learners and teachers to make actionable decisions.

Continual feedback and weekly meetings. Providing learners with continual feedback is critical to supporting learner growth and understanding. Beyond the day-to-day feedback, establishing weekly checkpoints for all learners to review progress and discuss future pathways forward was a common element in URD and one that was most frequently discussed by teachers and learners as being important.

Integrating learner voice. Encouraging learner voice in data collection through exercises such as self-reporting effort or engagement level provides both learners and teachers with the ability to determine what is working and what should be altered. If a learner is able to look at their own data and see a relationship between working with a certain group of learners and an inability to get a task done in a timely manner, then they may consider changing groups. In another example, if a learner continually decides to simply watch the instructional video, then incorrectly completes a practice task, the teacher might look at the data and have the student do a 1:1 check for understanding prior to starting a practice task.

Multiple means of taking action or demonstrating understanding. Again, although UDL serves as a cornerstone, with the observed personalized learning environments and research in URD (as well as the Center's current research), researchers found that purposeful effort must be made to encourage teachers to design environments that allow students to demonstrate understanding in more than one way, which provides for more personalized learning. Realistically, it is easier for teachers to assign one type of assignment (e.g., X questions or worksheet) with a specific competency or lesson goal than it is to allow multiple forms of understanding. Within URD, learners were required to demonstrate mastery at least 3 times prior to moving on to the next competency. Research in URD found that encouraging learners to demonstrate mastery in multiple ways, especially if they have some choice, provides for higher levels of engagement and more authentic and meaningful learning.

Limitations

The purpose of this research was to identify the operational elements in personalized learning settings and to identify potential outcomes for all students—especially students with disabilities—in those settings. This preliminary descriptive research should be further developed. While observations for other projects within the same district have yielded different perspectives than what is reported in this article, it is possible that, as the researchers conducted monthly observations over the 18-month window, observer-expectancy effect may have emerged unconsciously. If this emergence occurred, it would have affected the vision of the observers to only see certain aspects of these learning environments which would have potentially provided for confirmation bias, thus supporting misinterpretations. Further research in personalized learning should be conducted to either validate or revoke the findings of this research.

Implications for Future Research

As suggested in Abbott et al. (2015), there are five areas that need additional research to advance personalized learning. Participants at the National Summit found that, as a field, there is a need to study how educators and researchers use data, how technology is architected to support learners and associated pedagogical practice, how to educate personnel who are prepared to work in personalized settings, and how content and curriculum are developed to support personalized learning. These areas should be supported with a research and development agenda that advances the understanding of practice. The research conducted within this study would concur with the Abbott et al. (2015) findings but suggests that interdisciplinary research focused on overcoming barriers within the research community relative to working in siloed disciplines both in education and intersecting fields and disciplines (e.g., informatics, computer science, interaction design) would provide personalized learning with maximized growth and understanding. Minimally, this research supports the idea that partnerships among field-based practitioners, industry, and researchers could be utilized to encourage further understanding of these areas (Basham, Smith, Greer, & Marino, 2013). Moreover, given the current state of growth in online and personalized learning, investments should be made on further understanding the interworking dynamics as well as potential outcomes of these environments. Within this future research, it is important to consider the personalized learning outcomes beyond the standardized academic test. Developing personalized learning environments to program learners to perform well on an academic measure is vastly different than creating transformative environments that support greater human betterment. Investing research efforts on whole system reform rather than single or limited variable intervention (e.g., a personalized LMS, self-regulation) would be needed to fully understand the potential of personalized learning. Investing in long-term research will support understanding and development of educators, researchers, industry, and society at large.

Implications for Personalized Learning in Practice

As discussed previously, truly personalized environments are a major disruption of the status quo of education. This disruption both begins and ends with a focus on designing environments that are primarily targeted at improving the growth and development of all learners, individually. This focus starts with the belief that every individual learner can and will be successful and that it is every educator's responsibility to take ownership in supporting this success. In reality, personalized learning requires a completely unique approach to the design, implementation, and assessment of learning. In the implementation of personalized learning, teachers become designers or engineers of learning. The learning engineer can design environments that meet the parameters of success for all learners, and when these environments fail, must work to identify, solve, and test solutions through an iterative design process. For personalized learning to be operationalized in schools, environments must provide the learners and teachers with necessary capacity, tools, and strategies to support effective implementation.

Conclusion

There is an ever increasing push toward the development and implementation of personalized learning environments. This research found that when education is personalized, it has the potential to provide immense growth outcomes for learners with disabilities. In the development of these environments, the current academic research base is overly focused on the design of more sophisticated, advanced, technology-based systems for supporting personalized learning. The current research supports the idea that a more systems-level focus on curriculum, environment, pedagogic, school culture, and personnel development is also needed. In alignment with this research, education systems working toward personalized learning should invest in more than innovative technology; specifically, this research supports the understanding that potentially greater investments should be considered on the various other aspects of the learning environment. Investing in systematic reform that considers whole system changes based on learners as individuals is critical to advancing both understanding and practices within personalized learning.

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Note

1. Definition from Center on Online Learning and Students with Disabilities (COLSD) publication Equity Matters.

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