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The role of technology in addressing personalized learning

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The role of technology in addressing personalized learning

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Dedication

To my parents for ensuring I have better opportunities and to my husband for his unwavering support without whom this report would not be complete.

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Abstract

The role of technology in addressing personalized learning

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The purpose of this report is to provide the findings of a literature review that investigated the role of technology in addressing personalized learning (PL) within the education contexts, middle and high school as well as the first two years of undergraduate studies. A diverse set of sources, including government reports, advocacy papers, and scholarly articles, were used for the literature review. A working definition for the personalized learning yielded the identification of five factors: the adjustment of pace and sequence of content, access to learning materials from anywhere, interest-driven student work and student having agency to determine their learning experiences. For each factor, the following information was provided: the definition, influence of the factor on learning, the use of technology to address the factor and associated considerations. The result of the literature review indicates to address PL factors, it is best for technology to provide access to information and tools, as well as, provide opportunities to learners to make choices about how to learn.

Table of Contents

List of Tables

Chapter 1

1.1 INTRODUCTION

The report investigates the role of technology in addressing personalized learning through a literature review from diverse sources including government reports, advocacy papers and scholarly articles. Chapter one will provide the working definition for personalized learning (PL), including five factors of PL and the context for the use of technology to personalize learning. Chapter two is comprised of five sections, and each section provides the definition for a PL factor, the influence of the factor on learning, the role of technology in supporting the PL factor and considerations for using technology to address the PL factor. Chapter three provides a discussion of common themes concerning the use of technology in personalized learning and the effectiveness of PL towards providing better learning outcomes. Finally, chapter four offers concluding remarks regarding ideological implications for the use of technology in PL, limitations of this report and future research topics.

1.1.1 Developing a common language

The education field is riddled with terms that pander to different interests of various stakeholders that can lead to confusion and lack of consistency in how the terms are interpreted. Personalized learning is such a term.

> When we translate between one language and another, a lack of precision is obvious and often comical. But our lack of precision in the language we use to describe innovation in education is less obvious, and even more problematic.

> Nowhere is this more evident than when it comes to personalized learning and its related concepts (Culatta, 2016, para. 1).

Richard Culatta, a former director of the Office of Educational Technology for the US Department of Education provides clarity, following the quote above in a recent article. Culatta (2016) explained the definition of PL and distinguished the concept from other approaches such as individualized learning, differentiated instruction and adaptive learning. He defined PL as, "Learning experiences in which the pace and the approach are adjusted to meet the needs of individual students and in which the learning is tied to students' interests and experiences" (Culatta, 2016, para. 3). This definition framed PL as a set of learning experiences and highlights PL factors such as pace modulation and instruction adjustments to meet students' needs. In addition, he emphasized that students' interests and experiences need to be the driving factors for their learning experiences.

Culatta is one of many leaders who are working to bring clarity to the use of personalization in education. A report published in 2010 called *Innovate to Educate: System [Re]Design for Personalized Learning* is an example of this effort (Wolf, 2010). The report was written as a summary of a symposium attended by education leaders, which was sponsored by the Software & Information Industry Association (SIIA), Association for Supervision and Curriculum Development (ASCD), and the Council of Chief State School Officers (CCSSO). The report was selected to part of the literature review because of the variety of education field representatives who participated in the symposium. The report outlined essential elements for PL, as well as methods to achieve personalization. The PL factors embedded in the report's essential elements are: (a) students have the

flexibility to learn anytime everywhere; (b) students explicitly control design and development of curriculum to learning paths; (c) students determine the pace at which they cover content by enrolling in a competency-based program. A competency-based model allows students to self-pace through curriculum and progress after showing proficiency.

All the attendees of the symposium believed personalized learning can ensure "students gain proficiency independent of time, place, and pace of learning" (Wolf, 2010, p.7). In effect, the essential elements outlined in the report pointed to personalized learning factors: access to content anywhere, student controlled learning path, and self-paced curriculum.

In 2014, a working definition of personalized learning was created by a group of influential organizations including the Bill and Melinda Gates Foundation, Afton Partners, Eli and Edythe Broad Foundation, CEE-Trust, the Christensen Institute for Disruptive Innovation, Charter School Growth Fund, EDUCAUSE, iNACOL, the Learning Accelerator, the Michael and Susan Dell Foundation and Silicon Schools. This definition was selected for the literature review because of the diverse set of organizations who participated in the process, such as IT professionals, philanthropist and foundations. The working definition they developed is as follows,

> Personalized learning seeks to accelerate student learning by tailoring the instructional environment—what, when, how and where students learn —to address the individual needs, skills and interests of each student. Students can take ownership of their own learning[,] while also developing deep, personal

> connections with each other, their teachers and other adults. (A Working Definition of Personalized Learning, 2016, para. 1).

The definition includes similar PL factors as those identified by Culatta (2016) and Wolf (2010): self-paced, place agnostic education, and the learning experiences focused on students' interests as well as needs.

Apart from non-governmental agencies who have published reports about personalized learning, the Department of Education in a press release titled, "Fact Sheet: Redesigning America's High Schools" defined personalized learning as a set of "opportunities to support the educational needs and interests of individual students, optimize the pace of learning, and customize content and practices for students to master challenging academic content and pursue their interests" (Secretary, 2013, para. 4). The common factors of personalized learning mentioned in the definition are adjusting the pace of learning, meeting learners' needs and interests.

Additionally, in 2016 the Office of Educational Technology published the definition of personalized learning in the National Education Technology Plan as,

> Personalized learning refers to instruction in which the pace of learning and the instructional approaches are optimized for the needs of each learner. Learning objectives, instructional approaches, and instructional content (and its sequencing) all may vary based on learner needs. In addition, learning activities are meaningful and relevant to learners, driven by their interests, and often self-initiated…. (Education, 2016, p. 7).

The definition presented by the Office of Educational Technology includes personalized learning factors similar to those discussed earlier: adjustable pace and instructional approaches, as well as, content focused on students' needs and interests. The dissimilar factor mentioned in the definition provided by the Office of Educational Technology is the variability in the sequence of the content based on learner needs and interests.

In summary, the definitions presented above share certain common factors of PL and the following section describes the development of a working definition for the report based on these findings.

1.1.2 Working definition

A common set of factors underlying PL were identified based on the definitions reviewed in section 1.1.2: (a) pace adjusted to student's needs; (b) student work driven by their interests; (c) access to education from anywhere; (d) modifying the sequence of content to meet learner needs; (e) students having opportunities to experience agency. Table 2 illustrates the prevalence of identified common factors of PL within the definitions discussed in the previous section:

Table 1. Common factors of PL.

Sources	**Pace**	**Interest -Driven**	**Access from anywhere**	**Modifying sequence of content**	**Student agency**
Culatta (2016)	X	X			
Innovate to Educate: System [Re]Design for Personalized Learning (Wolf, 2010).	X		X		X
A Working Definition of Personalized Learning, (2016)	X	X	X		X
Department of education (Secretary, 2015)	X	X			
Office of Educational Technology (Education, 2016)	X	X		X	X

The working definition for this report was developed to be inclusive of all the common factors listed in Table 1. My working definition in this report is: PL is a learning experience comprised of five factors that need to be adjusted to meet learners' needs. The adjustable factors are (a) pace at which content is covered; (b) the access to learning material from anywhere; (c) the sequence of content being taught; (d) content and student work driven by their interests; (e) students have agency to make determinations about their learning experience. The following section, 1.3, will discuss the role of technology in personalizing learning.

1.1.3 Technology and Personalization

Collins and Halverson (2009) elaborated upon the advantages that technology offers and how information communication technologies (ICT) are compelling us to rethink education. Advantages explored by the authors include just-in-time learning, and increased interactivity between the learner and the content, as well as immersive experiences with games and simulations. From a personalization perspective, the authors

discussed two distinct potentials for ICT use in education. Firstly, ICT can support learner-controlled environments given technologies such as the internet. The internet is an example of an ICT that provides access to information in a manner that takes control away from centralized sources. For example, WikiLeaks is a site where anyone with internet access can read information provided by whistle blowers in various industries. Information that was known to only a few is now available for many to read. The second potential for ICT is the customization of content to a learner's preferences similar to platforms such as Google and Netflix that use data mining, analyzing high volumes of data with the use of algorithms, to identify information of interest to the user (Collins & Halverson, 2009).

Similarly, Stallard and Cocker (2001) in their book titled, *The Promise of Technology in Schools* forecasted how the use of data mining will support personalization in education. They predicted that by 2007, there will be a great demand for schools to provide, "individual learners with customized learning plans to suit their learning styles, cognitive development, and academic readiness, among other things" (p.86). Stallard and Cocker (2001) proposed that, with the help of data mining, schools will be able to employ algorithms to sift through data collected via student interactions with software applications. The types of data that can be collected are cursor movement when the student interacts with the software or the sequence of topics the learner clicks on while navigating presented material. The data would be analyzed for learning styles or be used to identify knowledge gaps; which would enable educators to address each student's particular needs. Additionally, Stallard and Cocker (2001) pointed to how the effective use of data mining

could lead to the development of accurate learner profiles that support the selection of the most appropriate activities for individual learners.

The prediction made by Stallard and Cocker (2001) over a decade ago was not the norm in education in 2007, as predicted, or even now in 2016, but it is the norm with commonly used platforms like Google, Netflix, Amazon and Facebook (Roberts-Mahoney, Means, & Garrison, 2016). Advocates of personalizing learning technologies argue that it is necessary for the advantages that such platforms provide to be leveraged in the education field because individuals are accustomed to a degree of personalization. Collins and Halverson (2009) pointed to how, "More and more, websites use sophisticated data analysis and 'push technologies' to cater to the online identity of a consumer" (p.15). Consequently, individuals are expecting knowledge and products to be personalized (Collins & Halverson, 2009).

Adaptive learning technologies (ALT) are an example of innovative educational technology that identifies patterns of behaviors through the analysis of high volume of data. Feldstein and Hill (2016) direct their readers to the commercialization of ALT employed by intelligent tutoring systems (ITS). ITS provide students one-on-one tutoring, collect data through interactions, and analyze the data to give timely and appropriate feedback (Feldstein & Hill, 2016).

Furthermore, Owston (1997) alluded to this potential for personalization by highlighting the World Wide Web's ability to allow students to access online courses from anywhere, and by showing that Web use in K-12 schools led to instructional approaches that leaned towards students having "greater autonomy in their learning" (p. 30). Given

examples of technology use to decentralize access to information and promote learner agency, or to provide individualized feedback with the use of ALT, effectively, the stage has been set in the last two decades for personalized learning to take root within the fertile ground created by the advancement of information communication technologies.

1.1.4 Historical perspective

The American education system largely originated out a necessity to address the needs of society in the wake of the Industrial Revolution. The Industrial Revolution tipped the scales for educational reformers. Horace Mann, along with other reformers, were pushing for universal education. The aim of universal education was to provide free and non-sectarian education for all children. From a policy perspective, the Industrial Revolution caused a dramatic increase in immigration which led to diverse urban populations. Universal education was promoted as a means for bringing social cohesion by giving new immigrants a common language as well as an understanding of American democracy (Collins & Halverson, 2009). From an economic perspective, state provided schools were tasked with the preparation of students for the needs of an industrialized economy that shifted away from domestic and craft industries to factories. From a social perspective, universal education was embraced by communities as means to address juvenile delinquency and competition from child labor in growing cities (Collins & Halverson, 2009).

Before the Industrial Revolution in the era of apprenticeship, American families were opposed to tax-supported schools and preferred to educate their children at home. As America became more urbanized and diverse, Collins and Halverson (2009) argue that it

was the, “burgeoning urban population (who) could vote in the new American republic made it possible for the new educational institutions to prevail against the rural populations” (p. 55). As a result, the American school design, shaped by political, economic and social forces, led to the evolution of education from an apprenticeship model to the school building model. The school building model required attendance in the form of seat time, divided children into age-based classrooms and developed Carnegie units to help universities understand what students learned in high school (Collins & Halverson, 2009).

Equipped with the knowledge of how education evolved, one can look to the future with great intrigue. Universal education presented in school as it now does not have to be the way of the future because education systems can evolve and indeed have to evolve to address the needs of a nation.

1.1.5 Knowledge Revolution

The social, economic and political forces that shaped the American education system still exist. From a socio-political perspective, student diversity increased with the population of Hispanic students growing from 18% in 2002 to 24% in 2012 and projected to grow to 29% in 2024 (U.S. Department of Education, National Center for Education Statistics, Common Core of Data (CCD)). From an economic perspective, schools are tasked with preparing students for a globalized economy and an unknown future. Unlike how the education system evolved in the past to these forces with uniformity, didacticism and teacher control, the next evolutionary change can be towards personalization, interactivity and learner control (Collins & Halverson, 2009).

Such an evolutionary change can be made possible because of the knowledge

revolution we are experiencing where ICT use is affecting how we work, communicate and live. The progressive advancement coupled with increasing affordability of information communication technologies has made them a ubiquitous resource for many to use. The technology infrastructure has developed to address accessibility and further the reach of ICTs. Prominent ICTs, such as smartphones, are being used by both yogis in Varanasi, India and hedge fund managers in Manhattan, New York.

The pervasive influence of ICT has been noted and investigated by many researchers and thought leaders (Castells, 2005; Collins and Halverson, 2009; Friedman, 2006; Owston, 1997). Thomas Friedman (2006) discussed how the world is becoming flatter with the flattening of accepted hierarchies as more individuals can access more information online. Prior to Friedman, Owston (1997) articulated this change in structures with regards to education when using the World Wide Web, "The Web is now causing educators, from preschool to graduate school, to rethink the very nature of teaching, learning and schooling (Owston, 1997, p. 27). Owston provides cases for how the World Wide Web can improve learning, make education more accessible and potentially more affordable

1.1.6 Political pressure for personalized learning

Personalization of learning has become a national priority in the American public education system. President Obama has set forth initiatives such as High School Redesign, to provide funding and resources for schools around the country to provide personalized learning opportunities, a core reform for this initiative. The administration will award more than $20 million in federal grants. A diverse set of organizations, ranging IBM to the Stanford d.School, and foundations, such as the Carnegie Corporation, have added an

investment capital of more than $375 million dollars to further the implementation of programs built around personalized learning under this initiative (Secretary, 2015).

Another White House initiative that focuses on personalized learning is the ConnectEd program. The mission of this initiative is to empower America's students with the skills they need to be employed in a global economy. This mission is said to rely, "increasingly on interactive, personalized learning experiences driven by new technology" (The White House, n.d., para.1). The initiative's aim is to connect 99% of America's students to next-generation broadband and high-speed wireless Internet by updating and installing necessary infrastructure in schools and libraries (The White House, n.d.).

Several technologies and publishing companies have become involved with President Obama's initiative by providing funding, resources and infrastructure. For example, National Geographic is providing access to eBooks, digital magazines and educational videos. Verizon is providing online and on-site professional training to teachers on the effective use of mobile technology (The White House, n.d.). Given the amount of funding and resources that are available for school under the personalized learning agenda, there is a political pressure for school districts to offer PL as a means to acquiring funding and resources.

1.2 METHODS

A diverse set of literature was reviewed for the report. Documents were selected based on core questions:

1. What is the definition of personalized learning (PL)?
2. What is the role of technology in providing personalized learning?

3. What technologies are associated with personalization?
4. What type of influence does PL have on learning outcomes?
5. What are the concerns regarding the use of technology for personalized learning?

1.2.1 Search terms

The University of Texas library site was used to search for relevant materials across various journals, books, and periodicals. The search feature on library site retrieved information from several databases such as Science Direct, JSTOR, and EBSCOhost Research Databases depending on the keywords that were used. Key words were determined based on the topic of the search. Table 1 below provides all the search terms. Additionally, the following terms were used to narrow the search for the educational context: middle school, high school, and undergraduate.

Table 2. List of search terms.

Subject	Search terms	Search terms related to technology use
Personalized learning	personalized, personalization, learning, customization, and tailored	Personalized learning technologies, ICT and personalized learning
Pace adjustment	pace, self-paced, benefits, curriculum, and learner-controlled	Learner controlled programs, ICT for pace control and learning
Path adjustment	sequence control, learner-controlled, curriculum, and student-driven	Technologies, learner-controlled sequence, ICT use for sequence control and learning
Access to education from anywhere	anywhere access to education and access to education from multiple locations	Online courses, technology and access to content, online education,
Interest-driven	learning and interest	Interest-driven learning and technology
Agency	agency and learning, autonomy and learning	Autonomy, agency, technology use, learning and education

1.2.2 Working definition development

Government publications and advocacy reports were the primary sources for developing a working definition because these publications act as references and provide a common language for practitioners such as district leaders, principals and teachers as well as third party vendors. Specifically, to develop the working definition for this report, press releases and reports from the US Department of Education, the Office of Education Technology (OET), the former director of OET, and the White House were used as well as advocacy papers *Innovate to Educate: System [Re]Design for Personalized Learning* (Wolf, 2010) and *A Working Definition* (2016).

Chapter 2

The chapter will expand upon the five factors that were identified in chapter one in my working definition of personalized learning (see Table 2). For each factor, an explanation as well as examples will be provided followed by a discussion of the value the factor contributes towards learning outcomes. The role of technology and the concerns with the use of technology will also be included for each factor.

2.1 PACE

One of the PL factors that was present in all the sources that were analyzed in section 1.1.2 is pace. Particularly, all sources mentioned how pace needs to be adjusted to meet learners' needs. A learning environment that supports the adjustment of pace to students' needs is designed to allow the learner to proceed from a topic to the next at a rate determined by the learner (Bautista, 2015). In effect, the learner controls his/her rate of exposure to learning activities without the dependency on the educator (Bautista, 2015). There are two approaches to adjusting the pace. Either the student can control the pace (self-paced), or the pace can be controlled by the educator or a third-party source such as adaptive learning technologies. In both cases, students' performance on assessments determines their progression to the next topic.

An example of how schooling can be designed to allow students to control pace is the school system of Adams County School District 50. This district in Colorado implemented the RISC (Re-Inventing Schools Coalition) model where they replaced grade levels with ten learning levels which students worked at their pace. Such an approach

enables students to progress at their rate while ensuring that state standards are met for content knowledge ("Competency-Based Learning or Personalized Learning," n.d.). The second form of pace adjustment, where technology or the teachers control the pace, will be discussed in detail in section 2.1.3 which is focused on the use of technology for adjusting pace.

2.1.1 Advantages of pace adjustment

Pace can be either controlled by the student or adjusted by an outside source such an educator or a learning technology. An advantage associated with students controlling the pace at which they cover material is that this practice enables them to spend time on topics they find challenging (Tullis & Benjamin, 2011). The study performed by Tullis and Benjamin (2011) had two groups of participants: one group was given a set of words and asked to learn the words at their pace and the other group was given the same set of words but was given a set amount of time to spend learning each word. Both groups had the same total amount of time for learning the words. The result of this study was that the group who could determine how much time they spent per word did much better because participants from the treatment group could spend more time on words that were difficult.

More generally, Bautsta (2015) noted the benefits of pace adjustment as:

1. Allowing for flexibility in the time a learner can spend on a task.
2. Providing an opportunity for students to work cooperatively with others to understand the material.
3. Encouraging mastery learning where a learner progresses through content based on their performance rather than the amount of time spent on covering the

material (Yudkowsky, Park, Lineberry, Knox, & Ritter, 2015). For example, in an environment where the pace is controlled by the teacher, a student will be assessed at the end of a specific period of time as determined by the teacher. The time spent on the topic might not be an appropriate amount of time for the student to understand the material. As a result, the performance on the assessment would be a result of the time spent on the topic rather than a reflection of how well a student can master the material that can be a higher without a time restraint.

2.1.2 Effectiveness of pace adjustment

Pace when controlled by a learner does not always lead to positive learning outcomes. Not all students engaged in a self-paced environment succeed. Tullis & Benjamin (2011) pointed to how, "The advantage of self-pacing was apparent only in subjects who utilized a discrepancy-reduction strategy—that is, those who allocated more study time to normatively difficult items. Self-pacing can improve memory performance, but only when appropriate allocation strategies are used" (Tullis et al., 2011, p.109). This observation implies that students who can identify difficult items are able to use their time to focus on these items. If a student is unable to determine difficult topics, then they do not benefit from being able to control the pace at which they cover material. This is an important distinction to make because self-pacing through content does not guarantee better outcomes. Students' learning outcomes depend on the strategies they use when controlling the pace.

Given that pace controlled by learners is not always appropriate, one needs to

understand how to leverage the benefits of pace adjustment while taking into account the stress pace control can place on learners. A possible strategy is to use the, "flipped classroom" model that can provide a balanced way to incorporate pace adjustment. The model is based on the notion that what traditionally happens during class and the work that students do for homework are flipped. In effect, students access content outside of class and work on activities during class (Gilboy, Heinerichs, & Pazzaglia, 2015). For example, students can listen to a lecture or watch a relevant video outside of class and then work on the paper or group project during the class with the support of a teacher. This model has resulted in students appreciating the opportunity to work at their own pace and time while being supported by the interaction with the teacher when they apply what they learned during class time (Gilboy et al., 2015). A "flipped classroom" is an effective form of course design that support students controlling their own pace while supporting student with structured activities in class. If students were unable to cover material outside of class, then instructors can address any hurdles students faced due to lack of prior knowledge during in-class activities.

2.1.3 The role of technology for pacing

A primary responsible for making "flipped classroom" a possibility is the information sharing capacity and the access to ubiquitous information provided by the internet. Teachers can find educational videos and podcasts by content experts to illustrate various concepts in the subject they are teaching. Instructors can create a curated menu of digital resources that can be posted on learning management platforms. A learning management system (LMS) that is a site or a platform online that provides a means to

organize course content for students to access. Students can access the LMS to review and learn the material at their pace, place and time. The following section will present a case study that explores learning outcomes of when students can access material posted by instructors on an LMS outside of class time.

Smith and Suzuki (2015) conducted a study to compare the learning of Algebra II content over a 4-week period with two different groups. The same teacher provided identical instructional content to both groups through either embedded blended learning or through a live lecture. The treatment group received the instruction through embedded blended learning, a technique where a teacher screen captures his/her lecture rather than using a third-party produced lecture. The treatment group accessed the multimedia lectures through Google Drive, which is considered to be an LMS in this case, on their iPads. The control group was exposed to a live-lecture. Pre and post tests were administered to both groups of students to assess learning of Algebra II concepts. In addition, a student survey was given to assess the level of satisfaction with the instruction.

Based on their data analysis, Smith and Suzuki (2015) found students in the treatment group scored significantly greater on the Algebra II tests and indicated their learning experience to be more positive than the control group. Furthermore, 80% of the students in the treatment group preferred the embedded blended learning over traditional live lectures. The survey responses from the treatment group were more positive with high level of student satisfaction (Smith & Suzuki, 2015).

Additionally, a majority of the students (93%) took advantage of the self-pace capability, where 54% paused the video an average of three times or more, and 83% of the

accessed the material outside of class. The treatment group's open survey responses triangulated the level of interactivity recorded in the video access data. Based on the open-ended survey responses, students from the treatment group specifically noted that the ability to control pace, the lack of distractions when accessing the lecture, the different role of the teacher in the flipped classroom, and accessibility of the multimedia lessons outside of class were key benefits. Though the treatment group did not experience a "flipped classroom," it was considered to be a "flipped classroom" because students could watch the video outside of class.

Furthermore, based on the Smith and Suzuki's data analysis, students from the treatment group were more likely to report that the lectures were easy to understand and clear. Though students accessed the video after class session, they also appreciated watchingthe videos in class with the teacher present so that they could ask questions in real time face- to-face. From Smith and Suzuki's (2015) study, it is clear to see that the benefits of a structured approach towards enabling students to control pace through a video technology can yield significant learning outcomes. When students had an opportunity to control their exposure to material presented in the video, they were able to better understand the content.

2.1.4 Considerations for using technology to adjust pace

From the perspective of educators, the planning that is involved in offering an environment that is conducive to students controlling the pace of their learning takes extensive amount of effort and time. Educators have to spend time creating a curated set of digital experiences in conjunction with planning active learning exercises for in face-to-

face class time. Having access to relevant resources such as instructional designers will support educators to do this kind of personalized learning. Additionally, instructors will need training for using technologies such as screen capture or for navigating the learning management system to present effective flipped classroom courses (Gilboy et al., 2015).

Finally, "flipped classrooms" that leverage the use of technology, were criticized for not allowing the students an opportunity to ask questions while they were exploring material out of class. A proposed solution is presented in the study done by Smith and Suzuki (2015) in which students watched the video in class. By watching the video in class with the instructor present, students were able to receive support when they had questions regarding the material that was presented. Another solution is to have online discussion boards available for students within a course site to allow them to ask questions as they arise and have the instructor or teaching assistants respond in timely manner, such as within 24 hours. Alternatively, the instructor can provide a short quiz or assessment at the beginning of the lecture to ensure that all students captured the key points of the content that was presented to them (Gilboy et al., 2015).

In conclusion, pace can contribute positively to learning outcomes. However, not all learners can benefit from having pace control. Students who find it challenging to allocate time effectively will not benefit from self-paced learning activities. Given this circumstance, technologies such as the LMS and the Internet can be tools to balance student control of pace with supportive instructional practices and course design, such as a flipped classroom or accessing the digital menu of resources while the instructor is present. Additionally for the use of technology to be successful, educators will need time, training

and ongoing support.

2.2 PLACE

When literature, in the form of advocacy papers and government communications, was reviewed to identify factors of personalized learning in chapter one of this report, the notion of students having access to educational materials from anywhere was a consistent theme. Recently, an article titled, “Study In Your PJs? What A High School 'Work From Home Day' Looks Like” described the virtual day that was implemented at Park Ridge High School in New Jersey. Students and teachers logged on to the learning management system from their homes and were engaged online for the entire school day. The reasons offered by the principal for the virtual day were to prepare students for life after high school when they might take an online class at a college or work from home. Apart from the administrator’s positive outlook about the value of the virtual day, students also responded very supportively. Ninety-eight percent of the student body attended school on the virtual day (Kamenetz , 2016).

2.2.1 Advantages of learner access to learning from anywhere

Many advantages are associated with supporting students’ access to education materials from anywhere. This practice is especially beneficial for students who are unable to attend classes on campus due to health issues, disabilities or logistical challenges. Learners who are in regions where a physical school is not within reach can use the ability to access material from any place to keep up with learning activities (Ally & Samaka, 2013). Additionally, in the section 2.3.2 the nature of advantages provided as a result of access to education from anywhere by technology will be discussed in detail.

2.2.2 The role of technology in realizing learning from anywhere

The Internet plays a key role in providing a means to offer access to education anywhere. Virtual schools and online, distance education programs that are not associated with a school, are examples of educational environments that are accessible from anywhere in the world as long as the learner has access to the Internet. Students have more courses to choose from when enrolling online (Reid, Aqui, & Putney, 2009) . Sussan and Recascino (2013) mention how students in virtual high schools have the option of taking traditional classes such as English and math as well as courses that are career-focused such as food marketing or retailing. The diverse set of options that a brick and mortar school cannot offer are available on line to students. As a result, students can personalize their learning experience by choosing courses of their interest while being able to accommodate their lifestyle choices, family obligations or other constraints which prevent them from attending school in person (Sussan et al., 2013).

Another technology that enables access to educational materials anywhere are mobile devices such as tablets and smartphones. The use of mobile devices has been steadily increasing around the world and it has changed the way we live and learn every day. A mobile device such as a smartphone is equipped with access to the cellular network, GPS, camera, microphone and an audio outlet. The affordances offered by this technology such as flexibility, accessibility, interactivity and engagement are very beneficial attributes for learning and consequently, there is an increased interest in using these devices in education (Liu, Navarrete, & Wivagg, 2014).

There have been many different definitions of mobile learning. For instance, any learning activity that takes advantage of mobile technologies which includes phone, tablets and PDA can be called M-learning (Hwang & Chang, 2011). However, Traxler (2007) argues that mobile learning is not strictly defined by the use of handheld devices. Traxler (2007) elaborates on the different types of M-learning that can happen:

- Given that mobile devices can connect to the Internet, M-learning can be seen as portable e-learning.
- Mobile devices can connect to other technologies in a classroom, such as an interactive white board, result in M-learning that takes place in conjunction with other devices.
- M-learning can be informal, outside of school or class time, personalized and situated.
- M-learning can provide on the job training and provide just-in-time support.
- For learners who are in rural areas where they have no access to a school or an Internet cafe, M-learning can connect them effectively to resources online.

Traxler (2007) urges his readers to not see M-learning as tied to mobile devices. Instead he encourages the focus to be on learner experience and the factors that distinguish M-learning from other forms of e-learning. One of the key features of M-learning is that the learner engaged in mobile learning can interact with their environment while in contact with the technology. For example, one can learn to fix the chain on a bicycle while watching a "how to" video on the phone.

Another example of M-learning is just-in-time support where learners can access relevant information at the time of need. This affordance of M-learning was investigated by researchers who studied the outcomes of a mobile initiative in a large school district situated in the southwest region of US (Liu et al., 2014). In regards to the student population, for 90% of English language learners (ELL) Spanish was the primary language spoken at home and there were varied levels of English language fluency among the students. Given the different levels of English proficiency, teaching ELL students was an academic challenge. In September 2009, the school district purchased an iPod touch for every ELL student and teacher at the middle school level. The district was hoping to increase English proficiency by supporting ELL students by using the devices for accessing additional educational resources 24 hours, 7 days a week. The researchers reported on the first year of implementation from 2010-2011 when only 6^{th} – 8^{th} graders participated, and second year of implementation from 2011-2012 when 4^{th} – 5^{th} graders also participated.

The researchers found that iPods were used to support second language learning through Internet based multimedia sources, to provide differentiated instruction to meet learner needs, and to extend the learning time from classroom to home for the students (Liu, Navarrete, & Wivagg, 2014). Specifically for content learning, students used the mobile device for just-in-time support by accessing translation applications on the iPods in different classes and outside of the school environment (Liu et al., 2014). The researchers' findings illustrate how M-learning can provide just-in-time support for students and can lead to better learning outcomes.

In conclusion, leveraging the affordances of M-learning, such as access to information from anywhere and just-in-time support, leads to personalized learning. Learners are able to address their needs for information or support, such as "how to" videos or translation applications, with the help of M-learning. In effect, M-learning meets the needs of the learner by allowing them to find, use and learn at any place.

2.2.3 Concerns about technology use for learning from anywhere

There are important concerns regarding the use of both M-learning and virtual school or online courses. M-learning activities are time intensive and teachers have to make an effort to learn the diverse functionalities of a mobile device, to choose an appropriate pedagogical structure and design an activity for their students (Liu et al., 2014). In regards to online courses or virtual schools, roughly 75% of K-12 school districts have introduced online courses developed by third-party vendors. However, in the 2011–2012 academic year, less than 30% of all students who enrolled in online schools were able to meet the state standards as assessed by standardized tests (Smith & Suzuki, 2015). These statistics pointed to how by offering access to learning experiences from anywhere needs to be supported in order to yield better learning outcomes. In fact, Sorgenfrei and Smolnik (2016) discuss how not all learners are equally capable of making appropriate decisions to succeed in online courses. The authors particularly highlight the feelings of isolation, frustration, anxiety, disorientation and distraction that have been shown to result from the amount of information that is often available in online learning environments.

Moreover, Selwyn (2014) communicates how having access to education all the time anywhere can deter individuals from a sense of well-being and instead enroll them in, "social

factories" where boundaries are blurred between informal and formal activities. Such a circumstance leads to the exploitation of individuals who, "feel increasingly compelled to engage with education regardless of appropriateness or potential detriment to other areas of life" (Selwyn, 2014, p. 133). For example, a student in high school might spend time doing school work outside of school at home and compromise the quality of the relationships she shares with her siblings or parents. The anytime and anywhere access to education can lead to erosion of healthy lifestyles.

Lastly, when students are able to access education from anywhere it is important to consider participation gaps that exists as a result of socioeconomic backgrounds of students. Initiatives such as the iPod program investigated by Liu et al. (2014) ensure that all students have devices available, however, the level of use among students has been to differ by their ethnic backgrounds (Hughes, Read, Jones, & Mahometa, 2015). Hughes et al. (2015) conducted a study to identify factors that predict middle school students' use of Web 2.0 activities outside of school. The researchers used 15 different Web 2.0 activities such as writing or reaching blogs, participating in social networking, using text based instant messaging. The researchers identified ethnicity based participation gaps existed particularly with students of Hispanic ethnicity who showed lower use of Web 2.0 activities outside of school (Hughes et al., 2015). Selwyn (2014) also pointed to how the use of technology for educational purposes is driven by social factors as much as individually factors. Therefore, even if access to learning materials is accounted for by providing devices to students, the way and how much students use devices is dependent on their social background. As a result not all learners will benefit from having access to educational

materials from anywhere.

2.3 PATH

Path refers to a sequence of selected topics that are explored to understand a concept or an area of study. In educational research, one of the ways learners can personalize the learning experience is through sequence control; wherein a student can choose how to navigate course topics with the potential of even skipping topics (Kraiger & Jerden, 2007). For the practice of personalized learning, the sequence of the content should be customized to the learner or the learner should be able to control/adjust the order of topics to learn.

For example, if an individual is learning about the periodic table they usually have to learn about the structure of an atom, the atomic structure of different elements and the trends that exist among different groups of elements based on their atomic structures. If a learner already knows about the atom, they can skip the atomic structure section. If a learner does not see the relevance of knowing the atomic structure, they can go to the section concerning trends among elements and then return to learning about the atomic structure.

2.3.1 Advantages of regulating the learning path

The organization of content plays a key role in how well a concept is understood by a learner. In a traditional classroom setting, all students are subject to the same path that can lead to individual needs not being meet by provided instruction (Michala, Salden, Corbalan, Paas, & Miclea, 2011). As a result, having the path adapt to the learner or the learner determine the path can lead to better learning outcomes.

In regards to a learner controlling the path, educational research has yielded mixed results. Michala et al. (2011) noted how findings point to both learners learning more when they are given control as well as poor learning outcomes when learners control their path versus following a prescribed path. Kraiger and Jerden (2007) in their meta-analysis of literature about learner control, which includes sequence control, suggest there is a positive impact, though it is small, as a result of learners controlling their learning experience. Particularly, they pointed to how when one is not experienced with a task, such as learning to drive, control over sequence leads to better outcomes than control of content (Kraiger & Jerden, 2007). For example, when learning to drive, a learner can benefit from controlling the sequence of what she needs to learn rather than controlling what she needs to learn. Based the prior knowledge, a person learning to drive can choose to skip certain content or spend more learning about a particular topics.

2.3.2 Effectiveness of path regulation

The path being controlled by the learner can yield varying degrees of benefits for different learners. A reason for this variability has been attributed to prior knowledge that learners possess when confronted with an area of study (Kopcha & Sullivian, 2007). Michala et al. (2011) explore the relevance of prior knowledge in their study and find learner control can be very beneficial for students with a high degree of prior knowledge versus for students with a lower level of prior knowledge (novices). Michala et al. (2011) conducted a study where students were exposed to three different types of control: (a) non-adaptive program control, programs that do not change content presented to students based on learner interactions and performance; (b) learner control, where learners have the

opportunity to control different aspects of the course; (c) adaptive program control, where the program changes the content presented to students based on student interactions and performance. Based on the findings from the study, Michala et al. (2011) conclude that prior knowledge plays a mediating role in a learner's ability to determine the sequence of the content being studied. The researchers pointed to cognitive load theory as means to understand the detrimental effects experienced by novice learners. The theory states that novices have a difficult time acquiring complex skills because of working memory limitations when confronted with new information. Students with prior knowledge experience lower cognitive load because they created knowledge structures and used these structures to lighten their load. Consequently, novices need external support to build knowledge structures, while students with prior knowledge benefit greatly by exploring material as they see fit to leverage the knowledge structures they developed. In addition, meta-cognitive skills, the ability to control cognitive processes involved in learning, developed by high prior knowledge students, enable them to guide their learning more effectively (Michala et al., 2011).

2.3.3 The role of technology in path regulation

Given that literature findings are inconclusive about the positive effects of learners controlling their own learning path, one can argue that technologies that regulate path are a possible solution. A good example of a technology that adjusts the sequence of content for a learner is adaptive learning software. The software takes into account a learner's performance, preferences and other data points to accordingly curate content for the learner including the sequence of topics. Educational research has shown that using adaptive

software that determines the sequence of the content based on individual learner needs can lead to better performance when training and transferring the skills from the training process to new learning situations (Michala et al., 2011).

An industry that is leveraging the benefits of an adaptive learning technology is the language learning industry. Philip Kerr (2016) explains an example of an adaptive learning software is a flash card application used to build vocabulary. The algorithms that the software employ take into account the learner's previous responses and then determine the order, and the number of times a word is presented to the learner (Kerr, 2016). Another example is a program like Duolingo where lessons and exercises are configured based on learner performance and preferences. Duolingo is able to adjust the path a learner takes by analyzing data from learners' interactions with the program's learning activities. For examples if a learner takes a Spanish quiz and spends longer time on a question, Duolingo makes a note of this longer time. The software uses such learner data to determine the sequence of content presented to the learner by making decisions such as, "If it's better to introduce plurals in the Spanish language lessons earlier in the learning process or later" (Cha, 2014, para. 4).

Another example is Knewton, an education start-up that is providing adaptive learning experiences in various subjects.

> Knewton's goal is to be able to tell not just what students do or do not do well but also what time of day they learn best, whether they're likely to pass a quiz, their final grade in the course and even how they will score on the SAT (Webley, 2013,

para. 2).

Knewton's software is able to learn about students by gathering data through student interactions, such recording every mouse click, and analyzing the data by employing powerful algorithms to generate predictions and moderate instruction. The collection of such large amount of data and then using ALT to find patterns and meaning is the process by which companies like Knewton are hoping to use adaptive learning software to change education (Webley, 2013).

2.3.4 Concerns regarding technology use for path regulation

The concerns regarding technologies like adaptive learning software that are supporting path modification are the collection of student data and the variability of efficacy across different software programs. The storage of large volumes of student data, colloquially called big data that is mined for patterns to characterize an individual's learning is a topic of concern because of data privacy issues. As Young (2015) noted,

> Big data raises privacy concerns on an individual level because it also excels at revealing unexpected correlations that may disclose not only someone's identity but some new "fact" about that person. Big data thus has the potential to actually create personally identifiable information without affirmative action on the part of the user whose data was collected. This dynamic may violate certain statutory privacy protections.

There are laws in place to protect student data. The Family Educational Rights and Privacy Act, established in 1974 before the data analytics movement, holds institutions accountable to the limited release of student data without permission. Given that the law is

dated, it does not ensure that all data is protected. For example, data that does not have any personally identifiable information (PII) is not protected under the law and that law applies to educational institutions that keep student records. Given that data is being collected by third party technology providers, the law does not sufficiently provide guidelines to protect student data. With such room for interpretation of what is PII data and porous limitations on the use of student data, it behooves the education community to reform laws to ensure protection of student data, especially data that can characterize student learning and ability that can be used to limit their opportunities in the future.

The second concern is the varying efficacy of the adaptive software. In a study done by Griff and Matter (2013), they concluded the LearnSmart adaptive software, developed by McGraw Hill Higher Education, did not result in significant improvements in student outcomes. Of particular interest is the fact that the authors highlighted the recorded improvement could be attributed to how closely a class followed the course learning objectives outlined by an associated textbook (Griff & Matter, 2013). This study shows how adaptive software can lean towards what the programmers, or a publishing company, deem to be the appropriate learning path and thus not necessarily serve the learner. In effect, that study also implies how adaptive software can be prescriptive rather than responsive to the learner.

In conclusion, there are serious concerns regarding the use of adaptive learning technologies. The concerns make one question whether it is beneficial for the learner to use such software at the cost of risking mismanagement of their data or falling prey to a prescriptive learning experience. Consequently, if it is more advisable for learners to

control the path, then one is faced with mixed research findings regarding sequence control by learners (Michala et al., 2011).

Under such circumstances, a possible recommendation is to use technologies that do not rely on algorithms for instructional support. Instead, technology can serve the learner by offering choices in a structured, scaffolded environment. An example is the math knowledge map employed by Khan Academy, a website that offers a personalized learning environment where one can learn about various topics from videos. The math site offers over 100,000 exercises in topics ranging from addition to calculus (Khan Academy, n.d.). This site offers PL factors such as allowing learners to cover material at their own pace and, with the math knowledge map, the site offers sequence control. The knowledge map in an interactive graphic that shows various math topics as clickable points on the map. The map also shows lines that connect one topic to another. Certain topics have multiple lines connected to them while others connect to just one other topic. When the learner clicks on a topic, they are presented with a set of problems to solve to master a concept.

One can choose to attempt problems in any topic; there are no restrictions placed on access. Given the visual design of the map and its functions, it enables learners to explore a path of their choosing while providing structure by communicating the connections between topics. For example, after one completes the module called "Subtracting Negative Numbers" one can choose to progress towards four different connected topics. Essentially, the learner can control the path they follow to learning a concept.

2.4 INTEREST-DRIVEN

For learning to be personalized, it must be interest-driven. Researchers define interest as an experience of a psychological state based on both affective, of or relating to feelings and attitudes, and cognitive elements of or relating to mental processing for understanding through thought (Sorić & Palekčić, 2009). An individual who experiences this psychological state tends to pay attention in a focused manner, shows an increased level of cognitive and affective functioning, and is able to put in persistent effort (Ainley, Hidi, & Brendorff, 2002). This notion has been of interest to many researchers in the education field. Evidence has been presented to show that Interest-based learning has positive outcomes (Krapp, 2005).

There are three factors that contribute to interest being a unique source of motivation (Hidi & Renninger, 2006). The first factor is the dual influence of affective as well as cognitive channels on interest. The second factor that distinguishes interest as a motivational driver is that affective and cognitive elements of interest are biologically rooted; there is neuroscientific research showing how there is a biological basis for the psychological state of interest. The third factor is that interest is an experience resulting from the interaction between a person and specific content, thus implying that interest is not just a predisposition but, in fact, can be cultivated and developed based on content and environment (Hidi & Renninger, 2006).

There are two type of interests discussed in educational research, individual and situational. Individual interests are related to one's own predispositions that are stable over time and situational interests that are influenced by environment which might not be

present over longer periods of time (Hidi & Renninger, 2006; Köller, Baumert, & Schnabel, 2001). It is important to note that both individual and situational interests can lead to the psychological state of interest (Hidi & Renninger, 2006) because of the implications for instructional practices. In effect, a learner can reach the psychological state of interest, where he/she is paying attention in a focused manner, shows an increased level of cognitive and affective functioning, and puts in persistent effort, either because of the individual interest or because of situational interests that can be offered to the students by the design of the activity.

2.4.1 Advantages of interest-driven learning

Hidi and Renninger (2006) indicated how researchers have on multiple occasions concluded that interest has a powerful influence on learning, specifically on attention, goal setting and levels of learning. Renninger, Hidi and Krapp (1992) reexamined historical models that theorized about the role of attention in learning, specifically when reading text. The researcher found that historical models that theorized about attention did not adequately account for the process of paying attention because the models did not take into account the effect of interest. Renninger et al. (1992) argued that attention to text while reading is dependent on the how interesting the reader finds the text. This assertion was taken a step further when Wild and Schiefele (1996) concluded that there was a negative relationship between attention, in terms of time spent on a task, and interest but a positive relationship between interest and content retention in their study. Essentially a person can spend less time on an interesting piece of information but retain the information more

effectively. Additional benefits of interest on learning were discussed in detail by Schraw (1994), which highlights how interest influences motivation, task engagement, persistence and recall.

Equally notable is the connection between interest-driven learning and self-regulated (SG) learning (Sorić & Palekčić, 2009). Self-regulated learning is not seen as a mental ability or an academic performance; it is a process by which learners are aware of weaknesses and strengths, monitor their behaviors and self-reflect about their progress towards accomplishing a goal (Zimmerman, 2002). Self-regulation skills are of great importance because those who develop these skills position themselves to be more successful after graduating from school (Zimmerman, 2002). In addition, SG skills enable learners to take advantage of PL factors, such as path, place or pace, by empowering them with strategies to self-direct their learning experiences. For example, SG skills can enable learners when they are controlling the pace to identify topics that are challenging so that they allot time appropriately. If learners are controlling the path, SG skills can enable them to identify the prior knowledge they need to effectively choose their path.

2.4.2 The role of technology in interest-driven learning

A possible role of technology in addressing interest-driven learning can be to offer a way to engage student interests while delivering content. Walkington (2013) investigated an adaptive technology-based intelligent tutoring system (ITS) for the purpose of providing personalized intervention for an Algebra 1 course. The system was designed to adapt instruction based on students' personal interests. For the learning experiment, 145 ninth-grade Algebra I students were randomly assigned to two conditions. For the first condition,

half of the students received algebra story problems without any personalization. For the second condition, the other half of the students received problems personalized to their out-of-school interests such as sports, music and movies, which were gathered through a survey. The results were that the students in the personalized condition solved problems faster and more accurately. The impact of personalization was especially evident for the skill of writing symbolic equations from story scenarios. In addition, personalization had a positive effect on students who were struggling to learn within the tutoring system.

After the treatment, personalization was removed and students who received personalization were able to write symbolic equations accurately and efficiently as the problems became increasingly more complex. Thus, the researchers were able to showcase positive learning outcomes for Interest-based interventions. The reason for this increased level of learning, researchers believe, is that interest-based connections facilitate the internalization of abstract ideas so that these ideas become easier to understand. Finally, they noted, "Adaptive learning technologies that utilize interest may be a powerful way to support learners in gaining fluency with abstract representational systems" (Walkington, 2013).

2.4.3 Considerations for use of technology to provide interest-driven learning

Though Walkington's (2013) study was able to showcase positive learning outcomes, it is important to note that the relationship between interest and achievement. Essentially, achievement can affect interests (Sorić & Palekčić, 2009). Sorić and Palekčić (2009) found "that students feel intrinsically oriented in areas in which they perceive themselves to be competent" (p. 547). The perception of competency, being able to achieve

a set goal, enables one to develop a particular interest. For example, if a person who never played tennis decides to try the sport and find themselves to be competent in directing the ball accurately with the racket, then this sense of competency can develop interest in learning to play tennis.

Sorić and Palekčić (2009) went a step further to hypothesize that the learning strategies used by a person have an effect on the individual's perception of their competency that in turn has a positive effect on developing interest (Sorić & Palekčić, 2009). Essentially, the researchers investigated how learning strategies were related to interest development. Learning strategies are described as being able to select and organize information, rehearse learning material, such as practicing a musical instrument, relate new information to information in memory and enhance meaningfulness of material and maintain a positive learning climate (Sorić & Palekčić, 2009). Through Sorić and Palekčić's (2009) research, they identified that learning strategies have a mediating effect on learning outcomes. Researchers also found interest to be part of a cyclical learning process where interest is a result and well as the cause for improved learning. This implies that one can be engaged in learning because of an individual interest or develop an interest based on perception of competency promoted by the use of learning strategies.

The dynamic nature of interest is important to note because it can affect how technologies are used. Either technologies can leverage learner interests or they can empower learners with a sense of self-efficacy to develop potentially new interests. Walkington et al.'s (2013) is an example of how learner's individual interests were used to increase engagement. On the other hand, technology can also be used to develop interests

by developing a sense of competency. For example, Scratch, a graphical programming platform, is effectively designed to empower students with a sense of self-efficacy that translates to interest in learning coding (Kalelioglu & Gülbahar, 2014).

2.5 AGENCY

Agency is the ability of an individual to make choices and to act upon those choices to make a difference in their lives (Martin, 2004). In education research, autonomy is defined as when one is given opportunities to set goals based on personal values and interests, make decisions about necessary steps for achieving those goals and take those steps to influence their own lives. Given the similarities between the definition of autonomy and agency, both of these terms will be used interchangeably in this report.

A pertinent macro-theory of motivation, self-determination theory (SDT), identifies autonomy, along with relatedness (a sense of belonging) and competence as psychological needs that when meet lead to greater well-being. In addition, based on SDT, students have more agency when they take ownership of their actions rather than when they act in response to the feeling of being controlled; this implies that there are different motivations at play depending on if one feels a sense of agency or not. In fact, researchers have identified two types of motivations, autonomous and controlled. Autonomous motivation is based on acting out of a feeling of free will while controlled motivation is based on acting out of a sense of pressure, exerted by external factors or internal thoughts, to satisfy demand or norms (Zhou, Ma, & Deci, 2009).

In the classroom, autonomous support can be provided by teachers to create a learning environment that is conducive for building agency. Based on literature,

autonomous support is where a person of authority, such as a teacher, minimizes the use of pressure and demands, instead focuses on acknowledging the feelings of others, providing relevant information and chances to make choices (Zhou et al., 2009). In addition, teachers can be supportive of students' agency, by making explicit the relevance of tasks to personal interests and goals of their students (Assor, Kaplan, & Roth, 2002).

2.5.1 Advantages of developing agency as a means for personalized learning

The role of agency has been studied by many educational psychologists because choice has been noted as a means to engender student's intrinsic motivation and deep engagement in the learning process (Evans & Boucher, 2015). For instance, a study was conducted by Cordova and Lepper (1996) to understand the relevance of choice, as well as personalization, in relation to intrinsic motivation and the process of learning. For the study, elementary school children were given the opportunity to learn the order of mathematics operation rules by playing a computer game based on them navigating in a space ship. The experimental group of students were given choices that did not interfere with the instruction but allowed students to affect the game environment. For example, students could choose a particular avatar with which they would play the game. Even with such limited choices, the researchers observed a greater increase in motivation and learning from the experimental group based on their post-test and survey results (Cordova & Lepper, 1996). Over ten years later, Zhou et al. (2009) noted that many studies have been conducted to show the relationship between behaviors resulting from autonomous motivation where one feels a sense of agency, and positive outcomes in academic settings, such as increased interest in course materials and conceptual understanding.

2.5.2 The role of technology in enabling agency

Apart from Cordova and Lepper (1996) study that used a computer game, hypermedia environments are an excellent example of a learning technology to consider for providing agency. Hypermedia can provide an opportunity for learners to have a high degree of choice over access to content (Scheiter & Gerjets, 2007). Hypermedia environments consist of information presented as graphics, video, text or audio, that are hyperlinked. If the hyperlinks are removed then it would be a multimedia learning environment because the information would not be networked and instead exist as separate pieces of knowledge.

Van Loon, Ros, and Martens (2012) investigated the use of hypermedia in a problem based learning exercise to understand the influence of autonomous support, a way that a person in authority can provide agency, versus providing structure, that engenders a controlled environment lacking opportunities for agency. For the study, 320 fifth grade and sixth grade students were given access to a hypermedia electronic learning environment website where they could freely navigate the resources that were available to them. The website had hypertext, images, graphics and video. The students had to design an effective advertisement, based on the resources provided on the website, by using Word or PowerPoint.

They studied four different learning conditions: (a) the digital task included autonomy support and structure; (b) the digital task did not included autonomy support but it did provide structure; (c) the digital task included autonomy support but did not provide structure; (d) the digital task did not include autonomous support nor provided structure.

The results found that the condition with both autonomy support and structure (condition 1) yielded the best learning outcomes. Students scored slightly lower when they were provided with structure but no autonomy support. In the condition with neither autonomy support nor structure (condition 4), even lower scores were found. The lowest learning outcomes were achieved in the condition in which autonomy support was given without structure (condition 3).

Given these results, the researchers were able to conclude the combination of autonomy support that promote agency and structure that limits student choices lead to better learning outcomes. This implies that autonomy support was impactful when it was combined with structure. The authors proposed a possible explanation to be that when students work on a digital learning task with autonomous support without structure, students can be easily distracted from the task. Additionally, students can become confused when presented with options without guidance. This confusion can lead students to become less focused and negatively affect their learning outcomes.

The results of this study imply that technology can be used as a means to provide agency, however, if the learning activities do not provide adequate structure by controlling the learning process to an effective extent, student learning outcomes will be negatively affected. It is necessary to balance providing agency with providing an appropriately controlled learning process to support students.

2.5.3 Concerns about using technology for agency

Technology such as hypermedia environments can be great tools for fostering and nurturing agency because students can navigate and make choices about resources they

would like to use. However, just as van Loon et al. (2012) noted, it is important to understand the influence of agency when using technologies such as the Internet where students freely navigate information.

2.6 SUMMARY OF FINDINGS

Below is a table that summarizes the findings from the chapter two:

Table 3. List of conclusions

PL factors	Role of technology	Concerns with technology use
Pace	The internet allows for educators to curate a set of digital resources that students can access on a learning management system. Students can access the digital menu of resources and control the pace at which the material is covered based on their needs.	Given that pace control is not conducive for all students, the access to resources outside needs to be structured through a method such as a "flipped classroom." Additionally, educators need time and training to create curated digital menu of resources for learners. Without training or time, instructors will not be able to successfully offer a learning environment that allows students to control the pace at which they can cover material.
Place	Technologies such as virtual schools and online courses allow learners to access educational content from anywhere and offer diverse set of courses that can be taken based on learners' interest. M-learning is allows for learning to take place anywhere. Specifically, M-learning can provide PL by allowing learners to access content while engaged in an activity, or provide access to material at their convenience and just-in-time support.	Instructors need training and time to learn the diverse functionalities of a mobile device, to choose an appropriate pedagogical structure and design an activity for students (Liu et al., 2014). Without the necessary time and training, instructors will not be able to successfully use M-learning for PL. For online course, low rates of satisfactory completion need to be addressed.

Table 3. List of conclusions (continued)

Path	Not all students can benefit from controlling the sequence of the content they need to learn. Adaptive learning technologies can be used to adjust path based on learner performance and interaction with the software to accommodate for cognitive load.	Adaptive learning technologies collect large volumes of students' data. Given that FERPA is outdated, ethical use of students' data is questionable. Adaptive learning technologies are also subject to biases. Based on the provider, ALT can be employing algorithms that are prescriptive and not personalized.
Interest-Driven	Technology can leverage students' interests to provide a personalized learning experience by presenting problems or material within the context of their interests.	Given the dynamic nature of interest, technology can do more than just contextualize materials. Instead, ICT can facilitate the development of interest by providing opportunities for students to engage in activities that engender a perception of competency.
Agency	Hypermedia environments can provide an opportunity for students to makes choices about resources and navigation of content. In effect, hypermedia environments support student agency.	The number of choices hypermedia environments provide can overwhelm learners. It is necessary for instructors to provide autonomous support and structure to appropriately use technologies such as hypermedia environments.

Chapter 3

3.1 Discussion

Based on the findings, the common role of technology is to offer learners access to information and choice of: (a) the path they can take to learn a topic; (b) the pace at which to cover content; (c) the place from which to access material. Additionally, technology can support contextualizing content based on a student's interests, and provide opportunities for students to exercise agency. The research findings indicate that technology meets all the PL factors identified in the report and the role of technology is to provide leavers access to content and opportunity to makes choices about how they learn to meet their needs and interests.

In order for technology to successfully personalize learning, such that learner outcomes are positively affected, it is necessary for the concerns listed in the Table 3 to be addressed. Three common concerns identified based on the findings of this report: (a) instructors needing time and training to effectively personalize learning with the use of technology; (b) compromised student data privacy; (c) the nature of adaptive learning technologies.

Firstly, the findings from this report point to instructors being key contributors for offering effective PL. Instructors are responsible for designing the learning experience to accommodate each PL factor. For example, when allowing for agency the instructor has to provide enough structure. In light of this finding, one of the common concerns identified in Table 3 is that instructors need time and training to effectively design experiences and use technology. A study investigating preparation of teachers for technology integration

concluded that pre-service teachers are under prepared and ill-equipped to integrate technology in a meaningful manner in their future classrooms (Hughes, 2013). Given this characterization of pre-service teachers and the increasing emphasis on the use of ICTs in the classrooms, it is discouraging to know the lack of preparation that teachers are receiving especially when pre-service modelling has been noted as a key influencer in a new teacher's use of ICT in the classroom (Hammond et al., 2009). If pre-service teachers are not receiving adequate training, then instructors will not be positioned to successfully use technology to provide personalized learning.

Secondly, the use of technologies such as adaptive learning software raises concerns regarding privacy of student data. As a consequence of FERPA being outdated and not positioned to address the advancing systems used for student data collection (Young, 2015), vendor contracts are being poorly designed. A study done in 2013 by Fordham Law School's Center on Law and Information Policy published their finding which characterized the use of students' data. They surveyed six demographically and geographically diverse districts who were using services for a variety of functions. They found widespread gaps in documentation of vendors-school contracts, lack of data privacy policies and a lack of communication to parents about their children's exposure to online services (Abilock & Abilock, 2016). With such a lack of protection of students' data, ethical practices are questionable and the use of student data for commercialization purposes is highly likely. A possible policy implication is for FERPA to be revised or amended to include user agreements and for third party vendors to disclose how student data will be used. Particularly, the revisions should ensure that terms and use of data are

communication in plain language, similar to how the Truth and Lending Act provide protection to credit card consumers. Student data privacy watch dog organizations can be established that rate different vendors based on the integrity of their protection of student data. Finally, laws can be put into effect to ensure that student data does not follow them into their adulthood.

Thirdly, it is important to pay special attention to the nature of adaptive learning software with respect to providing learning experiences that are adequately balanced between providing a prescriptive experience and autonomous support. Given research conducted for this report, it is not advisable to provide solely supportive environments; it is crucial that there is enough structure to offset the cognitive load for novice learners. Furthermore, given that learning analytics use algorithms developed by individuals in a corporation or institution, it is necessary to look for biased approaches to how learning or other features of the learning process are defined and represented in an ALT.

3.2 MOVING FORWARD WITH PERSONALIZED LEARNING AND THE USE OF TECHNOLOGY

When considering technology solutions, Feldstein and Hill (2016) encourage the reader to focus on solutions that have been vetted and which are within the context of course and curricular designs. The Feldstein and Hill (2016) focus their efforts on explaining the relevance of course design and offer the Essex County College (ECG) in Newark, New Jersey, as an example.

ECG tried to address the two root causes they identified for students who were not passing their developmental math course: (a) students entered the course with low levels of prior knowledge or bored in the class and dropped out; (b) students were never taught study

skills which the faculty could not address during class time. Both of these root causes are aligned with personalization because they can be addressed by one or multiple factors identified in this report. The solution developed by ECG is a course that was based on Self-Regulated Learning principles, which has been discussed earlier in this report. With these principles as the backbone of their course design, ECF offered a course where part of a student's class time was spent in a computer lab working at their own pace through an adaptive learning math program, which addressed their first root cause of students with diverse levels of prior knowledge. Outside of the lab, students meet with their teacher every week to discuss their learning goals, the progress they made towards their goals, the effectiveness of the strategies they used to reach these goals and to develop their goals for the next week. This practice addressed their second root cause. This model, the authors, argue, is an ideal approach to using personalized learning technologies within the framework of sound pedagogical approaches (Feldstein & Hill, 2016).

Feldstein and Hill (2016) also present two circumstances for when personalized learning is appropriate. One circumstance is was where students enter a course with a very diverse set of prior knowledge, such as introductory courses. For such a case, an adaptive learning system can offer the opportunity for students to explore content at their own pace to accommodate low and high levels of prior knowledge. The second circumstance for personalized learning is problem-based learning courses where the classes are flipped and students spend time during class working in groups to solve a course generated problem. In the pursuit of solving this problem, the students learn the objectives of the course.

Finally, Feldstein and Hill (2016) present six strategies for providing effective PL: (a) identification of the learner needs which have to addressed; (b) the design of pedagogical framework for the course; (c) based on the needs and framework to accordingly choose a technology that would the best conduit for the needs to the needs to be addressed and framework to be realized; (d) the provision of effective and appropriate training for educators so that they can choose and use the necessary pedagogical frameworks and technological tools; (e) along with training, on-going support should be provided to ensure educators can be successful from a pedagogical and technology integration perspectives; (f) participants should be open to failure and approach this process of course design and be open to re-design and to iterate. This culture of embracing failure needs to be present and educators should not be penalized for implementing a new course design.

With these six strategies in mind and positive influences to be harnessed from the movement towards PL, one can approach this change towards personalization optimistically in light of the concerns that need to be addressed.

Chapter 4

4.1 Conclusion

Throughout this report, one can see that PL factors in education can be addressed with the use of technology. PL factors were identified based on the definitions reviewed in section 1.1.2: (a) pace adjusted to student's needs; (b) student work driven by their interests; (c) access to education from anywhere; (d) modifying the sequence of content to meet learner needs; (e) students having opportunities to experience agency. In the previous chapter, the key features of technology for personalized learning were noted as learners having access to content and ability to choose: (a) the path they can take to learn a topic, (b) the pace at which to cover content and (c) the place from which to access material. Additionally, technology can support contextualizing content based on a student's interests, and provide opportunities for students to exercise agency. However, given the concerns such as data privacy and prescriptive nature of algorithms used in adaptive learning technologies (ALT), is it necessary to ensure that technology and personalization in education share a mutually beneficial relationship where learners are being respected and empowered.

As Roberts-Mahoney et al. (2016) pointed out, technology is never a neutral player. It is a tool that is "subject to and embedded within specific governmental rationalities and relations of power" (p. 2). Similarly, Selwyn (2014) discussed how the rhetoric towards a positive influence of technology in education renders itself to a hegemony where this notion is a dominant ideology that is pervading societal common sense. He explained further how if we further investigate this hegemonic nature of technology in education,

we will find, “a variety of different social groups and with different interests, values, and agendas are apparent” (p. 32). Given this context, Roberts- Mahoney et al. (2016) analyzed US Department of Education reports, personalized learning advocacy papers and published research to understand underlying assumptions and ideologies that are driving personalized learning with the use of technology.

Roberts-Mahoney et al.’s (2016) explained how personalization technologies, represented in the literature they reviewed, were providing “standardized customization” that converts complex characteristics of individuals into discrete skills which translates to data points that are subject to the authority of algorithms outside the control of learners, educators, schools or community (p. 1). In effect Roberts-Mahoney et al. (2016) found that the teachers’ role is diminished to a facilitator and ALT were entrusted with the management of the learning process through the analysis and collection of large volume of student data. Roberts-Mahoney et al. (2016) also pointed to how all the collected data will be owned by third party technology providers who can use this information for commercial gain. The authors conclude by saying how the underlying ideologies driving the personalization movement in education will cause more harm than good (Roberts-Mahoney el al., 2016).

Though my report did not explore the ideological basis for technology promotion in education, the sources of concerns highlighted by Roberts-Mahoney et al. (2016) are similar to ones identified in this report, data privacy and adaptive learning technologies. As a possible alternative to collection of high volumes of student data and algorithmically derived experiences, the report identified access and choice as key affordance of

technology for PL. This report offered the example of the knowledge map from the Khan Academy access to structured knowledge and allows learners the choice of sequence as well as pace. However, there are additional concerns that were discussed by Roberts-Mahoney et al. (2016), such as corporatization of education, that need to be investigated in future research given the limited scope of my report.

4.2 LIMITATIONS

The report did not consider how PL factors manifest in educational environments across age groups. The report primarily focused on grades 6-12 and early college years in the interest of limiting the scope of research for this report. Additionally, given the breath of factors covered in the report, the depth was compromised for each factor, especially in regards to technology use. There are a variety of technologies that can be employed to address PL factors, such as computer games or virtual reality that were not discussed in this report. Furthermore, ideological undercurrents for the use of technology were not explored in this report. The report provided evidence of support for PL with the use of technology but did not discuss how this rhetoric was established.

4.3 FUTURE RESEARCH

In light of Roberts-Mahoney et al.'s (2016) paper, the corporate interest in educational technologies for personalization should be investigated further. Based on Roberts-Mahoney et al. (2016), their analysis suggests that the current form of personalized learning technologies echo corporatization of education. The influence of corporations on the future of education is not a new phenomenon. As primary employers, their involvement in the education system echoes how the labor unions supported Horace Mann in

establishing universal learning and schools (Collins & Halverson, 2009). The nature of the involvement can be researched more critically to understand the true value of technologies being pushed to the education community.

Another area for further investigation is to understand if the current approach to PL with the use of technology leads to equity in access to high quality PL. It has been noted that the personalization movement is running on an equity platform (Childress & Benson, 2014; Duckett, 2010; Roberts-Mahoney et al., 2016; Selwyn, 2014; Wolf, 2010). The issue of access to the internet can be solved by initiatives such as ConnectEd. However, the nature of content that is available free of charge, which supports accessibility, is dramatically different from the material provided at a premium charge. For example, Massively Open Online Courses (MOOC) provide free content for everyone who can access the Internet, however, the learning experience pales in comparison to the experience of being at the universities that published the MOOCs (Selwyn, 2014). Moreover, students who have low prior knowledge or less developed meta-cognitive skills, will not be able to improve their learning outcomes. Effectively, some people can "thrive when set free from the traditional collective and communal institutions of education" however, many people do not succeed (Selwyn, 2014, p. 137). Though personalized learning technology is based on the principle of customization and accommodation, this mission is not fully realized in the current offerings of personalized learning technologies.

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