Chapter

# Categorization of Educational Technologies as Related to Pedagogical Practices

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## Abstract

Educational technologies are not homogeneous. This chapter proposes a framework to categorize various technologies in the K-12 educational setting into groups of operational technologies and pedagogical technologies by whether they directly participate in the process of teaching and learning. Furthermore, pedagogical technologies are split into tool-based and program-based technologies based on whether they are teacher-driven tools or algorithm-driven learning programs. Efficient adoption of tool-based technologies requires a redefinition of learning goals to embrace student-centered education. Program-based technologies need more research to be fully understood and improved, and current ones are under-researched and fail to engage and motivate students to learn.

**Keywords:** educational technologies, pedagogical practices, teaching and learning, artificial intelligence

## 1. Introduction

In 1994, when computers had just begun to be accessible to regular classrooms, an article titled "Why Use Technology?" was published [1]. The authors, Kyle Peck and Denise Dorricott, began the article by asking the question "If we removed all of the computers from schools tomorrow, would it make a big difference in the knowledge and skills students demonstrated upon graduation?" They answered, "Probably not." In the minds of Peck and Dorricott, the introduction of computers in K-12 schools did not create an electronic highway of accelerated learning but rather a dirt road without clear expectations or purpose. More than two decades have passed, and in that time, technological progress has surpassed anyone's imagination. Technologies are more capable, diverse, and accessible than ever. However, if we ask the same question again, we believe the answer is still no. This is probably because the pace of school reform is far behind the pace of digital progress. The techniques and tools that are used by today's teachers to achieve learning goals are not fundamentally different from the ones used in previous decades [2]. Teachers use *Google Docs* to replace printed worksheets and documents, use videos and *PowerPoints* to replace handwriting and drawing on backboards, use text messages as an alternative to traditional communications, and use digital student records instead of hard copies. Based on a 2017 report on a national survey, the aforementioned uses of technologies have comprised the most popular educational

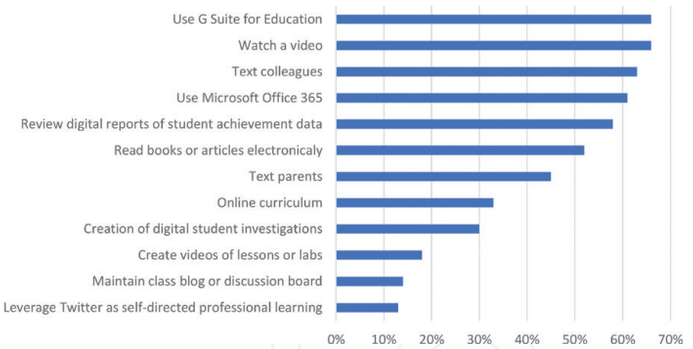


**Figure 1.**
*Percentage of K-12 teachers engaged in the use of technologies in the USA. Note: Data source from Project Tomorrow's 2017 Report [3].*

technologies in the US K-12 education [3]. Other more creative uses of technologies—such as guiding students to do digital investigations, creating videos of lessons, and making a class blog to enhance discussion—are much less popular among teachers (see **Figure 1**) [3]. Apparently, technologies have not fundamentally changed the activities of teaching and learning; neither have they brought much innovation into classrooms. It is true that technologies have been well integrated into science and engineering majors in higher education and now effectively help adults to fulfill self-learning through online courses on *Coursera* or *EdX*, for example. But somehow there is a decade-long struggle surrounding technology adoption in K-12 education. In order to make a breakthrough, we will take an in-depth look into current technologies that have been used in the education context and attempt to categorize them in relation to pedagogical practices. Thereafter, we will study factors that affect the use of technologies in different categories as well as explore the following questions: Can technology replace teachers? How can we take full advantage of the power of technology to improve teaching and learning in the age of digitalization and artificial intelligence?

## 2. Categorization of educational technologies

Digital technologies are very diverse—different technologies have unique functions and features that are distinct from one another, and hence, generalization should be avoided when studying the use of technology in any field. Unfortunately, most current studies on technology in the field of education regard them as a singular concept without making any distinctions among different kinds of technologies—as if all technologies are homogeneous. To correct this widespread and long-lasting oversight, we will attempt to categorize technologies that have been employed in educational settings.

### 2.1 Pedagogical technologies vs. operational technologies

Educational technologies can be categorized into two groups: *pedagogical technologies* and *operational technologies*. The first category refers to technologies that can be utilized in the process of teaching and learning. For example, teachers use *PowerPoint* presentations to deliver effective instruction, and students use the Internet to conduct independent research. Those technologies in the aforementioned uses are pedagogical technologies. The second category refers to technologies that are not directly involved in learning and teaching activities; instead, they assist in the operative or administrative part of teachers' work, such as using email

to communicate with colleagues and using an online data management system to keep student records. Those two categories are not completely distinct from each other. They could have some slight overlaps. For example, teachers can use some online learning management platforms to both keep assignment grades and simultaneously deliver feedback to students. Technologies are also interchangeable between the two groups—when *Word* is used to produce learning materials, it is a pedagogical technology, and when used to write work reports, it is an operational technology. The human use of technologies defines their essence. This categorization should only be considered in relation to a specific technology or a technological element under a specific use. It is hard to say which category of technologies is more popular in educational settings. It is also difficult to demonstrate which ones have a greater impact on teachers' daily work. But, for the purpose of this chapter, we only focus on technologies that directly influence teaching and learning—pedagogical technologies.

### 2.2 Tool-based technologies vs. program-based technologies

The process and resources needed for teachers to adopt technologies are qualitatively different across different kinds of technologies [4]. Countless individual technologies can be employed in pedagogical practices, and pedagogical technologies can be further categorized into two large groups: *tool-based technologies* and *program-based technologies*.

Tool-based technologies are the ones not specifically designed for education. They are merely tools that have been widely used in various fields, such as the Internet, *Smartboards*, and *Microsoft Office*, among others. Most technologies that have been widely used and studied in educational settings belong to this category. They came into education decades ago as society underwent digitalization. Tool-based technologies require teachers, either as individuals or as groups, to innovate and come up with designs and ideas to implement them in various teaching and learning activities.

Program-based technologies, on the other hand, are the ones that are specifically designed for pedagogical purposes with premade learning content delivered through algorithm-enabled instruction, such as learning games and online personalized learning programs that use artificial intelligence to give each student individualized academic exercises. They are often developed by companies and large not-for-profit organizations. They give classroom teachers less control over the design and content. They are designed to replace considerable portions of teachers' traditional work, such as delivery of instruction. Teachers and schools tend to focus on managing the logistics for the implementation of such technologies to fit into their learning goals. Program-based technologies are relatively new, emerging with the advancement of artificial intelligence. These technologies have received tremendous attention, largely due to Silicon Valley's increasing interest in this field. For example, *Facebook* founder Mark Zuckerberg, through his Chan Zuckerberg Initiative, developed the Summit Learning Program to promote online personalized learning of core subjects of grades 4–12 [5].

Digitalized contents, such as e-books, slide shows, *YouTube* videos, TED Talks, and online curricula teachers create or download online for self-learning or assisting teaching activities, are still considered tool-based technologies, despite their pre-made educational contents. They are created using tool-based technologies and rely on teachers to design their classroom use. The same logic applies to some learning management platforms that have been widely adapted, such as *Canvas* and *Blackboard*, to help teachers to assign homework and more effectively maintain online learning materials and students' records. Although they are made specifically

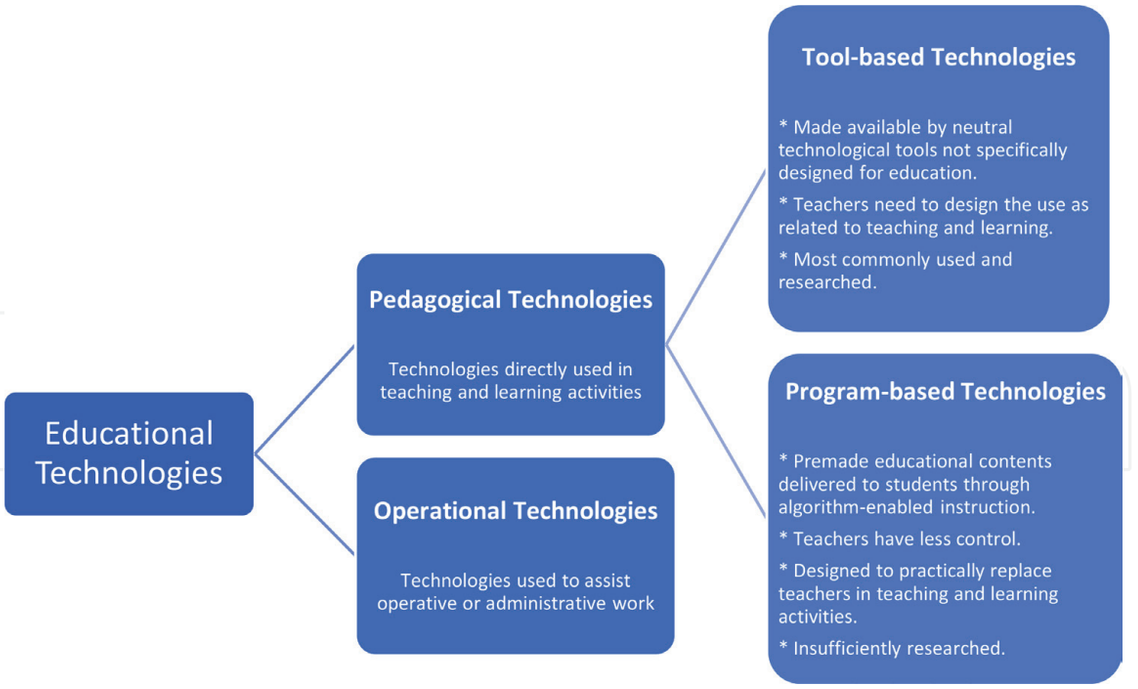


**Figure 2.**
*Categorization of educational technologies.*

for educational purposes, they represent an integration of traditional technological tools to assist teachers instead of being designed to replace teachers' pedagogical functionalities (**Figure 2**).

## 3. Adoption of tool-based technologies

Most studies on teachers' use of technology refer to the use of tool-based technologies. Teachers' successful adoption of this kind of technology, for themselves to either motivate students or deliver instructions more efficiently or for students to engage in learning activities using technology, depends on three crucial factors: professional support, teachers' attitude, and learning goals.

The use of tool-based technologies in educational settings highly depends on teachers' competency to innovate and design. A misconception is that the introduction of technological tools to schools is equivalent to the introduction of educational technologies. On the contrary, teachers tend not to innovate when technologies are provided [6]. Teachers need to develop knowledge and skills to employ technological tools for educational purposes. Therefore, adequate professional support is needed, so teachers will be able to master the effective use of technologies specifically within a classroom setting. Teachers who have received professional development are more proficient in using technologies and are more likely to use them, whereas without professional development, teachers are not only less proficient but also likely to resist integration of technologies [4, 7]. Unfortunately, educational technology training is lacking in teacher preparation programs in universities [8]. Thereafter, in the teaching field, the majority of teachers only receive <8 h of professional development on educational technology annually [9].

A successful professional development program needs to pay attention to both its content and its format. It should contain content knowledge in three areas [10]:

1. Knowledge about technological tools: technical knowledge that helps teachers to become equipped with skills to use hardware and software

2. Technology-supported pedagogical knowledge: specific knowledge and skills that teachers need to learn that help them to use technology to design materials, deliver instructions, or engage students to achieve the learning goals in specific academic domains

3. Knowledge about technology-related classroom management: knowledge giving teachers insight into students' reaction in a tech-infused learning environment, for example, how to prevent students from using the devices and the Internet to do inappropriate activities in disguise.

The effectiveness of such a program is closely tied to a school's ability to develop a supportive learning community [7, 11, 12]. Professional development programs on educational technologies work less efficiently when they are only content- and knowledge-based; communication and interaction are of high significance [10]. A successful professional development program should be a place where:

1. Teachers can discuss their tangible and immediate needs related to the use of technologies [7, 13].

2. Teachers can share successful examples of the use of technologies in real educational settings [14, 15].

3. Teachers can have opportunities to work with knowledgeable peers [11].

4. Teachers have adequate time to explore the technologies on their own [4, 16].

Learning with real examples in the field created by peers has been proven to be essential in professional development. This is also true of teacher preparation programs. Preservice teachers who have real in-school experience learning about technologies in real educational practices are more likely to succeed [8, 14, 15, 17, 18]. To leverage the power of tool-based technologies in teaching and learning, educational technology training should be very content-specific—for example, how to use the visual features of *PowerPoints* to demonstrate abstract geometry concepts in math classes and how to guide students to make an online survey in social studies. It is crucial that teachers do not receive vague information in professional development but rather have opportunities to discuss and learn specific techniques to assist immediate pedagogical needs with peers.

Teachers' attitude toward the effectiveness of technology affects the adoption of tool-based technologies as well. Such effects can be played out on both personal and interpersonal levels. Teachers who individually believe technologies will help them conduct better education are more likely to succeed at using them [15, 16, 19, 20]. Many of these teachers believe that technologies can help to better engage students, introduce project-based learning, help students access more information, and enhance communication and collaborative learning [21–23]. However, it is common for teachers to hold negative impressions toward the use of certain technologies, which makes it harder for them to integrate those technologies [19, 24, 25]. This situation often happens when teachers are not given sufficient information and training to learn the specific benefits of technologies, which leads them to worry about risking educational resources and teaching time to integrate unnecessary or potentially detrimental technologies [26, 27]. Additional common negative attitudes among teachers include fear of losing control over technologies, technological misfunction and lack of IT support, and concerns about the lack of time to adjust to new pedagogical practices, risking student test scores [26–28].

On the interpersonal level, experienced teachers' attitude toward technology significantly influences young professionals' impressions about technology. When experienced teachers exhibit a more positive and welcoming attitude toward technology, that often translates into a school culture that embraces technology and encourages teachers to support one another in terms of developing and designing learning programs that take specific advantage of technology [24, 25]. Moreover, a positive attitude among teachers also translates into positive attitudes toward education among students and better learning engagement [29].

Research also shows that teachers who believe technologies can help them transform from lecture-based learning to student-centered learning are more likely to welcome technologies [21, 23]. Therefore, the foundation provided by a school's learning goals, often reflected in institutional policy as well as practice, also significantly affects teachers' adoption of technologies [7, 16, 30]. Teachers tend to avoid technologies if they believe technologies, even if helpful, deviate from the school's learning goals [31]. For example, teachers may believe certain technologies can help students to do collaborative projects, but given the limited time and pressure from standardized testing, teachers may choose to teach to tests instead of integrating the technologies for new learning tasks.

Our current education model was largely invented for and defined by the Industrial Revolution, designed to meet the need of massive labor demand with standardized skill sets [32]. The advantage of technology has been restricted by the nature of our traditional education paradigm, where teaching and learning occur in a mechanical way with learning goals aimed at the mastery of knowledge. This learning goal can be very often achieved by traditional pedagogical techniques that do not require technological integration, such as direct instruction. Therefore, teachers often do not see the need to use technologies to conduct education in an efficient way to help students to achieve learning outcomes set by graduation standards and measured by standardized testing [1]. On the other hand, teachers are likely to have a positive impression of technology if they believe in constructivist learning [33, 34]. From a constructivist perspective, technology can serve as a powerful tool for both teachers and students to conduct research, assist in self-directed learning, and design and produce media-infused projects. Indeed, teachers tend to increase the use of technology if the learning goals are set up to be student-centered and project-based, focused on high-level skills such as creativity, research, and critical thinking [7, 21].

### 3.1 A need to redefine learning goals

Fundamentally, technologies should be offered as a way to achieve schools' learning goals, and the question we should ask is: What can we do now with technology that was not possible before? [1]. However, very often, we do not have an identified problem in education that we hope technologies can help us solve, and we do not have a clear goal or expectation about how technology should be positioned in education to help with our learning goals [35]. We realize that technologies are something good to have, and it seems irresponsible if we fail to harness this power for education. Therefore, we have introduced technologies into schools, without changing any of our traditional practices, in an effort to enact their great potential. Instead, what we have largely done is carve out some tiny spaces for technology to fit into the traditional learning paradigm. If we go into a classroom, we will find out that the most popular technologies in schools are projectors, document cameras, and smartboards. Those technologies are helpful, but not necessary; the functions they perform could be done adequately before we had technology. Teachers who see technologies merely as supplemental tools for instruction are less likely to

successfully adopt them [7]. Technology in today's school setting gives teachers a third hand. It is something good to have, as it allows teachers to accomplish some tasks in a more convenient and efficient way [36]. However, its existence only brings quantitative difference without qualitative difference to the advancement of pedagogical practices [35]. Teachers who are experienced in teaching without technologies often do not see the necessity of having them [24, 25, 30]. Therefore, a true, successful adoption of tool-based technologies in education should start at the institutional level by redefining the learning goals that cannot be accomplished without technologies. For example, if our learning goals go beyond mastering of testable knowledge that can be obtained through direct instruction to creative and collaborative skills in project-based learning, we would arrange our class in such a way that students, under teachers' guidance, could conduct research on the Internet and produce digital media such as videos and *PowerPoint* presentations.

Tool-based technologies are only as good as the way in which they are used by teachers. These technologies are not educational in nature but rather require teachers, through design and proper implementation, to transform technological tools into tool-based technologies that enhance teaching and learning. In the case of tool-based technologies, this adoption process is more important than the technologies themselves. Therefore, teachers are the key instead of machines, and teachers need to have the incentive and adequate skills to realize the process. Unfortunately, schools tend to spend tremendous resources to purchase and maintain equipment but often neglect to invest in helping teachers to adopt them [37]. The adoption process starts with redefining learning goals. Learning goals that demand less mechanical learning of content knowledge and value high-level skills—aligned with student-centered, constructivist learning and creative instruction—motivate teachers to see the unique value of technologies and develop a positive attitude toward their use. Suitable learning goals set direction for professional development for both preservice teachers in universities and in-service teachers in the field. Positive attitudes create a solid foundation for a collaborative learning community to take place, which helps teachers to be equipped with sufficient content knowledge and

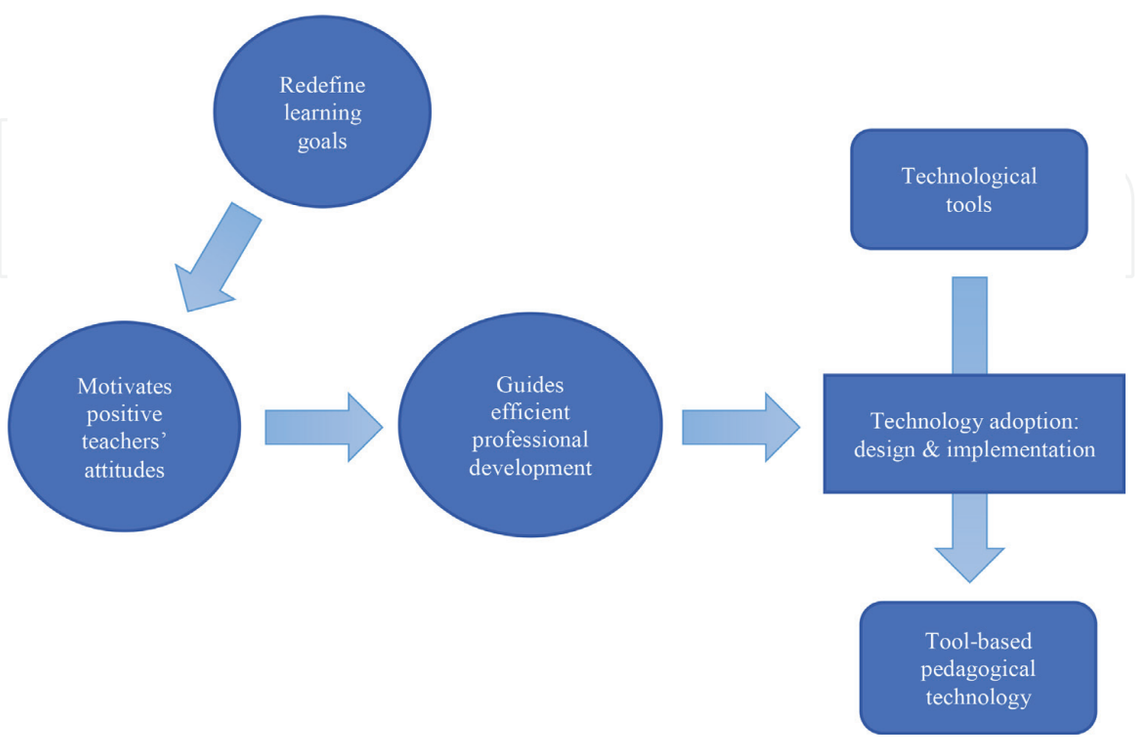


**Figure 3.**
*Teachers' adoption of tool-based educational technologies.*

skills for adopting technologies to assist pedagogical practices. An efficient and thorough change starts with redefining learning goals, which are hopefully initiated top-down. The role of school leaders and experienced teachers is of the utmost importance (**Figure 3**).

## 4. Double-faced program-based technologies

With recent advances in technology, we have entered the Information Era, especially after the invention of the Internet. Technology made digitalized content become the main resource from which we gain information and knowledge [38]. If we think of learning as a broad, lifelong process, most knowledge we learn today is not in classrooms. With technology, we expand the learning environment, which means that learning is no longer restricted to formal classroom instruction. Some believe that if we focus solely on the work of passing information and knowledge, technology is probably able to replace some components of traditional teaching. Others predict that mobile learning will partially take the place of teachers [39]. Mobile learning has several advantages. First, technology makes information and knowledge more accessible, and students can access more enriched resources of information through mobile learning. Second, learning environments can be expanded, and as long as students can access technology, they can learn anything, anytime, and anywhere. Third, mobile learning allows students to customize learning [40]. Among all the expected benefits, personalization of education has stirred up the most hope—traditionally, dozens of students receive the same information from one teacher in a classroom. However, with technology, every student has the opportunity to learn topics that have been individually tailored. Using technologies to fulfill personalized education has recently attracted tremendous attention from Silicon Valley, fueled with hundreds of millions of dollars from the Chan Zuckerberg Initiative [5, 41]. A program developed out of this initiative is called Summit Learning, which has been collaborating with hundreds of US schools to implement its personalized learning programs. These programs deliver individualized learning content of core academic subjects of grades 4–12, from a computer to a student, with the hope that students will study better with technologies than teachers [5]. These personalized learning programs are given to individual students based on an analysis of their learning attributes using an artificial intelligence algorithm. In such programs, technologies and learning contents included have been predeveloped by technology companies that give teachers little autonomy over the balance of teaching between teachers and machines. Also, many aspects of how the algorithm works often reside in a black box, remaining largely unknown to teachers or researchers. Learning through these technological programs, or, in other words, program-based technologies, is a fundamentally different pedagogical practice and learning experience than the use of tool-based technologies, which are still largely driven by teachers. However, program-based technologies are primarily driven by digital programs.

### 4.1 The promise of program-based technologies

Although in the technology industry such distinction has been seldom made, the field of educational research has classified personalized education into two categories: outcome personalization and process personalization [42]. Outcome personalization gives students autonomy in the learning process. Many student-centered, project-based learning programs are designed in such a way that students may design a project of their choice, while the education process helps students

to master necessary skills and knowledge to achieve the project. Outcome personalization is often filled by tool-based technologies, which give both teachers and students more creative power. However, most program-based technologies are used to fulfill process personalization, which gives students little choice over the learning process. Students are merely given customized learning materials selected based on computer algorithms, and the end goal of the process is to help students achieve standardized learning goals. In essence, program-based technologies could sufficiently fit into the demand of the traditional educational paradigm that emphasizes mastering standardized knowledge and skills. If implemented well, program-based technologies are expected to replace a considerable portion of teachers' functionality.

Advocates for the use of program-based technologies in personalized education believe that technologies can do a better job than traditional teachers because these technologies can unremittingly monitor individual students' learning progress and simultaneously provide learning contents that are most suitable to individual students' habits and learning attributes [43]. With a highly sophisticated algorithm, big data, and a large pool of well-tailored contents, technologies are expected to have certain advantages over human teachers in terms of delivering more effective instruction to each student. Additionally, advocates believe that technologies are more economically efficient and more accessible than human teachers, which can help to scale up good education and improve equity and equalization in education [40, 43]. Finally, teachers could be liberated from the mechanical work of teaching students basic knowledge and skills so they could be more focused on helping students with additional higher-level learning.

### 4.2 The problems of program-based technologies

Before using artificial intelligence for personalized learning, program-based technologies were largely made of learning games, with the hope that learning could be delivered in an attractive format. However, the downfall came when it became more and more clear that most educational games were not as attractive to students as regular computer games, and students easily lost interest over time [44, 45]. As a consequence, the interest in learning games has been gradually disappearing in the industry. Unfortunately, personalized learning technologies seem to share the fate of learning games—not only the fate of failure but also the specific inability to engage and motivate students in the learning process.

Very little research has been conducted on the effectiveness of Summit Learning's personalized learning technologies; nor has there been much research on other program-based technologies on personalized learning [45]. Besides questionable learning outcomes, these technologies face tremendous challenges due to students' negative reaction toward the learning experience under such programs. A study shows that students significantly feel less engaged in and experience less enjoyment in school due to lack of human interaction [46, 47]. Also, there have been news reports showing that personalized learning technologies face backlash among students and parents. Some students claim they feel they were like zombies sitting in front of computers all day long [41]. The intangible "joy" of learning, so often derived from human discussion and interaction, seems to be compromised by such programs. Overall, concerns about these technologies are as follows: they reduce students' reported joy of learning; jeopardize students' bond with teachers, while a healthy relationship between children and adults is essential in their development; isolate students; encourage unhealthy competition by exposing the difference in students' learning progress; and are prone to misuse of student data by big corporations [48]. With all these perceived negative images in the public

arena, it is not hard to assert that current efforts of using program-based technologies to conduct personalized education to replace teachers, represented by Summit Learning, will be far from successful. However, there is not much rigorous evaluation of such programs through imperial research, nor does it seem that the developers of these programs have any immediate intention to grant access to scholars to conduct any evaluation.

### 4.3 A need for research on program-based technologies

Given that program-based technologies in education are largely developed by the technology industry instead of educators or educational researchers, as well as a special commercial interest in the industry, those technologies have seldom been well-examined in an empirical way, nor have their developers been given the incentive to conduct considerable research or comprehensive program evaluation. Chan Zuckerberg's Initiative originally planned to work with the Harvard Graduate School of Education to examine the effectiveness of its Summit Learning Program, but it was called off by the initiative before the research started [41]. By the time this paper was written, we still did not know, despite students' negative emotional reaction toward the program, whether the program could deliver its academic promises. Many factors may determine the success of program-based technologies, such as the content of learning materials, the artificial intelligence or other algorithms to assess students' learning progress, and the implementation in school settings in relation to teachers' assistance and other school activities. Many of the promises of technology-enabled personalized learning do not lose their attraction because of the failure of a first attempt. Future research is urgently needed to comprehensively examine these new technologies.

The significance and advantage of human teachers cannot be easily replaced. Although knowledge can be easily accessed through program-based technologies, a lack of human interaction and motivation results in reduced knowledge acquisition among students. As learning is not a mechanical cognitive activity, students' negative emotions could lead to *not learning*, which does not refer to being incapable of learning but a term describing the psychological state of resistance to participation in learning activities [49]. It is highly possible that program-based technologies could never work alone. They might need to open space to work closely with human teachers to be effective. Unlike tool-based technologies, which have been thoroughly researched, the adoption of program-based technologies has seldom been studied. Many do not even see the distinction between those two groups. We urge the industry and the scientific community to conduct more research on program-based technologies, which will surely open a new frontier in our understanding of the use of educational technologies in pedagogical practices, as what it takes to adopt teacher-driven tool-based technologies could be vastly different from newly emerged algorithm-driven program-based technologies. We suggest not only to research the technologies themselves, including their learning contents and algorithm, but also how these technologies are positioned in the ecological system in school and how human interaction can work together with the algorithm.

## 5. Conclusion and a look into the future

It has been a long-held misconception that educational technologies are homogeneous and they behave in a similar way in relation to teachers' adoption and school implementation, among other factors. It is an oversight in the field of educational

research that we have seldom made any distinction in the kinds of technologies that have been used in schooling, instead often studying them in a singular set. This was not an influential mistake when most technologies used in pedagogical practices were tool-based technologies and indeed shared many similarities. However, with the recent introduction of artificial intelligence into personalized education, new categories of technologies have emerged that are drastically distinct from the ones before. Therefore, a careful categorization of educational technologies should be made to help us study issues on educational technology in a well-structured way. Educational technologies are composed of pedagogical technologies (used in direct participation of teaching and learning activities) and operational technologies (used in the operative and administrative work of teachers).

Pedagogical technologies can be further split into two groups: tool-based technologies and program-based technologies. Tool-based technologies are the most common, have a longer history, and have been well-researched. They refer to technologies that are not specifically designed for educational purposes and are versatile tools in nature. Teachers' adoption of these technologies through a process of design and implementation transforms these technological tools into pedagogical technologies that assist in teaching and learning. Teachers are less inclined to use tool-based technologies if they are considered supplemental instructional tools for efficient lectures. On the other hand, teachers are more likely to use such technologies for student-centered constructivism learning because of technologies' power to hone creative and critical thinking skills. Therefore, efficient adoption needs to be top-down, starting by setting learning goals that demand high-level creative skills instead of the mechanical acquisition of content knowledge. Suitable learning goals motivate teachers to see the value of developing positive attitudes toward technologies, which should fuel professional development programs, which should not only deliver adequate content knowledge but also create supportive and collaborative learning communities among preservice and in-service teachers. As such, teachers could be equipped with the skills, knowledge, and emotional drive to adopt tool-based technologies.

Program-based technologies are predeveloped with learning contents that are delivered to students in a preprogrammed way. They leave less control to teachers and instead drive learning by their own artificial intelligence or other program algorithms. Although there has been high hope that they could replace teachers' instruction to provide students with a personalized learning experience, the lack of human interaction often makes students feel less engaged in schooling and results in learning resistance. More research should be conducted in this field to study these technologies and the possibility of teachers working with algorithms in a more collaborative way instead of a either teacher or computer modal.

Technologies bring the Information Era to schools. As the economy has shifted from labor-demanding to innovation-demanding, learning of basic skills and content knowledge is far from enough. A new competence set of creativity, collaborative learning, and research is more valuable than ever, which translates into new learning goals that demand students to be innovative and proactive learners. Technologies can help with that, but, without question, the role of teachers is still critical. Technologies cannot exclude teachers but should rather work with teachers to transform education from instruction-centered to student-centered. Tool-based technologies give teachers the means to be innovative and achieve that goal. Program-based technologies should be developed in a way that work seamlessly with teachers through research-based practices, instead of repeating the failure of pursuing student-centered learning by replacing teachers. After all, information can be digitalized, but learning itself is still a very human business.

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