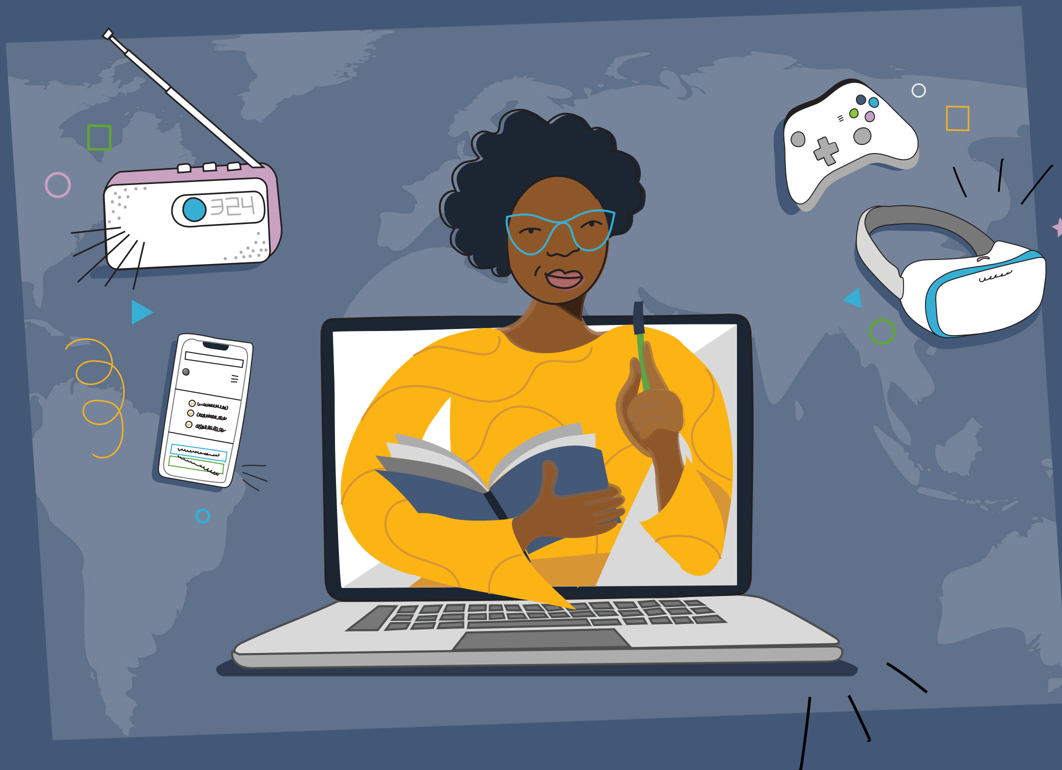

DISTANCE EDUCATION FOR TEACHER TRAINING:

Modes, Models, and Methods

Mary Burns

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Washington, DC

Education Development Center

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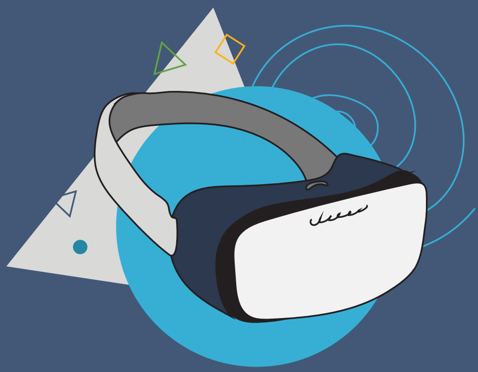

Section I. Chapter 4

MULTIMEDIA-BASED DISTANCE EDUCATION

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EDC

Multimedia applications, if designed well, offer diverse and school-based professional development opportunities.

4.1 Overview

Multimedia is what its name suggests—media that combine multiple formats: text, audio, video, still images, or animations. It can be as simple as a *PowerPoint* with embedded audio and video or as complex as *Minecraft for Education* or virtual reality. It can be accessed online via websites, browsers, and courses (for example, within a learning management system) or offline. Or it can be hybrid—existing both on- and offline.

Multimedia can be professionally created by game and software designers. It can be do-it-yourself—designed by teachers and learners using authoring tools such as *Storyline, Presenter 360, H5P,* or simpler-to-use Web-based tools such as *Canva, Prezi,* or *Slides.*[1] It can be developed by textbook publishers and media providers—Egypt's Knowledge Bank online repository uses content developed by Discovery Education and National Geographic. Or it can be open educational resources repositories such as Creative Commons. Multimedia is used for content, instruction, assessment, and as digital textbooks. Like almost everything technology-related, most multimedia resides on the Internet—in the kind of content repositories that will be discussed in *Chapter 12: Developing Content* and as part of online and blended courses.

This chapter examines various forms of multimedia as modes of both open[2] and distance learning for teacher learning and as supports for teaching. As readers peruse this chapter, they will come to appreciate the heterogeneity of multimedia, its potential for learning, its dynamism, the convergence and shapeshifting of its various forms, and both its integration with and independence from the Internet. In many ways, multimedia, more than any other distance technology, defies attempts to categorize it.

4.2 Multimedia Learning

The attraction of multimedia in education rests with the fact that it combines text, audio, video, and animation. As the previous chapter noted, the human brain does not organize multimedia as separate elements of words, images, or text. Rather, it "dual codes" multimedia representations to dynamically produce logical mental constructs. This "multimedia learning" or "multimedia effect," touched upon lightly in Chapter 3, can help both students and teachers learn more effectively and meaningfully because it engages learners in active processing and thus aids learners' working memory (Mayer, 2009).

[1] See, for example, https://multimedia.journalism.berkeley.edu/tutorials/26-useful-tools-for-producing-multimedia-content/

[2] Again, open learning is learning that is flexible and independent.

This dual coding makes for powerful learning. However, not all multimedia is designed with the same intentional focus on learning nor is it evaluated rigorously to ensure positive outcomes for learners. With this caveat in mind, the next section examines an array of multimedia that offer promise as teacher education tools.

Figure 4.1
Personalized, Individualized, Adaptive Learning

The terms *personalized learning*, *individualized learning*, and *adaptive learning* are often used interchangeably but are in fact different.

With **personalized learning**, learning goals and instruction *differ* for each learner; thus, the instructor or a computer program may customize instruction for a particular learner. This learning may be self-paced or done as part of a group (Burns, 2021, p. 31). Although thought of as a technology, personalized learning is in fact a type of instruction.

Individualized learning refers to a type of instruction that is also paced to the learning needs of different learners. However, it differs from personalized learning in that learning goals are the *same* for all students. They can progress through the material in a self-paced manner, either on or off a computer, according to their learning needs (Burns, 2021, p. 31).

Adaptive learning refers to technology that monitors learner progress in a course and uses those data to modify instruction in real time. Adaptive learning programs do this by detecting information, diagnosing it, and enacting new tasks based on this diagnosis. Adaptive learning is not a type of instruction; it is a *technology product*. Many, though not all, personalized learning programs are adaptive (Buckley et al., 2021b; Feldstein, 2013).

4.3 Teaching and Learning with Multimedia

In many parts of the globe, where Internet connectivity is unstable and teachers have limited access to technology, multimedia applications have traditionally served as an important vehicle for pre-service and in-service teacher education, for self-study purposes, and as part of formal teacher professional development. For decades, education institutions such as the United Kingdom's Open University used Web-, CD-ROM-, and DVD-based materials for teacher self-study at regional centers. Typically, teachers across the globe access multimedia in one of three ways: (1) via storage devices such as CDs, DVDs, USB drives, and Secure Digital cards (SD cards); (2) via the Internet or a cellular network; or (3) in the form of playlists of multimedia apps and content loaded onto laptops, tablets, and phones, particularly in marginalized and refugee contexts. Paradoxically, however, as multimedia has become a more immersive tool to support teaching and learning processes, its use for *student* learning has increased while its use for *teacher* learning has decreased.

4.3.1 Computer-Aided Instruction (CAI)

Computer Aided Instruction (CAI) involves computers presenting content-specific skills (math, science, reading) and monitoring the learning that occurs. Although frequently categorized as one type of technology, CAI is highly diverse and may assume a variety of forms, such as tutorials, cognitive (or intelligent) tutoring systems,[3] integrated learning packages, drill-and-practice software, and diagnostic assessments or online lessons that complement non-technology activities (Burns, 2021).[4]

CAI is multimedia-based. It can be as simple as vector animations with audio or as complex as

[3] Although conflated with CAI, Intelligent Tutoring Systems (ITS) are *technically* not the same as CAI for two main reasons. First, while a good deal of CAI is adaptive, not all of it is. ITS is always adaptive (or should be). Second, CAI provides tutoring at the *answer* level while ITS provides feedback at the step level—providing hints, scaffolds, and feedback on every action or step the learner makes in solving a task (DuBoulay, 2016, as cited in Burns, 2021).

[4] Unfortunately, the plethora of variations of CAI make their adequate coverage in this guide impossible.

video-based immersive virtual worlds. CAI has been around for decades, and its earlier iterations were more behaviorist, dichotomous, and focused on individualized learning. However, CAI has become increasingly more multimedia-based, learner-centered, individualized, personalized, and in some cases, adaptive (Figure 4.1 explains these terms). Learners may progress at their own pace and work individually, in a group, or with the assistance of the instructor. The programs generally provide feedback and increasingly adapt the task to the learner's ability, based on student responses to a prompt.

CAI can be *integrative* (used during class along with teacher instruction) or *substitutive* (used as a substitute for teacher instruction). It can be accessed online or offline; in school, at home, or after school; with instructor support or as a self-paced instruction; and, depending on the type of CAI, as a self-directed tool.[5] Depending on the type of computer-aided program, CAI may come with large banks of test items, and depending on the program, CAI can run on desktops, laptops, phones, and, in some cases, on gaming consoles (Burns, 2021).

In a "what's old is new again" motif, CAI—much maligned in the past for its behaviorist and didactic design—has become popular again, in part because the behaviorist and didactic design of many CAI applications can help learners attain basic skills. (Figure 4.2 differentiates between behaviorism and constructivism.) CAI interventions are increasingly common in low-resource environments, and findings on the effectiveness of CAI for student learning in such environments are tantalizing indeed. In three countries—the United States, India, and China—randomized controlled trials (RCTs) and meta-evaluations suggest that *students* using CAI, either in class or after school, show significant learning gains in mathematics, natural sciences, social sciences, and Hindi (Escueta et al., 2020; Kulik, 2003; Mo et al., 2014; Muralidharan et al., 2016). Like instructional television and IAI, CAI may be able to compensate for poor teaching quality or teacher absences and, like audio-based learning and instructional television, CAI works better to *support* teachers rather than to *replace* them (Snilstveit et al., 2015; The Economist, 2021).

Figure 4.2
Behaviorism vs. Constructivism

Behaviorism is a philosophy of learning that emphasizes the importance of behavior, as opposed to consciousness and experience, in learning. Under its original definition by the American psychologist John Watson, the emphasis was exclusively on reflexes and conditioning. In a behaviorist paradigm, learners are environmentally conditioned: The teacher creates a learning environment that elicits a certain behavior and controls learning by predicting and directing learning outcomes. The learner assumes an active role in learning, practicing the new behavior and receiving feedback that reinforces the behavior.

In contrast, *constructivism* is a philosophy of learning that emphasizes learning through experiences and consciousness. Within a constructivist paradigm, learning is a quest for understanding and meaning. The learner actively constructs knowledge by interacting with a variety of experiences, resources, and individuals. The role of the teacher is significantly different than in a behaviorist paradigm. In a constructivist paradigm, the teacher designs learning experiences that promote inquiry, exploration, and problem solving. The teacher is then a facilitator, who guides and supports learners as they construct knowledge.

These philosophies of learning shape instructional design and in turn the ways in which teachers teach and students learn.

[5] The terms *self-paced learning* and *self-directed learning* are often used interchangeably. Although there is some overlap, they are different. In *self-paced learning*, learners proceed from one topic to the next at their own speed or pace. In *self-directed learning*, learners choose to initiate their own learning. They diagnose their own needs, formulate learning goals, implement learning strategies, and evaluate their own efforts and outcomes (Knowles, 1975). While this learning may be self-paced, that is not always the case.

CAI: Helping teachers learn

CAI is used in other fields for adult learning, especially as part of corporate training. It also has been used over decades for teachers' training, particularly as part of computer-aided language learning (CALL) (Krashen, 2014; Meihami & Esfandiari, 2021). For decades, CAI was a foundational technology in Asia's open universities. For example, both Bangladesh's Open University and the Allama Iqbal Open University of Pakistan deployed CAI as part of pre- and in-service teacher instruction. However, its more contemporary use for teacher education seems to have diminished.

The difficulty of finding contemporary research on the effects of CAI on teacher learning forces a return to earlier research. Data from the 1980s and 1990s, when CAI was more commonly used as part of teacher training, suggest a number of benefits for pre-service teachers. CAI can improve their basic and intermediate content skills, as in algebra and second language learning. It meets the diverse needs and characteristics of adult learners by providing opportunities for self-paced individual and group-based learning (Lauzon & Moore, 1989, as cited in McIsaac & Gunawandera, 1996).

In one of the few contemporary studies on CAI for teacher learning, a quasi-experimental study in Turkey assigned 14 pre-service teachers to a computer-based piano teaching program and 14 to a human instructor. After ten lessons, pre- and post- test levels of the experimental and control groups revealed no significant differences in terms of piano skills. However, in the experimental group, where CAI was implemented, learners' "success and the permanence of learning was better and more effective" than that of learners in the control group (Kaleli, 2020, p. 244). This is one small study, however. More evidence-based evaluations measuring the impact of CAI on teacher learning are needed before we can make any real determinations of its efficacy.

CAI in the form of computer-aided language learning (CALL) has been shown to be effective in developing decontextualized linguistic knowledge, and potentially in improving second-language acquisitions skills of adults (Krashen, 2014)—a finding that holds positive implications for teachers. *Duolingo*, the commercial platform-based language teaching program, offers gamified, micro-lessons on the World Wide Web or via an app, to help users learn a second language. Two efficacy studies[6] evaluated the listening and reading proficiency levels of 540 U.S. adults who used *Duolingo* exclusively as their Spanish- or French-language learning tool. While there were a number of factors affecting test results (e.g., variability in learning rates, concern about the ceiling effect of the Spanish test, and age and motivation issues that might affect engagement of beginning and intermediate-level learners), *Duolingo* showed acquisition levels comparable with those of university students at the end of their fourth and seventh semesters, respectively, in French or Spanish (Jiang et al., 2021; Krashen, 2014).

CAI: Helping teachers teach

CAI has a number of benefits, not least of which is that it can serve as an instructional support in areas where there is no teacher (Banerjee et al., 2007; Tausin & Stannard, 2018). But CAI—especially programs that are *adaptive*—appears to have four direct benefits for teaching.

First, it measures learner progress in a learning task and uses those data to adapt instruction in real time, thus potentially helping teachers better evaluate the learning needs of students and tailor instruction and supports to personalize that instruction (Baron et al., 2018; Mo et al.,

[6] "Efficacy" is a measure of effectiveness. It's the ability of a product, behavior, or intervention to produce the desired results or effects. Efficacy studies measure whether a treatment or intervention works, especially when compared to outcomes in a control group.

2014; Muralidharan et al., 2016; Rivera et al., 2022; Snilstveit et al., 2015).

Second, CAI also can serve as an important teaching support for junior and senior secondary teachers who have large classes and who have a diverse range of learning abilities within those classes. Barrow et al. (2009) found that CAI may increase student achievement in pre-algebra and algebra by at least 0.17 of a standard deviation, on average, with somewhat larger effects for students in larger classes. This suggests that CAI has the potential to significantly enhance student mathematics achievement and that the gains are comparable to those achieved with drastic class size reduction versus any specific change in teacher practice.

Third, CAI can be used to support and facilitate teachers changing practice from direct, whole-group, lecture-based instruction to more diverse instructional practices, such as blending learning. It also can

- free up teachers to work with students who need tutoring, develop students' non-cognitive skills, and promote group learning strategies (Muralidharan et al., 2016);
- help teachers spend more time on creating more personalized and individualized learning opportunities for students; and
- provide enrichment and remediation activities for students who need them.

Finally, CAI might be most useful for teachers who are teaching outside their content areas or who have weak content skills—a recurrent theme in this guide in particular and in education research in general (Bau & Das, 2020; United Nations Educational, Scientific and Cultural Organization Institute for Statistics, 2016). For instance, in Puerto Rico the Technology Application in Mathematics Teaching program (*Aplicación de la Tecnología en la Enseñanza de las Matemáticas*—ATEMA), implemented by the University of Puerto Rico, uses Khan Academy videos to build the content skills of grade 4-8 math teachers and their students. (Rivera et al., 2022).

4.3.2 Digital Learning Games

Multimedia programs may be "gamified" by adding motivational elements and mechanics to multimedia that are not necessarily designed to be games—for example, points, badges, or a leaderboard. Or they may be "game-based," where the games themselves are designed to be intrinsically motivational and are used to teach specific objectives (EdSurge, 2013).

It is the latter—digital learning games or digital game-based learning (DGBL)—that can support teaching and learning processes specific to particular learning outcomes. In contrast to simple games—structured forms of play undertaken for fun or, in many cases, for education—digital learning games combine both the characteristics of video games and those of computer-based games (De Freitas, 2006).

Digital learning games typically have three specific educational uses: (1) as *curricular interventions* used in formal classroom settings or in informal contexts but with a specific *curricular focus*; (2) in *non-didactic activities* to engage students in the learning process; or (3) as vehicles to assess student knowledge and skills (Clark et al., 2009, p. 28).

Digital learning games are highly platform-independent. They can be Internet-based or played on mobile devices such as portable gaming systems (e.g., the Wii, Xbox, or PlayStation), or on televisions, computers, iPads, and smart phones. Input can be touch-, joystick-, keyboard-, or motion-based. Cumulatively, digital games can be both off- and online, collaborative (multi-user/multiplayer), or solitary learning tools. Adding to their expansive nature, digital learning games are so varied in their content, structure, dimensions, and focus, that they may best classified as "genres."

Clark et al. (2009, p. 28) classify *all* games as belonging to one of three categories: (1) games of *short duration*, which can be played in a few

Figure 4.3
Genres of Digital Learning Games (Adapted from Lucas & Sherry, 2004, p. 512). Note that many of these will overlap.

Genre	Description of This Type of Game
Action/Adventure	Players participate in an adventure (e.g., *Little Big Planet; Pentiment*)
Alternate reality	Players find clues and solve puzzles that blur the boundaries between the game and real life (e.g., *World Without Oil; Superstruct*)
Athletics/sports	Games are based on athletic or sporting events (e-sports)
Content-based	Players learn general content or specific content topics (e.g., *Walden; Virtuoso*)
Fantasy/role-playing	Players assume a character role (e.g., *World of Warcraft; Elden Ring*)
Fitness	Players engage in physical activities (e.g., *Supernatural; Dance Dance Revolution*)
Problem-solving	Players solve a real-world problem (e.g., *Urgent Evoke; Mortality*)
Quest/mission	Players complete a task or fulfill a mission to gain rewards (e.g., *Dorfromantik; Mission: ISS: Quest*)
Quiz/trivia	Games test players' knowledge (e.g., *NatGeo Kids; Worldle*)
Reenactment	Players become characters living in a certain historical period, dealing with issues of that period (e.g., *The Hajj Trail; Maya Quest*)
Simulation	Games mimic or simulate real environments and issues associated with that environment (e.g., *Climate Action Simulation; EcoMUVE*)
Strategy	Games employ strategies and planning skills (e.g., *Hit the Road; Community in Crisis*)

minutes online or on handheld devices; (2) games of *fixed duration* with a set start and stop time; and (3) games of *ongoing participation*, in which players become members of an ongoing community and which usually occur online. One example of the latter is Massively Multiplayer Online Role-Playing Games (MMORPGs) or Massively Multiplayer Online Games (sometimes called MMOs or MMOGs).

Digital learning games have a decades-long presence in education. For example, American readers of a certain age may remember *The Oregon Trail*, a computer game developed in 1971. In the game, students set out in a covered wagon in the late 1840s from Independence, Missouri, to travel to Oregon's Willamette Valley—a journey of over 2,000 miles. Their expedition involves encounters with nature, wild animals, terrain, weather, Native Americans, and decisions about food, safety, and travel. Still in use today (with its retro graphics), the multi-textured game often supplements instruction or provides a deeper dive into westward expansion. The game also has inspired *The Hajj Trail*, a multimedia game that introduces students to the history of the early modern Ottoman Empire and the Islamic World [circa 1500–1800 CE] through a historical simulation of the Hajj pilgrimage. The game is used in schools in Turkey and Malaysia and involves assuming a role, making choices, and experiencing consequences (The Economist, 2022b; The Hajj Trail, 2022). *Walden*, a free language arts and social studies game developed by the University of Southern California's Innovation Lab, allows students to explore concepts of civil disobedience and self-reliance. It comes with teaching guides, lesson plans, and a *Facebook* group where teachers support one another in game-based learning principles.

Educational benefits of digital learning games[7]

Digital learning games enable players to approach problems by engaging in activities and scenarios; conceptualize issues by employing culturally or professionally mediated "lenses;" and solve problems by learning to "think like" scientists, historians, or journalists, who employ systematic methods of inquiry and problem framing in order to investigate an issue.

Approximately three decades of empirical research on learning with games points to positive educational benefits of digital-based learning games, as outlined in Figure 4.4.

Figure 4.4
"Engagement"

Engagement is a much revered but ill-defined concept in learning. Part of the difficulty in defining it is its complexity: Engagement has cognitive, motivational, behavioral, social-behavioral, and cognitive-behavioral components. Engaged learners are attentive and interested, show effort and persistence, participate with peers, and use self-regulation and self-directed strategies to complete a task (Pekrun & Linnenbrink-Garcia, 2012).

Well-designed digital games for learning balance a number of important design elements that contribute to engagement—the story of the game, roles of the players, game objectives, feedback, levels, control limits of the player, and reward and punishment mechanisms. All of these are carefully crafted to promote analytical, creative, and design-oriented thinking skills (Bakan & Bakan, 2018).

Learners who engage with such well-designed digital learning games set goals, monitor feedback, become immersed in the activity, pay attention to what is happening, and enjoy the experience—so much so that often they experience a sense of "flow," where they are so engrossed in an activity that time and space disappear (Csikszentmihalyi, 1990; Hanghøj et al., 2018).

Digital learning games for teacher professional development

As is evident from Figure 4.5, there is a longitudinal body of research on the positive potential of digital learning games for *student* learning; yet very little research exists on games for *teacher* learning. As with instructional television, discussed previously in Chapter 3, this is an unfortunate omission. Given the popularity of games and demographics of gamers, many teachers (particularly younger ones) are undoubtedly gamers, and games have cross-over potential as didactic tools for teachers. Digital learning games may be particularly helpful where teachers lack strong content knowledge and thinking, reasoning, and problem-solving skills—or when they need models and ideas for making learning more creative and interactive.

Enigma, for example, is a digital learning game that helps adults who struggle with certain aspects of literacy improve their reading (Southern Methodist University's Simmons School of Education and Human Development, 2022). Games also can help to cultivate important behaviors—persistence, problem solving, and risk taking—that are as important for teachers as they are for students (Gee & Shaffer, 2010). Teachers who use digital learning games as part of teaching report positive outcomes: They are able to address a wider range of objectives, teach core and supplemental content, assess students, and expose students to a wider variety of game genres and digital tools (Takeuchi & Vaala, 2014).

[7] Visit https://www.filamentgames.com/blog/research-roundup-k-12-game-based-learning/ for a host of updated studies on digital learning games.

Figure 4.5
Benefits of Digital Learning Games

Claim: Games can	Explanation	Citations
improve conceptual understanding associated with a particular domain	• A number of studies, including meta-analyses, have found positive learning benefits in math, vocabulary, and science knowledge for digital game-based learning in preschool, elementary, and secondary school settings. • The game design itself, the instructional focus, and the use of supplemental materials can combine to improve learning.	Byun & Joung, 2018; Chen et al., 2018; McCarthy et al., 2018
promote problem-solving skills	• Many games employ a problem-based methodology. Learners use facts, artifacts, and evidence to identify the problem, generate hypotheses, evaluate alternatives, and make decisions. • In so doing, they develop high-level skills such as analytical thinking, reasoning, decision-making, and problem-solving.	Bakan & Bakan, 2018; Yang, 2012
help learners attain national content standards	• Games can provide an instructional and curricular support to teachers, thus helping them teach to national content standards. • Game-based learning can teach and measure many of the same constructs and skills promoted by the Council for Economic Education standards, Next Generation Science Standards, and National Council of Techers of Mathematics Standards (These are all U.S. standards).	Buckley et al., 2021a
by design, be higher-order learning tools	• Games embody adaptable challenges, clear criteria, personalized feedback, and a broad range of challenging topics as intrinsically motivating ideas. • Games can serve as entry points into conceptually complex content in ways that lead learners to investigate a concept further through immersion in the process. • Games often require players to collaborate and communicate with others, both in online environments and in the physical spaces where gameplay occurs; solve complex problems; modify the game; map out complex variables; and find solutions to challenging "boss" levels.[8]	Gee & Shaffer, 2010; Klopfer et al., 2009; Spires, 2015
elicit evidence of deeper understanding and cognitive processes	• Interpretation of streaming data from gameplay or interaction with a carefully designed digital user interface allows researchers to evaluate how people go about solving problems and can lead to more targeted feedback. • Learners develop conceptual thinking by interacting with and manipulating complex systems and alternate, virtual environments in which they outfit themselves with virtual identities or avatars in order to practice ways of knowing within a situated, authentic context.	Buckley et al., 2021a; Chen & Law, 2016; Chung, 2014; De Freitas, 2006; Gee, 2003; Gee & Shaffer, 2010; Yang, 2012

[8] Gee and Shaffer (2010) write: "'Boss battles' at the end of a level in a game are often used to assess whether the player has mastered the skills of the level just finished, and whether he or she is prepared for learning the more demanding challenge of the next level" (p. 13).

Claim: Games can	Explanation	Citations
foster collaboration and motivation	• Collaboration, in addition to scaffolds within digital game-based learning, can significantly positively impact intrinsic motivation. • Collaboration (and competition) may positively impact above-average-students over below-average ones.	Chen & Law, 2016; Ter Vrugte et al., 2015; Yang, 2012
assess hard-to-measure skills	• Game-based assessments include rich, scenario-based programs, such as virtual worlds, simulations, and multi-user virtual environments. • They provide students with a developmental sequence of challenges that gradually increase in difficulty so that players are working at their highest abilities. • As learners manipulate complex systems, their instructors can measure difficult-to-assess skills such as higher-level thinking skills and 21st-century skills of persistence, creativity, self-regulation, problem solving, and collaboration, as well as affective states (such as engagement) via the use of eye-tracking and facial recognition software. • Game-based assessments also provide feedback, hints, and just-in-time resources, as well as capturing and storing multiple sources of data over prolonged periods to provide information about the student's work so teachers can tailor tasks and problems to the individual student.	Buckley et al., 2021a,b; Gee & Shaffer, 2010
improve science, technology, engineering, and mathematics (STEM) knowledge	• Compared to non-digital game learning activities, digital game-based learning has a moderately significant effect on learners' STEM achievement. • Digital game-based instruction can be more effective than other instructional strategies on learner STEM knowledge, indicating that intervention of digital games seems to improve learning.	Wang et al., 2022

Finally, digital learning games also can provide teachers with ideas for nondigital gaming scenarios, content framing, and instructional approaches that they can use in class. Games should be one component, not the sole menu item, of a professional development program. They should also be facilitated by a skilled instructor who can help teachers persist with the game, particularly when it seems disorienting, when it becomes difficult, and when navigation issues become problematic. Skilled facilitators also can help teachers reflect on their own learning via digital learning games; discuss ways to use games to promote students' propositional knowledge and procedural skills; and design experiences that transfer some of the games' engaging digital experiences to the teacher's analog classroom to enhance student learning.

4.3.3 Immersive Environments

Digital learning games have rules. This next category of multimedia—immersive environments—have no rules. This can be a strength or a drawback (Wheelock & Merrick, 2021).

"Immersion" is the extent to which a system presents a vivid virtual environment while shutting out physical reality (Cummings & Bailenson, 2016). Thus, as their name suggests, "immersive environments" allow learners to become totally enveloped in a self-contained artificial or simulated environment while experiencing it as real.

Figure 4.6
Examples of Immersive Rooms

Two well-known educational immersive rooms are the Cave Automated Visualization Environment (CAVE) and EvoRoom.

CAVE is a small surround-screen projection space developed for professional preparation, training, and simulation, in fields such as mining and aviation.

EvoRoom, a simulation of the rainforest ecosystem of Borneo and Sumatra, is designed by Encore Labs as an integrated element within a Grade 11 biology curriculum unit. The environment is hardware intensive. Implemented within a "smart classroom" research environment, the room is equipped with computers, servers, projection displays, and customized software to coordinate the flow of participants, content materials, and data collection.

The smart classroom technology includes a user portal, allowing students to register and log into the room; an intelligent agent framework, allowing custom software "agents" to track real-time interactions among students, peers, and materials; and a central database for curriculum materials and the products of student interactions. In order to support a common, shared experience for students, the room is set up with two sets of large projected displays and two interactive whiteboards.

The interactive whiteboards are located at the front of the room. The simulation files are networked and controlled with a custom tablet application that allows the teacher to manage the time spent in each portion of the activity, thus controlling the pedagogical flow within the room (Lui & Slotta, 2014, p. 64).

This illusion of immersion can be amplified by wearing haptic[9] clothing (gloves or a vest) to simulate the experience of touch. Immersive environments can offer rich and complex content-based learning, while also helping learners hone their technical, creative, and problem-solving skills. Like virtual worlds, with which they are sometimes conflated, immersive environments are increasingly common in education, though more often with students as opposed to their teachers. However, immersive environments are gaining attention as a potentially powerful tool to help teachers transfer learning from the theoretical to the practical (Ledger et al., 2022) and will be examined as such in this chapter.

Immersive environments generally come in the following flavors:

- **Immersive rooms,** which are a dedicated physical space equipped with technology. Audio and visual media are projected on walls, with learners sometimes using three-dimensional (3D) goggles or head mounted displays. In the room itself, learners experience a sense of being "immersed" in a historical, biological, or geographic environment. Because these environments are so rich and visual, users tend to be highly engaged. Figure 4.6 explains immersive rooms in greater detail.
- **Virtual Reality or Augmented Reality "head mounted displays"** (HMDs), such as Oculus Quest2/Meta Quest 2 or Microsoft HoloLens vary in their design, but typically contain a pair of stereoscopic lenses, stereo sound, sensors to track the user's movement and a light emitting diode (LED) display. The HMD, or any type of VR goggles, distorts the image on the screen so the user experiences it as an alternate reality— in 3D versus 2D.
- **Desktop enabled environments** are partially immersive environments[10] that can be accessed via a laptop or desktop computer and, in many cases, via a mobile device.[11] They involve

[9] Haptic technology creates the illusion of touch by applying vibrations or motions that the user experiences as real.

[10] Another example of the numerous contradictions of technology. Though we can argue whether "partially" immersive is truly immersive, it is considered a category of immersive environments, such as virtual reality (See for example, Roundtable Learning, n.d.)

[11] There appears to be a strong consensus in much of the gaming discussion that desktops are better than laptops for graphics-intensive games.

learners in activities that are game-like or represent other worlds. They include many types of games, simulation software, and sites such as, *YouTube VR, Tatsumeeko,* and *Discord*. Though not fully immersive, desktop-enabled environments use icons or features to create at least a partially immersive environment.

As to which is better for learning, a 2020 meta-analysis synthesizing findings from 35 studies comparing immersive VR via head mounted displays to less immersive desktop VR came down on the side of HMDs for improving knowledge acquisition as well as skill development (Wu et al., 2020, as cited in Makransky & Mayer, 2022, p. 10). The analysis did not examine immersive rooms.

There are numerous subcategories of immersive environments. Indeed, the whole taxonomy of immersive environments can be confusing for the layperson—and even for those involved in educational technology. Since immersive environments encompass a number of multimedia and Web-based applications, the term means different things to different people. For example, immersive environments include simulations, virtual worlds, virtual-reality programs, Web-based games, Multi-user Virtual Environments (MUVEs), and Massively Multiplayer Online Games (MMOGs) (Najafi, 2009, as cited in Burns, 2010).

What they all have in common is that they submerge learners in situated, game-like, content-related scenarios, typically in real-world situations that prompt learners to think like or adopt the mindset of some real or assumed role. Experiences can be synchronous or asynchronous, persistent, community-based, and conducted via avatars using networked and non-networked computers (Burns, 2010).

Immersive environments[12] are clearly at the high end of the multimedia continuum. They involve high-end graphics cards and desktops; robust bandwidth; highly audiovisual and 3D design; and a willingness on the part of teachers and learners to suspend belief and participate in an open-ended, alternative, networked experience. These requirements, combined with the frequent need to fit them into the curriculum, mean they are not widely used in teacher training colleges or teacher education departments in universities across the globe (Takeuchi & Vaala, 2014).

Immersive environments can be created in a number of ways, as discussed above, but the real drivers are increasingly Augmented Reality and, to a far greater extent, Virtual Reality.

Augmented Reality

If you've ever used a *Snapchat* filter, then you have a basic understanding of Augmented Reality (AR). AR is an "immersive" interface that allows a combination of real-world elements captured through a camera with multimedia elements such as text, images, and video. In contrast to Virtual Reality (discussed below), which completely immerses the user in a synthetic world *without* the ability to see the real world, AR enhances or "augments" the environment by superimposing virtual objects and cues onto the physical world, thus enabling learners to interact with—but not manipulate—this three-dimensional augmented environment in real time (Wyss et al., 2021, p. 2). To use AR, learners require a head-mounted display, like Microsoft's HoloLens or Google's AR glasses; an app on a device; and a "trigger"—paper, a photo, a location— that initiates the AR experience and turns 2D content into a 3D experience.[13] AR, like VR, can be part of in-person, blended, online, or mobile learning.

[12] Immersive Education is a nonprofit international collaboration of universities, colleges, research institutes, consortia, and companies working together to define and develop open standards, best practices, platforms, and communities of support for virtual reality and game-based learning systems. See http://immersiveeducation.org/

[13] To see how this works, visit https://www.youtube.com/watch?v=emiGJNa9gwg

AR is steadily making inroads in education across the globe. For example, in South Korea, schools designated as "smart schools" extensively employ AR (Lim & Kye, 2019).[14] *Mondly* is a popular AR-based language learning app used in many countries. Portugal's *EduPARK* initiative creates original, attractive, and effective strategies for interdisciplinary learning in natural sciences, physics, chemistry, mathematics, and history. Its mobile interactive Augmented Reality application allows teachers and learners to participate in exploratory, geocaching activities in outdoor environments (EduPARK, n.d.).

The incorporation of AR into educational practices for effective learning places numerous demands on educators. The first is a change of mindset. As with digital learning games—toward which many educators often express reservations—university pre-service or in-service teacher professional development programs may be reluctant to use or integrate AR into their curriculum (Russo et al., 2021; Wyss et al., 2021). This speaks to the need to provide distance instructors and the teachers they teach with AR tools and train them in methodologies using AR technologies (Marques & Pombo, 2021). More so, it speaks to helping instructors and teacher learners see the pedagogical utility of AR—that its value does not rest solely on the use of the technology, but is driven by how AR is designed, implemented, and integrated into formal and informal learning environments (Wyss et al., 2021, p. 3).

As a potential tool for teacher training, AR is promising. Because it is immersive and highly sensorial, it shifts learning from the informational to the experiential. Chapter 1 discusses the cognitive load teachers face when reading text from a screen. AR, by its highly visual design, reduces that load. Second, Wyss et al. (2021) note that the educational value of AR is not so much its technical features but rather "its pedagogical possibilities and alignment with learning theory" (p. 663). The few studies that exist on AR for teacher education—one from Switzerland and the other from Portugal—suggest that pre-service and in-service teachers are quick to grasp the pedagogical potential of AR (Marques & Pombo, 2021; Wyss et al., 2021).

Finally, a glance at professions beyond education shows how AR alone or in combination with VR—a combination known as "extended reality" or XR—might be deployed in distance education. For instance, AR is used extensively in solar energy installation. A junior electrician on a job site might struggle with the proper installation of solar panel. Alone, with no immediate support, he connects his Head Mounted Display to his laptop for a remote, live, VR-based meeting with his supervisor, a master electrician. The master electrician can use AR applications to point out errors in the installation process. If that doesn't work, she can remotely take over the junior electrician's laptop in real time and, using her AR application, overlay the steps for correct installation on the junior electrician's actual device (S. Ives, personal communication, November 26, 2022).

Virtual Reality

While Augmented Reality *partially* immerses the user in a virtual world, Virtual Reality (VR) can *fully* immerse the user in a new, digital, all-encompassing simulation of a physical world, often via a head mounted set like Meta Quest 2. While the user may *know* the experience isn't real, it certainly feels real, thus the power of such an experience. Students can participate in virtual field trips of the Acropolis through Google *Arts and Culture*, participate in a tour of the White House guided by a U.S. president, or create a digital 3D model of an animal cell with identifiable organelles using the VR tool *CoSpaces*. Files can be converted to a GLB format and then uploaded and viewed and analyzed via ClassVR

[14] This information is based on the author's 2011 visit to several South Korean smart schools.

headsets. For those schools who have access, the same model could be converted to an STL file to be printed on a 3D printer.

Though VR is generally considered a fully immersive experience, there are in fact three types of VR which vary according to their degree of "immersiveness:"

- **Non-immersive virtual reality** in which the user can interact with the virtual environment through a computer screen, for example a video game, or a simulator. It is considered a virtual reality category because the user can to some extent control the movement of virtual objects on screen.
- **Semi-immersive virtual reality** provides *partial* immersion by overlaying digital components over real-world objects. This type of VR is mainly used for educational and entertainment purposes.
- **Fully immersive virtual reality** provides a 360° sensory simulation for the user to step in and experience (Mattoo, 2022).

This degree of "full" immersion is further categorized according to "degrees of freedom" —that is, the ways an object can move through 3D space.

- **360° degree VR uses three degrees of freedom.** Learners can look left and right, up, and down, pivot left and right, and can interact with the virtual environment via gaze control or a pointer on handsets. But they *cannot* move throughout virtual space.
- **Full VR uses six degrees of freedom.** Learners can move forward and backward, up, and down, and right and left through virtual space. They can observe and interact with objects placed in the virtual environment as they would if those objects were real.

This degrees of freedom distinction has professional development implications— it means teachers will either be stationary or able to move (Roundtable Learning, n.d.)

A long-running joke about VR is that it is the future of education—and always will be. Despite such cynicism, VR has in fact expanded dramatically in education—even beyond the usual educational innovators and early adopters.[15]

Companies like Mursion offer pre-service educator preparation, clinical practice simulations, and practice sessions for adult interactions, such as parent-teacher conferences, via virtual reality (Mursion, 2022). Thus, pre-service teachers learn how to deal with a difficult student or situation before real-life consequences occur. Arizona State University has partnered with Dreamscape, an immersive virtual reality company, to create a nine-module VR simulation of a zoo for learners majoring in biology (Arizona State University, 2020). VRsatility, developed by students at the Harvard Graduate School of Education, provides pre-service teachers with an immersive virtual space to engage in realistic mock simulations to practice high-stakes decision-making scenarios and various instructional strategies before entering the classroom (Bauld, 2019). And Crosswater Digital Media uses VR to "teleport" educators into conflict environments, which could ideally serve as preparation to teach in such environments (Crosswater Digital Media, 2022).

Virtual worlds

While VR often drives an *individual* learning experience (because of the use of headsets), virtual worlds —a sub-category of VR and a common format for digital gaming—are more social and highly synchronous. Within a virtual world,[16] people are represented as avatars who interact with one another and with 3-D artifacts,

[15] My thanks again to Shane Ives, serious gamer and VR enthusiast, Albuquerque, New Mexico, for letting me use his Oculus headset and tutoring me on the finer points of VR applications.

[16] Virtual worlds are also referred to as Multi-User Virtual Environments (MUVEs).

take part in a range of educational and social experiences, and create their own content. Virtual worlds also can be accessed via headsets, but most are simply accessed via a computer screen. The virtual world contains similarities to the "real" world, such as topography, movement, and physics that provide the illusion of "being there" (Warburton, 2009, p. 418). This has made them a powerful professional education tools for health workers and those in the hospitality and tourism industry, for example—and increasingly, for educators.

Virtual worlds are being accessed increasingly via social virtual reality commercial platforms, such as Microsoft's *AltSpace* VR, or via HMDs. However, many of the most popular virtual worlds in education can still be accessed without HMDs (i.e., "desktop enabled"). These include *Quest Atlantis*, *Whyville*, *Open Sim*, *Sim on a Stick* (a virtual world on a USB drive), *Minecraft for Education*, and *Second Life*. *Minecraft for Education* has, over the years, been integrated into a number of formal education systems. For example, the Welsh Government in 2019 provided every teacher in Wales access to *Minecraft for Education* and established five Minecraft Learning Centers across Wales (Llywodraeth Cymru [Welsh Government], n.d.). The North American Scholastic eSport Federation sponsors annual international e-sport competitions with school teams from the United States and Canada competing against student teams (in 2021 and 2022) from Japan, Israel, Kuwait, Egypt, Jordan, the United Arab Emirates, and Palestinian Territories, in part to promote intercultural understanding and language learning (North American Scholastic eSports Federation, 2022).

And though its popularity has waxed and waned since its inception in the 1990s, *Second Life* has been used extensively for teacher preparation, classroom management, language learning, special education, science, mathematics, educational technology, and parent-teacher engagement (Davis et al., 2022, pp. 3–4; González et al., 2011). Warburton (2009) itemizes the array of educational offerings in *Second Life:* discussions, self-paced tutorials, displays and immersive exhibits, role plays and simulations, data vizualisations and simulations, historical recreations and re-enactments, living and immersive archaeology, treasure hunts and quests, language and cultural immersion, and creative writing (p. 421). *Second Life* may be the best vehicle for understanding the notion of the Metaverse (discussed below).

Given its maturity, the use of *Second Life* for teacher education has been examined in empirical studies, summarized in literature reviews, and its benefits and limitations are well-documented. In their study of *Second Life* as part of teacher pre-service education in Australia, Ledger et al. (2022) reported several advantages:

- It allows pre-service teachers to experience a broader range and depth of practical experiences than would be the case in face-to-face settings.
- The utilization of virtual worlds such as *Second Life* can provide collaborative, reflective, and skill development opportunities of engagement for pre-service teachers.
- It offers opportunities and challenges in facilitating a learning environment that can assist pre-service teachers in developing pedagogies of practice via representations, decomposition, and approximations of practice (Davis et al., 2022, pp. 7–9; Grossman et al., 2009).
- As a participation-based network, *Second Life* may help learners build communities of practice, collaborate with peers in group work, and create and share content.

The Metaverse

Virtual worlds have a high degree of overlap with the Metaverse—a loose term that describes an immersive, three-dimensional, virtual-reality–driven, extended reality Internet. Think of the Metaverse as a user-built world with social media, accessed via virtual reality headsets, and powered by Artificial Intelligence, cryptocurrencies, blockchain, and non-fungible tokens (NFTs) (Herrman & Browning, 2021). Within the Metaverse, as it is envisioned, users can play games, talk, attend lectures, buy things, and create their own worlds. All of these activities already exist in applications such as *Second Life* and in Massively Multiplayer Online Games, social media, and other virtual worlds; the Metaverse brings them together seamlessly and immersively and allows them to interact with the real world.

The Metaverse, at the time of this guide's publication, was in its very initial stages, so this section simply describes it. The Metaverse may well indeed mark the culmination of computing from the desktop to the pocket "overlaid on our world," as some predict (The Economist, 2022a)—or it may ultimately be much ado about nothing. But if it does what its parent company, Meta, hopes, we can imagine the Metaverse as a future potential tool for teacher professional development.

Simulations

In contrast to virtual worlds, which involve multiple users, simulation programs tend to involve one user and be more closed and structured. Simulation software is used extensively across numerous professions, such as aviation, to allow individuals to engage in repeated trials involving high-stakes situations without risking the loss of valuable resources (e.g., money, time, and people) (Dieker et al., 2013). Simulations are incrementally becoming more popular as part of pre-service teacher preparation to help future teachers develop effective and equitable approaches in their teaching in a safe space (Davis et al., 2022). This openness toward simulations is in part because of the accumulating research showing that pre-service teachers can gain valuable and meaningful practice in their teaching through engagement in classroom simulations (Childers & Hite, 2022).

One example is *SchoolSims*, developed by the Graduate School of Education at the University of Pennsylvania for pre- and in-service teachers. The application involves teachers interacting with a simulated classroom and engaging in real-life vocational-related scenarios (for example, an angry parent). Learning is achieved, not by arriving at a correct answer, but by enabling users to consider options, make mistakes, and draw conclusions from experience (SchoolSims, 2022). Thus in contrast to virtual worlds, simulations pre-program responses to "complex threads of interactions" between a teacher and simulated students or their simulated parents (Bradley & Kendall, 2015, as cited in Davis et al., 2022).

There are numerous simulation applications for teacher pre- and in-service instruction, including *simSchool*, *Sim:Classroom*, *At-Risk for High School Educators*, *At-Risk for Middle School Educators*, *Step In*, *Speak Up!*, *Cook School District*, *Teacher Simulator,* and *DTkid* (which trains teachers to work with children who have autism).

Mixed Reality

Mixed reality involves blending and combining physical and virtual environments to produce a unique environment where physical and digital objects interact in real time. This often involves combining the use of computer avatars (digital representations of a person) and actual human beings.[17] Because of this live human element, mixed reality programs have been harnessed to help pre-service teachers prepare for either their school-based practicum or their first classroom upon receiving their degree as the two mixed reality examples below illustrate.

Mixed reality for coaching. At the University of Virginia's Curry School of Education and Human Development's Curry School of Education, researchers have tested mixed reality simulations to study the causal effects of coaching on

[17] Just to make it even more confusing, mixed reality in some circles is considered a type of augmented reality (AR). In others it is considered part of the virtual reality continuum, with physical reality at one extreme and immersive virtual reality (VR) at the other.

candidates' perceptions and teaching skills. This involves (1) *computer generated* "students" who behave like unruly teens; (2) the human pre-service teacher who tries to manage her unruly virtual students; and (3) live human coaches who assess the pre-service teacher's classroom management efforts. Researchers randomly assigned the 105 pre-service candidates into one of three treatment arms using the simulator. The effects of these are listed in parentheses.

- Model 1 Coaching Only: This involved a short coaching session after each practice simulation to review and give feedback. (Overall quality treatment effect:[18] 2.55)
- Model 2 VBIE and Coaching: This involved a live "bug in the ear" approach (explained in Chapter 6,) with a coach dispensing advice via the teachers' Bluetooth headpiece during the practice simulation. (Overall quality treatment effect: 2.60)
- Model 3 Self-Reflection Exercise: This followed the simulation to guide the teachers to think about classroom management techniques on their own. (Overall quality treatment effect: 2.60)

There were more treatment effects for different outcomes than those listed above, and all were robust (Cohen et al., 2020, p. 219). Researchers concluded that the mixed reality simulators could improve candidate practice in the simulator in substantial ways, especially when supported by reflection and by "bug in the ear" technology—the latter experienced particularly steep gains. However, the "big empirical question" is whether or not such an approach can result in transfer into real classrooms (Cohen et al., 2020, p. 226).

Mixed reality for microteaching. TLE *TeachLivE* is an immersive environment[19] developed by the University of Central Florida that helps pre-service teachers develop a range of skills for teaching students with special needs and various levels of disabilities through practice teaching a classroom full of student avatars. The teacher enters a physical room where everything looks like a classroom, including props, whiteboards, and students. But it is a mixed reality setting with avatars who act like teenagers, depending on the objectives of the experience. Unlike the "students" in the previous mixed reality example from the University of Virginia, these "students" are actually human actors connected via audio or video who speak through the avatars. Thus, the experience is live and spontaneous because actors respond to the teacher as students would (Dieker et al., 2013). There is also another set of human beings—education instructors (humans)—who observe while hidden from the pre-service teacher and who provide feedback.

The teacher candidates interact with virtual students to review previous work, present updated content to students, provide guided practice in a variety of content areas, and monitor students while they work independently or collaboratively. If a teacher performs poorly or if they want to experiment with a new teaching idea while using TLE *TeachLivE*, there is "no adverse effect on any real student, though the experience itself feels real" (Dieker et al., 2013, p. 25).

The program has proved popular with pre-service teachers, since it allows them to make mistakes in a safe environment, receive feedback from their education instructors, and prepare virtually for live interactions with real students. Since its inception in 2005, TLE *TeachLivE* has expanded across the U.S. and is used at pre-service institutions in Australia, Italy, Malaysia, México, Switzerland, and the United Arab Emirates.

However, a synthesis of research on virtual and mixed reality simulations showed mixed results

[18] The average treatment effect is a measure used to compare treatments in randomized experiments. It measures the difference in mean outcomes between units assigned to the treatment and units assigned to the control.

[19] *TeachLivE* is alternatively referred to as a "mixed reality simulation" and a "virtual world"—thereby confirming lack of definitional clarity of technologies, and of immersive environments in particular.

for *TeachLivE*. For example, continued exposure helped pre-service teachers improve teaching self-efficacy, but this improvement dissipated 30 minutes after exposure to the simulations. Coupling this simulation with instructional coaching allowed for increased and individualized remediation for teacher candidates in terms of instruction and classroom management practices (Ade-Ojo et al., 2022, pp. 6–9).

Though simulations, mixed- and virtual-reality–based immersive environments are far less common in education than in other professions, they are becoming more popular and more formalized as educational tools for online, blended, in-person, and mobile learning (Gandolfini, 2018). (Indeed, many VR programs assign point values, give feedback, and are powered by learning analytics.) They possess several potentially powerful features for teacher training.

First, immersive AR and VR-generated environments allow for learning experiences that would otherwise be impossible, impractical, too expensive, or dangerous to do. For example, pre-service teachers studying life sciences can enter a 3D virtual representation of the COVID-19 virus and manipulate and examine spike proteins, or conduct numerous virtual dissections on the human body, or travel through the human digestive system. No other application is so visual, spatial, manipulable, or able to infinitely expand space.

Next, in all of the immersive environments described above, teachers are able to practice with virtual students across a range of ages, cultures, backgrounds, behaviors, and abilities (high- and low-incidence disabilities) prior to encountering real students in physical classrooms (Dieker et al., 2013, p. 29; González et al., 2011). Through an avatar, teachers can experience cognitive processing from the point of view of a student with autism, dyslexia, or a physical disability. Since these worlds are computer generated, the realty, context, and characters can be continuously modified and updated, and levels of ease or difficulty can be adjusted—which is harder to do with human or analog role playing.

Third, pre-service or novice teachers who enter these virtual environments must meet session objectives. If they fail to do so, they can reenter the virtual environments with a new plan and try again to teach the same students the same concept or skill after having received feedback and being given a chance to reflect on their practice. In simulated environments, instruction, and management routines, as well as content, may be repeated with an individual teacher or across several teachers using the same instructional context until the skill or routine is mastered. Thus, they allow pre-service teachers to practice teaching strategies in a virtual world before trying them online, and then practice online before carrying them out with students in a school-based practicum. This minimizes the potential harm that can be inadvertently inflicted by novice teachers learning on the job (Dieker et al., 2013, p. 29).

Fourth, like their students, teachers can visit virtual environments to view, analyze, evaluate, and create content. Teachers can recreate and reimagine existing architecture or art and use avatars to create new personae and experiences for students and themselves. And because nothing happens in virtual worlds without others, they facilitate collaboration. Immersive environments can provide opportunities for teacher collaboration with regard to ideas, strategies, resources, and rich media (Chen & Law, 2016; González et al., 2011; Yang, 2012).

Finally, in contrast to teacher preparation programs, which often focus heavily on cognition and accumulating a body of knowledge, the immersive models above are practice-based so teachers learn by doing (The Economist, 2021). VR helps to develop pre-service teachers' psychomotor and affective domains because they have immersive experiences that, though they aren't real, *feel* real (Dieker et al., 2013; Grossman et al., 2009). Integrating sensory experiences (via stimuli) with active learning produces learning that is skills-focused and long-term (Mayer, 2009; Robles, 2018, p. 9).

This is how learning to be a teacher should—but mostly does not—occur (The Economist, 2021). Perhaps the main critique of teacher pre-service preparation programs is that that they do not adequately prepare teachers for *how* to teach (Burns, in press). Through virtual, extended, and mixed reality environments, pre-service teachers experience what it feels like to be a teacher and they experience teaching itself. This affective learning, plus the practical classroom management skills they learn, can then be applied to a real classrom where pre-service teachers undergo their teaching practicum or where they go for their first teaching job, so that they feel more prepared to teach than has often been the case (Burns, in press; Grossman et al., 2009).

Immersive media, *ipso facto*, do not necessarily improve learning. However, implementing effective instructional methods *within* immersive virtual environments and contextualizing these immersive learning experiences within a lesson *can* improve learning (Makransky & Mayer, 2022). But for this to occur, some conditions must be met.

First, because of their steep learning curves, VR-powered immersive environments require significant human, technical, and financial investment (González et al., 2011). Second, immersive environments must provide a sense of "real presence," much like the difference between a pre-service teacher *reading* about behavior management versus actually *trying* to manage a group of students in a classroom (Makransky & Mayer, 2022). "Presence" involves the learner drawing upon spatial cues to perceive him/herself being located within this computer-mediated space. It also involves the ability to act and react as if the mediated environment is a plausible space and, as in a physical environment, perform professionally—integrating pedagogy, content, and technology in the role of a teacher (Gandolfini, 2018; Cummings & Bailenson, 2016; Dieker et al., 2013). Finally, reflection—both "on the action" and "in action" before, during, and after the immersive experience—is essential so student teachers can reflect on successes, misconceptions, and errors (Dieker et al., 2013).

4.4 Considerations: Multimedia for Distance Education

4.4.1 Benefits of Multimedia-based Open and Distance Education

Multimedia has long been valued as a tool for *student* learning, as opposed to *teacher* learning. Yet multimedia offers numerous potential benefits as a distance and open learning model[20] that could be part of any distance education program. These benefits are outlined here.

Provide teachers with self-study opportunities

Offline multimedia-based learning has traditionally played a prominent role in self-paced teacher learning as part of pre-service and in-service education programs. Across Sub-Saharan Africa, in Namibia, Zambia, Uganda, and the Democratic Republic of Congo, and refugee camps in Kenya, the Central African Republic, South Sudan, Nigeria and Ethiopia teachers access self-paced units of study, downloadable reading materials, glossaries, quizzes and interactive materials provided to them on CD-ROMs, DVDs, SD cards for phones, and USB drives.

In 2011, the Higher Education Commission of Pakistan revised the base qualifications for teachers, from a two-year Associate Degree in Education (ADE) to a four-year Bachelor of Science Degree by 2013. Thus, in-service teachers with an ADE degree were required to begin the process

[20] Because the computer acts as a teacher and multimedia is typically used as a self-paced, self-instructional tool, we refer to this model as open learning that may or may not form part of a distance education program.

of upgrading their qualifications.[21] For many female teachers, however, geography and cultural constraints made it impossible to travel to attend in-person professional development. More often than not, these women also lacked Internet access.

In response, USAID Pre-Service Teacher Education Project developed a "blended learning" (i.e., multimedia DVD-based) toolkit, with eight blended learning modules that included teaching early literacy; assessment; collaborative learning; and teaching primary-level science. Teachers read about an approach, watched animations explaining how to set up the approach, and analyzed an interactive classroom video example of the approach ("interactive" since the video posed reflection questions to teachers after each segment). Though there are no data on the effectiveness of this approach, the toolkits provided teachers access to training that otherwise would have been unavailable. The toolkit is presently used in three of Pakistan's Provincial Institutes for Teacher Education[22] and affiliated Colleges of Education (Sarwat Alam, personal communication, June 30, 2022).

Provide access to curriculum resources and teaching materials

Governments often have provided multimedia curriculum content to teachers who may lack access to technology, learning materials, textbooks, or who may not have the skills to develop curriculum-based lessons and materials. Between 2003–2007, as part of its National Distance Learning Program for All Rural Schools, the Chinese government distributed CD players and CD-ROMs with curriculum materials and educational content to 110,000 village classes and 380,000 rural primary schools.

China's Jiangsu Radio and Television University, in partnership with China's Central Radio and Television University, focused on the use of multimedia as a main component of its upgrading of teachers' qualifications and pedagogical competencies in English-language instruction. Findings revealed that the multimedia program helped lower the teacher attrition rate from the radio and television–based university, increased learner (i.e., teacher) satisfaction, and improved learner outcomes (Zhang & Hung, 2007).

In addition to government-provisioned multimedia, Open Educational Resources (OER), because of their open and repurposable nature, provide teachers with teaching and learning materials that they can adapt and reuse for teaching. Additionally, teachers can remix original OER to create multiple derivatives and versions (Wiley, n.d.). OER will be discussed in greater detail in *Chapter 12: Developing Content.*

Drive changes in instructional design and instruction

Across many parts of the globe, teachers often have large classes and no teaching and learning materials aside from a textbook or a chalkboard. They are forced by necessity to teach in highly traditional, lecture-based ways, while students copy notes into a notebook or onto a slate. A number of efforts have attempted to capitalize on teaching and learning materials to help teachers change instruction and learn how to teach with technology.

One such effort is Teacher Education in Sub Saharan Africa (TESSA), a consortium of the UK Open University and institutes of higher education that have teacher education programs. The consortium, through Open Learn, offers highly structured OER study units to support school-based teacher learning.

Teachers are encouraged to use the open resources in ways that meet their needs. To help teachers learn instructional design skills, materials can be shared and easily reused or customized, reflecting

[21] For more information, see https://hec.gov.pk/english/services/universities/RevisedCurricula/Documents/2011-2012/Education/ADEinService.pdf

[22] These three institutions are in Khyber Pakhtunkhwa, Sindh, and Baluchistan provinces.

local contexts and language needs, without being completely reworked. Access to technology makes design and modification, revision, and exchange of ideas easier than would otherwise be the case (F. Wolfenden, personal communication, October 14, 2022). As of 2012, almost 300,000 teachers had interacted with TESSA materials via their Sub-Saharan Africa partner institutions. The program has since expanded to India (TESS-India) (McAleavy et al., 2018, p. 35).

These OER, which include graphic organizers, *PowerPoints*, video, and audio, are indexed to national curricula of 23 countries[23] and are available in English, French, Arabic, and Kiswahili (Wolfenden et al., 2012). Until 2019, teachers and teacher educators received support and instruction to adapt these materials to their national curriculum and teach with these materials. Since 2019, many programs, such as Zambia's Education School-based Training (ZEST) program, have continued to use these multimedia materials even without the personal support (F. Wolfenden, personal communication, October 14, 2022).

Help teachers adopt learner-centered approaches with technology

Technology has a uniquely motivating effect on teachers who are generally and genuinely keen to learn how to use it (Burns, in press). The use of multimedia, combined with digital technologies, can successfully spur teachers to change teaching practices. In Yemen, EDC, in partnership with Intel Ireland, provided junior secondary math and science teachers with a suite of multimedia apps as well as intensive professional development. Teachers learned to use the apps to supplement their teaching, learned how to integrate the use of apps into project-based learning, and learned how to design lessons that integrated multimedia and project-based learning.

A well-known example illustrating the potential of multimedia to shift instruction is the OER4Schools initiative in Zambia (2009–2017) and its extension to Zimbabwe (2019). Researchers reported that teachers were more likely to use engaging pedagogical techniques such as practical and group work after participating in the program (Haßler et al., 2020; McAleavy et al., 2018; Walker et al., 2022). Lesson videos of interactive teaching in the local context were embedded in a multimedia resource. The resource also included built-in educator notes and prompts to facilitate discussion and support teacher reflection and development of their own practices (Hennessy et al., 2016).

Similar interventions that helped teachers to teach with and design learning activities involving multimedia and technology show that teachers who engage with multimedia are more likely to embrace learner-centered approaches and more likely to be rated higher on measures of constructivist approaches than are teachers who do not use multimedia (Dimock et al., 2001).

Provide teachers with a range of diverse, technology-based learning

Multimedia applications, if designed well, offer diverse and school-based professional development opportunities. Rich media can engage teachers on several cognitive levels and can address multiple ways of learning. Interactive software, such as *Geogebra* and other types of multimedia, allows teachers to learn content alongside their students and builds teachers' confidence in their content knowledge and use of technology (Wartella et al., 2016). Animations can help teachers follow procedures and processes. Simulations can engage teachers in learning experiences that might otherwise be physically or logistically impossible and/or prohibitively expensive. A good Intelligent Tutoring System (ITS) may substitute for a university tutor, assess teacher learning, and adapt content to the

[23] These are Angola, Botswana, Ethiopia, the Gambia, Ghana, Kenya, Lesotho, Liberia, Malawi, Mauritius, Mozambique, Namibia, Nigeria, Rwanda, São Tomé and Príncipe, Seychelles, Sierra Leone, South Africa, South Sudan, Swaziland, Uganda, Zambia, Zimbabwe. It should be noted that as of June 2022, there were no Portuguese-language materials, despite the inclusion of three Lusophone countries in the TESSA database.

teacher's cognitive level. And digital learning games can instill motivation to learn, thinking and problem-solving skills, enhanced content-based knowledge, skills, and behaviors, and can help teachers refine content skills or engage in game-based educational play, help with self-regulation, and increase awareness of the importance of collaboration in learning—all qualities that we would hope to see, not just in our students, but in our teachers.

Promote teacher empathy regarding how students learn

Participating in immersive, engaging, and challenging multimedia environments can help teachers see learning from the point of view of a student and understand the importance of multiple representations of information, motivation, fun, play in learning, and multimedia learning in action. Such a cognitively and affectively empathetic understanding of student learning might influence how teachers structure classroom learning opportunities. While a teacher might not have the digital tools or skills to create an online immersive environment, he or she could integrate elements of game-based learning into offline games and activities.

4.4.2 Limitations of Multimedia-based Open and Distance Learning

Despite its many potential benefits, the broad category of multimedia is not without its drawbacks. These include the following.

Heterogeneity of design

While this is a strength of multimedia, it also can result in qualitatively different learning experiences and levels of learning (i.e., lower order versus higher order). One multimedia application may be open and exploratory in its design, where the application functions as a tool for inquiry and higher-order thinking. Another may be focused on information regurgitation, in which learning is rote and passive and the multimedia application itself is merely a delivery system for fact-based, low-level thinking. This latter accusation has been leveled particularly at the "tutoring" aspects of CAI. Indeed, a lot of multimedia suffers from the "old wine in new skins" syndrome, promising critical thinking and exploration but delivering learning that is didactic and behaviorist. They may be easy to "game"—learners will rapidly repeat the same answer or blank answers to elicit the correct answer from the system (Baker et al., 2010); they promote lower-order versus higher-order thinking; or they offer "feedback" that does nothing to scaffold the metacognitive processes necessary to correct misunderstandings and arrive at a correct response.

Lack of quality assurance

A good deal of multimedia, particularly commercial educational technology products, are not assessed for quality (Van Nostrand et al., 2022). There may not be standards by which to assess quality. Most multimedia applications are not available in local languages. Digital learning games may not be culturally appropriate. Teachers may have a very difficult time using software that demands problem solving, hypothesis generation, pattern seeking, and extemporaneous thinking when they have never been asked to do so previously. Numerous games are marketed as learning tools that, though engaging, and stimulating, offer little in the way of deep content learning.

Fixed mindsets about multimedia

Multimedia, such as digital learning games or virtual reality, may be seen by administrators and policymakers as frivolous games or toys or too dystopian and "out there" to be appropriate models of teacher education. As noted earlier, Virtual Reality has long been the "next big thing" in teacher education but its actual use is minimal and suggestions about its potential effectiveness as a teacher education tool are often met with eyerolls.

The opposite also may be true: Multimedia (for example, CAI or Intelligent Tutoring Systems) may be seen as a financially attractive option for teacher professional development that can eliminate the need for human facilitators and the costs and logistics associated with any larger program of professional development. While the Artificial Intelligence that programs ITS has dramatically evolved, it still cannot perform the many critical actions that human-mediated forms of distance learning can do, such as sensing emotions, comforting a troubled learner, and offering deep encouragement.

Many types of multimedia are expensive to purchase and create

Many multimedia applications are free, while others may be quite pricey. This is particularly true for many digital games and VR and AR applications. VR and AR headsets can run from a few hundred U.S. dollars for Meta's Quest 2 VR headset (on Amazon) to $3,500 for Microsoft's least expensive Hololens 2 (Microsoft, 2022). Immersive environments, in particular, are expensive, and because they are "locked" systems, they currently are impossible to modify. However, there is more of a détente between third-party developers and proprietary systems (Warburton, 2009). For example, *Open Wonderland*[24] is an open source, Java-based kit that allows users to create their own virtual 3-D world. *OpenSim* and *Second Life* have released their code as open source. Vuforia Augmented Reality Development Kit offers free-trial versions of its platform and apps. Popular platforms such as *Unreal Engine, Discord, Panoform, Frame,* and Google *Expeditions* allow teachers and teacher educators to create augmented and virtual worlds and immersive activities, while platforms like *Roblox* allow users to play games created by other users. Further, distance education providers can create their own games (such as Escape Rooms), VR-like features and simulations, and virtual tours with simpler and less expensive digital tools such as *Genially, Articulate Storyline*, and *ThingLink.*[25]

One feature that also should take a bite out of cost is that HMD VR does not require laptops—everything takes place within the headset. However, it does require robust bandwidth, and many serious VR users invest in extra bandwidth.

Certain types of multimedia have high adoption barriers

In addition to expense, immersive environments, such as virtual worlds and simulations, possess numerous barriers to adoption. They can be disorienting, and teachers will need scaffolding and technical support, especially initially, to navigate either desktop-based VR or head mounted display VR. It may be difficult for teachers who have never before been asked to suspend disbelief, think critically or independently, or interact with avatars to do so in an environment as surreal as a virtual world. It also may be hard for teachers to interact with complex simulation software. Without on-site support and scaffolding, teachers who lack persistence will simply give up when faced with technical problems or with the open-ended nature of many immersive environments. Some immersive environments, like some digital learning games, may involve the use of avatars, tasks, and behaviors that in many cultures may be considered inappropriate. These issues, combined with the research gaps around AR and VR in in teacher training (Wyss et al., 2021) and aforementioned high costs, may work against any sort of large-scale adoption of AR or VR for teacher education.

Immersive environments can pose physical and emotional challenges for learners

This is particularly true with AR and VR. For many teachers or teacher educators, VR may range from the physically disorienting to hallucinatory. The illusions induced by movement-based VR such as flying simulations or playing a sport can be nausea inducing for some.[26] Even non-movement VR applications make tracking and navigating via hand controls or one's fingers difficult or frustrating, at least at first. Users may experience eye strain, dizziness, neck and shoulder pain and headaches. Indignities abound in the use of VR headsets. The author nearly fell out of her chair

[24] See http://openwonderland.org/

[25] For examples of digital learning games created via *ThingLink*, see: https://www.thinglink.com/scene/688406138344964096

[26] VR experiences feel so real that motion sickness has been a common side effect. This has spawned a host of accessories for VR users, such as an acupressure anti-nausea wristband for VR systems and stabilization VR headsets. See https://www.healthline.com/health/vr-motion-sickness.

and onto a coffee table making a leaping catch of a (virtual) baseball. Being the only person engaging with virtual activities wearing an HMD will undoubtedly provoke a good deal of attention, some befuddlement, and even laughter from non HMD-wearing classmates or onlookers.

Though the above issues raise questions about the viability of using virtual worlds and immersive environments for large-scale teacher professional development, the potential learning benefits of immersive environments certainly warrant exploration in some well-designed pilot or proof-of-concept programs (Warburton, 2009, p. 418).

4.5 Summary of Multimedia-based Distance Education

Figure 4.7 summarizes the role of computer-based multimedia as a distance learning tool for teacher education and lists its strengths and limitations as a mode of distance education.

Figure 4.7
Summary of Multimedia-based Distance Education

Roles in Teacher Professional Development	Strengths	Limitations
• Teachers interact with content that is provided in a number of different formats: text, audio, animation, video. • Multimedia can be used for self-paced self-study or group-based collaboration or competition. • It is typically used to expand teachers' content knowledge and understanding of processes associated with certain events. • Many types of multimedia, such as virtual reality and extended reality, are used to provide teachers with learning and experiences that would otherwise be too difficult, expensive, or dangerous. • It can be used to help teachers think like subject-area specialists (such as historians or mathematicians) to help develop content-based thinking. • Web-based, displayed on mobile devices or portable gaming systems, or stand-alone applications provide interaction with a variety of media. • Virtual worlds can be used to help teachers develop knowledge habits of mind and 21st-century skills, such as creativity and problem solving.	• Allows local content producers to create contextually genuine learning content, increasing the relevance of the training message to their audience by providing it in local language and with authentic media and graphics. • It may give teachers ideas about more interactive pedagogies and ways to address their students' varied learning styles. • Offline multimedia content makes learning available to the billions of learners at the "bottom of the pyramid." • Immersive environments allow learning by discovery, experimentation, guidance using a variety of instructional approaches, or practice and feedback. • Games, immersive environments, and multimedia applications can assess deep understanding, inquiry, or problem solving in the classroom. Teachers can use this information to make beneficial changes in instruction. • Depending on the design, it may model higher order thinking skills (problem solving and analysis), as well as 21st-century skills (collaboration, learning, and innovation skills, as well as media and information skills).	• Complex software may require both time and ongoing technology training to be effective. • Teacher-candidates/teachers who have not had practice in developing higher-order thinking skills as part of their teacher formation may be lost and unable to participate in multimedia learning without extensive professional development and ongoing support. • After some time, especially with more simple games and applications, users become bored as they exhaust all of its potential. • "Gaming the games:" Evidence shows that learners figure out how to manipulate poorly designed or simple games versus truly mastering the domain of knowledge. • Even commercially produced software may not meet basic standards around engagement, active learning, and appropriateness. • Expenses include hardware, software, robust video cards, high-speed Internet access and training. • Multimedia may be expensive, not culturally appropriate, and unavailable in a local language.

Roles in Teacher Professional Development	Strengths	Limitations
	• It may be used to teach content to students in areas where teachers' knowledge about that particular content topic is weak.	• Discrimination is a must—there is a lot of really poor educational software on the market. • Games, CD-ROMs, and other multimedia may not be aligned with teacher training standards or curriculum standards.

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