

CHAPTER 9

THEORETICAL UNDERPINNINGS

Affordances of Technology

In this chapter, we will:

- Provide the theoretical underpinnings of multiliteracies and the “digital turn” in multimodality,
- Highlight the consequences of inequitable access to computers and the internet,
- Consider some guidelines for judicious use of artificial intelligence in the classroom, and
- Lay out the research evidence for the efficacy of such access for emergent bilinguals.

In earlier chapters, we discussed the importance of building on the linguistic resources that emergent bilingual students bring to school and of choosing appropriate pedagogical and curricular approaches to support their academic growth. Throughout, we have signaled examples of applying digital technologies to classroom instruction for these purposes. In this chapter, we bring these technologies to the fore, as our world is increasingly networked and communication is increasingly digital in our working, playing, and learning lives (Castells, 2007; Cummins, Brown, & Sayers, 2007; Kleifgen & Kinzer, 2009; Leu et al., 2013). We draw together threads of increased human mobility across national borders, new digital technologies that support collaborative learning environments for multilingual speakers, and the enhancement of multimodal resources to teach emergent bilinguals. As in the other chapters, we first provide the theoretical underpinnings for technology use, including *multiliteracies*, a term we introduced in Chapter 4, and the associated approach known as *multimodality*. Next, we point out some consequences of inequitable access to digital resources in a society permeated by new information and communication technologies (ICTs). Finally, we discuss the research evidence for the benefits of such access for emergent bilinguals.

The need to provide innovative instruction for all students, especially emergent bilinguals, has never been greater. We will show that digital technologies enhance learning and achievement and, in addition, that using these tools requires new literacy skills (Kinzer, 2010), which these students are also entitled to learn. Our argument is grounded in the theoretical and empirical underpinnings discussed next.

In the mid-1990s, a group of international scholars known as the New London Group (1996; see also Cope & Kalantzis, 2000) wrote a manifesto—a “pedagogy of multiliteracies”—calling on educators to recognize and respond to the intertwining of two phenomena: the increased linguistic diversity of learners populating our classrooms and the proliferation of new resources for learning owing to the rise of digital technologies. Their call rings true even today, as more of our students come to school with different language practices and bring their diverse assumptions about the world into the classroom. Our tools for learning today are providing greater access to other forms or modes of communication, such as graphics, image, sound, and video, which can be deployed conjointly with the spoken and written modes of multiple named languages during the learning process. The central argument that the New London Group made over 30 years ago still stands: All students should benefit from a pedagogy designed to provide a future of full participation in their working, civic, and private lives.

One of the authors of this manifesto, Gunther Kress, wrote extensively about the concept of *multimodality*, which seeks to explain how people communicate not only through what is perceived as “the linguistic” but also through other communicative modes (Kress, 2003, 2010). His work on multimodality is grounded in the social-semiotic theory of M. A. K. Halliday (1978, 1993). Before we discuss the link between multimodality and digital technologies, let us examine the idea behind *social semiotics* in a little more detail. Basically, semiotics is the study of signs used as elements of “making meaning,” to use Halliday’s phrase, in communication. Signs can take the form of words, gestures, images, sounds, and so on. Briefly, social semiotics takes the position that people draw on available signs within a particular context to make meaning. In terms of linguistic signs (spoken or written), rather than thinking of language as a “thing” made up of rule-governed forms, Halliday’s approach underscores the importance of the “meaning potential” in any given communicative context because people draw on socially situated options—what he terms *semiotic resources* or *modes*—for communicating. (Notice how his approach resonates with our own shift away from focusing on *language* as a noun to *language practices*, or *languageing* as a verb, an action.) Studies on multimodality by Kress and others expand Halliday’s historical focus on the spoken and written modes by identifying and examining more closely the nonlinguistic modes that people draw on in different communicative contexts. These scholars contributed detailed analyses of the functions of these other modes; examples include Kress and van Leeuwen’s (1996) focus on images and van Leeuwen’s (1999, 2011) work on film, music/sound, and color. These deep-dive studies of individual modes then shifted to the exploration of how the different modes are *combined* to make meaning, bringing forward a multimodal approach to analysis (e.g., Jewitt, 2009; Kress, 2010; Kress & van Leeuwen, 2001; O’Halloran, 2008).

Researchers have written extensively about the importance of multimodality in education (e.g., Bezemer & Kress, 2015; Jewitt, 2002; Jewitt & Kress, 2003; Kleifgen, 2006; Kress et al., 2001; Lemke, 1998). In some ways, this is not a new idea:

Classrooms themselves are multimodal spaces filled with textbooks, worksheets, talk, body posture, and gestures; classroom walls are adorned with posters, diagrams, images, texts, and illustrations that serve to guide student learning or to display student work; teachers design and use these resources in different ways, which can in turn affect student learning differentially, as is richly illustrated in a study of high school English classrooms in the United Kingdom (Kress et al., 2005). Learning in the disciplines such as science, mathematics, and history entails the use of linguistic modes surrounded by many nonlinguistic modes such as diagrams, maps, and photographs. Often, the educational potential of nonlinguistic modes for emergent bilinguals goes unmentioned in research: In a review of 40 studies of students studying science through an additional language, Williams and Tang (2020) reexamined the function of nonlinguistic modes, which were not prominently featured in the original findings. The authors found that integrating the nonlinguistic modes in science learning improved the language learners' science discourse in these studies. Moreover, this improvement occurred especially in contexts of translanguaging, which enhanced the use of learners' linguistic modes along with nonverbal modes in the science learning environment.

Unfortunately, however, racialized emergent bilinguals from low-income communities tend to be relegated to a limited set of modalities, namely practicing discrete reading and writing skills, which often even exclude authentic and agentic opportunities for student talk and body movement in the classroom (Adair & Colegrove, 2021). A multimodal social-semiotic theory of communication helps educators think about the interrelationships among all the modes—including the linguistic modes *together* with the other modes (Kleifgen, 2019)—that may be brought to bear during any given learning situation, and which, if integrated in the classroom, can expand the learning opportunities for emergent bilinguals.

In terms of technology, which is our focus in this chapter, students who are using computers and the internet are making meaning with vast and growing numbers of semiotic resources that reach beyond the boundaries of the classroom: still and moving images, sounds and music, colors, and spoken and written language(s). Students who are engaging with one another and exploring the multimodal resources available on the computer screens before them are participating in complex forms of communication to learn. In Kress's (2003) words, they are learning with "ensembles" of modes that may differ and change depending on the context of the learning activity (p. 70). Each mode within a given ensemble contributes to the whole of meaning-making or, shall we say, to the learning of something new. As we will see, this complexity is further heightened and enhanced when the spoken and written modes that are part of these ensembles entail the use of more than one language; emergent bilinguals can exploit this complexity by using their home language practices online to scaffold their learning.

Central to this theoretical approach is human agency. People who are interacting and learning together bring diverse languages, cultures, and understandings into this complex digital environment. Kress (2010) states:

In a social-semiotic account of meaning, individuals, with their social histories, socially shaped, located in social environments, using socially made, culturally available

resources, are *agentive* and generative in sign-making and communication. (p. 54; emphasis added)

Using a multimodal social-semiotic approach to learning, educators can facilitate optimal ways to use the wide-ranging modes, including multiple language modes, that are available on the internet and other ICTs to build new knowledge (Bezemer & Kress, 2015; Jewitt & Kress, 2003). Two of the 10 authors who formed part of the New London Group (1996), William Cope and Mary Kalantzis, have recognized the concept of *translanguaging* as a major contribution to the spirit of the multiliteracies concept published in 1996. As we noted in Chapter 4, they now offer a different term, *transposition*, that takes into account the fluidity of translanguaging integrated with other meaning-making modes (Cope, Kalantzis, & Tzirides, 2024). Cope and his colleagues focus particularly on the educational context in the new media age. They illustrate how taking a multimodal view, where different modes mutually elaborate each other in the process of meaning-making, spotlights the fact that the linguistic modes of speech and text are radically different, where speech is closely aligned with sound and text aligned with image, for example. The affordances of these modes are different, and they become even more so in digitized form. Thus, the authors underscore the need to rethink theoretical discussions and pedagogical practices in the digital age: They advocate for a more expansive approach to understanding and teaching meaning-making that surpasses traditional language analysis, and they also argue that these pedagogical tools must be made available to all language teachers in support of all students.

But what happens when emergent bilinguals have little or no access to ICTs in their schools or homes? We outline some consequences next.

INEQUITABLE ACCESS TO DIGITAL TECHNOLOGIES

There is little doubt that to function in contemporary society, one must have digital competence, the ability to use and evaluate digital technologies for communication, learning, employment, and everyday life (Llomaki et al., 2016). The Organisation for Economic Co-Operation and Development (OECD, 2005) identified skilled technology use inside and outside the workplace as one of the key competencies that graduating students need to participate fully in society. Fortunately, the good news is that, in recent years, physical access to the internet, a prerequisite for gaining digital competence, has increased for many households. According to the Pew Research Center (2024), 95% of adults report using the internet. Nevertheless, lower income groups tend not to have broadband at home. Overcoming barriers to connectivity—physical access to the internet—is only a first step to digital competence according to van Dijk and colleagues (van Dijk, 2017; van Deursen & van Dijk, 2018). Other levels of access beyond *connectivity* include access to *devices* (computers, smartphones, tablets, etc.) and, crucially, access to *digital skills*, that is, receiving instruction on how to retrieve and evaluate information, conduct research, communicate, and create content on these devices.

Among the indicators of educational access (such as school funding, books, and highly qualified teachers and curricula) is computer use. Yet, according to a study conducted by the National Center for Education Statistics (NCES, 2018), poor and minoritized youth between the ages of 5 and 17 have less access to computer technologies than do white affluent youth. Similarly, a Pew report on digital technology use (Poushter, 2016) found that people around the world, including the United States, who have lower incomes and less education are less likely to gain access to the internet or to own smartphones than those with higher incomes and more education. In the United States, state education departments, recognizing the need to incorporate digital technologies into curricula for all students, including emergent bilinguals, are revising standards to foster the effective use of these tools. According to the State Educational Technology Directors Association (SETDA), 32 of the 50 states have developed state-wide digital education plans to date (Gifford, 2023).

Despite some gains in access to connectivity, devices, and instruction in the use of ICTs for learning, Linda Darling Hammond (2024) presents a bleak summary of what she calls an “anatomy of inequality” still present in the education system, which begins with poverty in a community, leading to inadequate allocation of school resources, fewer qualified teachers, unequal access to a high-quality curriculum, and a dysfunctional school. To address these issues, Darling-Hammond asserts that schools must be reinvented so that they are, among other things, “culturally and linguistically connected and sustaining . . . and equitable in the opportunities provided and outcomes achieved” (p. 1). The Computer Science Education Justice Collective has argued that in recent years the teaching capacity for computer science education has increased. Yet, the needs of diverse students for relevant computer science education remain unmet (Computer Science Education Justice Collective, in press).

Differential access to ICTs can exacerbate the problem of educational inequities for underserved students, many of whom are emergent bilinguals. With proactive help from policymakers and educators, emergent bilingual students, too, can benefit from appropriate uses of technology for learning. We now turn to empirical studies showing examples of ways in which these digital tools, when used judiciously and focused on these students’ needs as well as the funds of knowledge they bring into the classroom, can promote educational attainment.

HOW DIGITAL TECHNOLOGIES CAN BENEFIT EMERGENT BILINGUALS

The research is clear. New digital technologies, if made available and when used thoughtfully, can enhance student learning. The emphasis on multimodality in educating emergent bilinguals is very much attuned to our conceptualization of translanguaging (see Chapters 4 and 5), which is, as we have said, an agentive process by which students select and suppress the features of their unitary language system to communicate and learn. A verbal repertoire forms part of a broader communicative repertoire (Rymes, 2014) that includes embodied modes such as gestures, facial expressions, eye movements, posture. Sometimes, certain modes in

this larger communicative repertoire become more prevalent than at other times. For example, the Deaf community employs sign language accompanied by facial expressions and body posture in order to make meaning in social interaction. Emergent bilinguals select those features from their complex spoken language repertoire that, depending on the context, are best suited for communicating with one or more interlocutors. In both cases, participants may draw on additional modal resources in the surrounding environment during their interactions. In today’s classrooms, students increasingly enjoy access to an expanded multimodal system facilitated by technology to select appropriate modes—linguistic, visual, and others—to collaborate and learn. Before we describe research showing how the affordances of ICTs can support emergent bilingual learners, we pause here to discuss a digital resource that has come onto the educational scene where interaction is not between human participants but between a human and a machine that can write and generate other meaning-making modes: artificial intelligence (AI). This resource brings with it some problems along with promises, and we emphasize again the importance of appropriate, thoughtful, judicious educational use of AI and other ICTs.¹

Generative Artificial Intelligence (Generative AI)

We use the umbrella term *generative artificial intelligence* (generative AI) to refer to a type of technology that can create novel content, including text, talk, images, audio, and code (U.S. Department of Education, Office of Education Technology (2023)). We focus on text-based generative AI, in which a *chatbot*—a computer program that simulates human spoken or written conversation—receives a *prompt* (a question or instructions) from a user like a teacher or student and then draws on a *large language model* (LLM)—where vast pools of data reside—to produce a response. The quality of the output depends on (1) the prompt that a user submits to a chatbot and (2) the training data that an LLM has received. The following is an overview of the affordances and challenges that generative AI presents for emergent bilinguals and for education, broadly conceived, along with some suggestions for ameliorating negative impact.

Large language models. LLMs are a specialized type of AI that is pretrained on a massive store of data extracted from the internet as well as from books, images, and other sources; most of the training data are composed of digitized texts. LLMs can comb through more bodies of digitized texts and do so more quickly than any human can. These binary computing machines

have “read” almost every word ever published. This because almost every published word has by now been digitized and in multiple languages—an estimated five billion words. After statistical analysis of this corpus, the AI can now predict the probability of the next word after any given word. (Cope & Kalantzis, 2023, p. 7)

However, just as the internet itself contains false along with factual material, these LLM data sets can contain “hallucinations”—erroneous or misleading

information; the term also encompasses biased material, such as the dominance of content in English representing mostly Western perspectives (Zhuo et al., 2023). Thus, falsehoods and *prejudicial* (Cheuk, 2021) data stored in the LLM can show up in the text produced by the chatbot in answer to a prompt.

Chatbots and prompts. Chatbots such as ChatGPT have the capability to produce original and well-designed responses, reports, or other genres of texts in answering user prompts, and they can do so rapidly. Prompts are ways of communicating with AI by entering an instruction or question into the system in order to elicit a specific result. But chatbots cannot think; they are not capable of evaluating the source material for falsehoods or bias. Thus, designing or “engineering” more sophisticated prompts is an important skill for teachers and students to acquire. For example, the prompt should set a context and give specific instructions regarding what the chatbot may select from the LLM to generate. A key point is that these models do not understand language; rather, the texts that are generated by chatbots are based purely on statistical analysis of patterns in characters (Cope & Kalantzis, 2023).

Student cheating with AI. Many educators have concerns that their students might use ChatGPT or other chatbots to cheat by submitting the output as their own original writing. Teachers may find it difficult to distinguish AI-generated text from student writing. There is no way to prevent the possibility of cheating, aside from perhaps requiring in-class handwritten submissions. Most scholars say that cheating is not the most serious drawback to the use of these tools. Instead, they recommend that educators guide students in (1) learning about how generative AI works and (2) learning how to critically assess these tools’ strengths and weaknesses. (See, for example, Roschelle et al.’s [2020] expert panel report from the U.S. Department of Education’s Office of Educational Technology.)

Kalantzis and Cope (2024, pp. 26–28) call for a “cyber-social literacy learning” that includes improvements in areas such as detailed prompt engineering, computer applications that sharpen the accuracy of generative AI models with facts drawn from sources external to the chatbot, and the overarching need to attend to “education justice for all.”

With this background and caveats around AI, we can now examine some specific applications of ICTs to the education of emergent bilinguals, including the educational application of chatbot-prompted LLMs with novel affordances such as digital translation, speech recognition tools, and intelligent language tutors.

Empirical research has demonstrated the positive outcomes of implementing computer-based technologies in classrooms and beyond, including studies showing the learning benefits for emergent bilinguals (Darling-Aduana & Heinrich, 2018; Vogel et al., 2020). In addition, the WIDA Consortium (2014) has issued a brief focusing on the use of technology in classrooms with emergent bilinguals.

When thoughtfully used, ICTs as learning tools offer a variety of affordances: *accessibility*, *retrievability*, *interactivity* (Kleifgen et al., 2014),² and *creativity*. Although these affordances are tightly intertwined, and they overlap to produce a positive effect on learning, we separate them for illustrative purposes in our discussion, with examples from research findings.

Accessibility

Students need access to information so that they can become both consumers and producers of knowledge. The internet is a potential virtual library holding a massive and growing global archive of information for students to explore without the limitations of distance or time. With the internet, learning becomes ubiquitous. As Leu and his colleagues (2013) put it, the internet “has become this generation’s defining technology for literacy in our global community” (p. 1159). This virtual library provides ready-to-hand multimodal content—video and sound recordings, maps, graphs, photographs, and of course, texts. Web-based texts themselves are almost entirely embedded with other semiotic resources and/or hyperlinks that take students to additional related content.

In schools where low-income students receive one-to-one access to computers and the internet, it has been found that these students take advantage of using the technology at school because their access elsewhere is limited; their increased access has resulted in achievement gains (Darling-Hammond, Zieleski, & Goldman, 2014). A two-year longitudinal study by Grimes and Warschauer (2008), where low-income students in three diverse schools participated in a laptop program, found that the students in laptop classrooms showed positive test scores beginning in the second year of the program, and that they used laptops at school and home to write. Results showed that they were inclined to write and revise more, using multiple modes and a wide variety of genres, including project-based reports.

Students with access to mobile devices have the added benefit of ubiquitous use. Kukulka-Hulme and Wible (2008) provide examples of users learning “in the wild” with mobile phones in a range of settings, such as the transmission of video, audio, and images by undergraduates doing geology fieldwork; the building of a learning experience with photos, text, and voice in a museum; digital collaboration among students in class with students taking a tour in the outdoors; and student creation and sharing of learning games with mobile phones.

Immigrant families who have access to smartphones are using them in various ways to adjust to their new circumstances with the support of the home language and other meaning-making modes. In an ethnographic study carried out by McCaffrey and Taha (2019), Middle Eastern refugee families settling in New Jersey were observed using tools such as Google Translate, WhatsApp, and English-to-Arabic machine translation on their smartphones to negotiate resettlement issues through translanguaging and other communicative modes such as emojis, videos, and photos. Their children also used smartphones during ESL classes at school to exchange knowledge in multiple peer languages. However, the families’ concerted efforts to make use of these tools to help them adjust to life in a new country did not always ensure helpful responses, leading the authors to point to the need for educators and other service providers to recognize that refugees are accessing smartphones and machine translation apps and recommending that more be done to proactively promote intercultural/translingual contact with newcomers to the United States.

Many languages and different ways of using language live on the internet. We argue that emergent bilinguals can draw on this home language resource and use today's internet to strengthen their academic English practices along with their home language practices. For example, they can improve their understanding of a text written in English by accessing translation tools on the internet to receive a translation in their home language. The advent of machine translation (MT) such as Google Translate and similar tools has brought new opportunities for student learning. For example, in a case study of an immigrant student from China, authors Vogel, Ascenzi-Moreno, and García (2018) show that when an emergent bilingual is given access to machine translation tools in a classroom where the teacher applies translanguaging strategies, the student benefits from an ensemble of modes for learning. The student in this study participated in translanguaging interactions with his classmates for better understanding of the assigned writing task, then used resources on the internet such as images and texts in Chinese for note-taking, the Google Translate tool for rendering his Chinese notes into English, and the online writing software to complete revisions of his Chinese and English responses.

The benefit of gaining access to the home language in a multimodal context was also shown in a study by Kleifgen, Lira, and Ronan (2014), which was part of a 4-year web-based intervention project funded by a federal grant to support emergent bilingual adolescents' learning. Kleifgen and her colleagues studied a bilingual science classroom of Spanish-speaking immigrants, who were just beginning to learn English. The students used a web-based research and writing system to study complex concepts about evolution.³ The system contained a library of historical and scientific resources related to evolution, including bilingual texts, maps, labeled diagrams, images, and videos, all curated by the projects' researchers and school partners to ensure historical and scientific accuracy. Students could select from an extensive number of documents to study the key concepts in Spanish as well as English. For example, students had online access to a description of fossils in both languages [*Los fósiles proporcionan un registro de organismos que vivieron en el pasado . . . / Fossils provide a record of organisms that lived in the past . . .*].

Videos included in the digital library were used by participating teachers to introduce new instructional units. If the videos were recorded in English, Spanish subtitles were provided, as seen in Figure 9.1, a screenshot from an animated music video of Darwin's voyage to the Galápagos Islands (Borlase & Haines, n.d.). The system's collection of digital images and diagrams was gathered from the internet, scanned from science texts, or designed by the teachers. These were often accompanied by captions in Spanish to provide a mutually elaborating ensemble of information for understanding.

Over the course of six instructional sessions, students used the system's pop-up function to open a notepad and one or more resources on the screen to examine them and take notes. They used the accumulated notes to develop an essay in response to a writing prompt. Records of their notes and essay drafts showed

Figure 9.1. Mr. Darwin's Music Video With Subtitles in Spanish



that they drew on ensembles of modes for learning—images, videos, and texts in both Spanish and English—as they gained content knowledge about evolution and put their ideas into writing. Students were able to construct an argument supported by evidence and examples, thus developing foundations for academic literacy.

When a classroom teacher opens the door to translanguaging strategies and provides *access* to online tools for exploring resources in the home language, students have access to new forms of knowledge. In this way, students are able to read about topics in subjects like science, history, or language arts, which can aid their understanding of what is being studied in class. Teachers, too, can use the internet to provide home language versions of subject-matter content to support student learning. As noted throughout this book, research shows that learning subject-matter content using home language practices while adding English practices to the repertoire facilitates academic achievement. In short, by combining *access* to home language practices with other modes available online, students can go through this content-learning process efficiently and at the same time develop their bilingual language use.

Retrievability

Closely related to the accessibility of content on the internet is the notion of *retrievability* of that same content. Using the internet, emergent bilingual students can easily return to materials multiple times to examine them for deeper understanding. In the study described previously, Kleifgen et al. (2014) also analyzed log files, which captured students' digital behaviors in the web-based system, including which items in the library they chose to open and how often they returned to any given item. The authors found that the students returned often to the multimodal curricular resources and that some resources were viewed repeatedly, a signal that students deemed them important enough to review in order to gain information for note-taking and writing.

Similarly, Ronan (2014, 2017) studied student behaviors using the same web-based system in a different school. She describes how four students in a social studies class accessed a variety of multimodal resources, many of them more than once, to learn about and take notes on the civil rights movement. The digital library held 31 resources associated with this instructional unit. In her analysis of students' choices about which kinds of resources they selected from among these digitized materials—texts, video and audio recordings, photographs, maps—Ronan considered the overall counts recorded in the log files indicating how often they clicked on the resources for a pop-up view on the computer screen. In addition, she analyzed the corresponding transcripts of students' talk, writing, gestures, and their interactions with the online space to determine precisely how the students incorporated a given multimodal resource from the internet into their talk and notes. Each of the four emergent bilinguals, who represented different English language proficiency levels, took distinct paths to initial examination and subsequent retrieval of the online materials based on their interests and language choices. Ronan's (2017) work, showing students' agency as they varied in online selection and *retrieval* of bilingual materials along with other semiotic resources, provides a strong argument that “unlike traditional textbooks that impose a sequential structure upon a reader, open-ended digital spaces . . . allow students to direct their own learning” (p. 102).

Other integrated online environments that focus on language learners' writing allow students to review their developing essays as well as their teachers' feedback. For example, David Wible and his colleagues (Wible et al., 2001, 2003) describe the *retrievability* of archived essays and comments in a writing platform called IWILL (Intelligent Web-based interactive Language Learning). Students using this system, who were Chinese speakers learning to write in English, were able to retrieve and review their collection of compositions, conduct pinpoint searches of their persistent writing difficulties, and search for their teachers' comments to find patterns of difficulty; teachers also could search and retrieve students' writing and provide targeted instruction in frequent problem areas, such as word choice, sentence fragments, subject-verb agreement, and so on.

In sum, with digital technologies, students can construct, retrieve, and review texts in one or more languages as a way to comparatively analyze the material, thus

attaining a clearer understanding of concepts and improving their written language production.

Interactivity

We approach the examination of the affordance of *interactivity* by focusing on two aspects: student interactions with digital tools and interactions among students while using the tools.

Interacting with digital tools. Studies have shown that underserved students benefit academically from highly interactive activities on computer-based tools. This was one of the key findings in a literature review conducted by Zielezinski and Darling-Hammond (2016); their review of more than 50 studies confirms that when students are given the opportunity to collect and analyze data online or to engage with multiple resources such as simulations and video instruction modules to gain understanding of concepts, their learning is enhanced. One of the studies cited in their review (Bos, 2007) shows that an experimental group of 96 low-achieving high school students' mathematical achievement improved significantly when they studied quadratic equations using the Texas Instruments InterActive software lessons to manipulate interactive graphs and tables; this software was assessed as high in cognitive and mathematical fidelity (Bos, 2009). The struggling students' achievement scores were greater than those of the student control group who studied the same material in conventional classes consisting of lecture, notes, and drill and practice.

In terms of highly interactive AI applications in pedagogy, chatbots are popular for skill building, particularly when used as a conversational partner for students learning an additional language. Huang, Hew, and Fryer (2022) reviewed 25 such studies that showed a number of advantages to interacting with an AI agent on a chatbot in the target language: the nonhuman conversational partner is available around the clock for continuous practice and is adaptable to the learners' interest and learning level. Further, language learners can easily access the chatbot using their computer, tablet, or mobile phone. Besides conversational practice on specific scenarios like asking for directions or making reservations, users engage in simulations and pose grammatical, vocabulary, or other language-related questions. More advanced learners may ask academic questions such as procedures for developing a research question or a literature review. Applications for younger children are also in development, as in the integration of multiple AI models to design an embodied AI partner for shared storytelling that offers the potential of promoting early narrative skills (Li & Xu, 2023). However, it is important to note the need to develop regulatory mechanisms that take into account young children's learning and privacy needs before making available AI-supported software.

Cope and Kalantzis (2013) describe a robust web-based learning and writing platform, Scholar, developed at the University of Illinois and designed for fourth-grade level and above. They show how this digital space affords learning transformations or “openings” such as ubiquitous access to the system from any device in or out of school, student knowledge production using multiple modes, and interactive

collaboration with and feedback from teachers and peers. They also stress that the system occasions another pedagogical opening: “differentiated” learning, which is based on individual students’ developing understandings and requirements. This feature is particularly important for low-income students, including many minoritized emergent bilinguals, who may not have had equitable educational opportunities in school or internet connectivity at home; with the Scholar learning environment in their classrooms, they can work at their own pace, receive individualized teacher support, and find their own writing voices. More recently, to supplement the collaborative feedback given by teachers and peers on students’ multimodal compositions, the authors and their research colleagues developed an app called CGMap to be used within the Scholar platform, which moderates the responses given by OpenAI’s GPT through, for example, prompt engineering and the provision of additional text-based resources that have been vetted for trustworthiness. Students can now revise and resubmit their work based on *interactions* with both human and AI-based reviews (Cope & Kalantzis, 2024; Tzirides et al., 2023).

The work of MIT’s Michel DeGraff (2013) and his colleagues demonstrates that putting into students’ hands powerful *interactive* software translated into Haitian Creole (Kreyòl) for engaging in scientific experiments has the potential to positively impact learning in the entire country of Haiti. The MIT–Haiti Initiative began working in 2010, first to translate and design digital tools alongside non-digital materials for active learning in mathematics, physics, biology, chemistry, and biochemistry in the home language, and second to conduct workshops and publish guides for teachers of high school and university students on ways to use these tools and materials effectively in their classrooms (DeGraff & Stump, 2018; Miller, 2016). Examples of the highly interactive science software include StarGenetics, which simulates genetics experiments with yeast, fruit flies, and Mendel’s peas; PhET, which simulates physics experiments in density, electromagnets, and gas properties; and Mathlets, for learning about differential equations and complex arithmetic (MIT–Haiti Initiative, n.d.). Supporting teachers in their adoption of a discovery approach to learning and their comfort with digital tools in the classroom was crucial to the success of this work. Because the country is suffering extreme impoverishment and strife due to recent political turmoil and gang violence, the MIT–Haiti Initiative has been forced to move all of its efforts online. Fortunately, the digital platform now provides a library of instructional materials in Kreyòl for teachers of all disciplines and grade levels, including a series of active-learning guides for physics, chemistry, and biology.

While currently the Haitian people are experiencing political instability and insecurity, historically, they also have suffered impoverishment and injustice due to the postcolonial exclusion of the home language from the nation’s classrooms, thus depriving Kreyòl-speaking learners of an equitable education (DeGraff, 2020). The MIT–Haiti Initiative is built on a framework that accounts for the learner’s language and the school’s capacity to deliver high-quality instruction using digital tools for learning.

The continued success of this support depends not only on an amelioration of political instability but also on respecting a 1982 language-education policy (the

Bernard Reform) that designated Kreyòl rather than the colonial language, French, as the language of instruction. The Bernard Reform was meant to benefit students as well as teachers, most of whom do not speak French. Yet, over time, the Ministry of Education began to promote “early transition” from Kreyòl back to French as the language of instruction, thus negatively affecting the majority of students whose home language is Kreyòl. Fortunately, the current Minister of Education is making efforts to return Kreyòl to its place as the main language of instruction at all grade levels (DeGraff, Frager, & Miller, 2022). It will take such decolonizing work to reintegrate the *home language practices* of Haitians with *technology* and a *proven instructional approach* to achieve positive attitudinal changes in pedagogy for participating teachers and students in Haiti. (For more examples of decolonial efforts to challenge linguistic domination in education both in Haiti and beyond, see DeGraff, in preparation.)

It is essential to underscore the fact that not all software claiming to be interactive is associated with positive academic outcomes. Studies have shown that when “programmed instruction” tools such as drill and practice activities for rote learning are the only digital options offered to students from low socioeconomic status backgrounds, their test scores are negatively affected (Warschauer & Matuchniak, 2010; Wenglinsky, 2005). Well-designed interactive programs for complex learning must also be available to “allow students to see and explore concepts from different angles using a variety of representations” (Darling-Hammond, Zielezinski, & Goldman, 2014, p. 7).

Interactions among learners with and through technology. Interactivity includes not only an individual’s interaction with engaging software but also students’ conjoint meaning-making and design. More research is demonstrating the educational value of students’ collaborative interactions while using technology. For example, Ronan’s (2014) study of students in a social studies class documents the collaboration among learners as they participated in a classroom activity while engaging with web-based multimodal materials to accomplish an online writing task. Multimodal transcripts were constructed and analyzed to illustrate student-pair interactions as they shared a common space on the computer screen. During this activity, the students conjointly examined online visual and textual resources, used gesture along with talk in two languages, and along the way applied these resources to construct a written note. The analysis uncovered the process of transformation of a student’s writing while engaging with different modalities for examination, discussion, and note-taking. Ronan’s findings help us “(understand) writing as a multimodal/multilingual, *socially interactive practice*” (2014, p. 247; emphasis added).

Besides collaboration among users as they are working in pairs or small groups on web-based activities, another setting in which technology enhances interactivity is through users’ collaborations that occur almost entirely online. For example, online collaborative inquiry that leads to culminating projects can take place between classrooms located in different regions of the world. Project-based learning (PBL), said to originate in the work of John Dewey (1938), was first adopted at the turn of the century by classroom teachers to engage students in collaborative investigations around authentic problems and develop projects or presentations to address them (Thomas, 2000). Research has shown that when the PBL approach is integrated

into digital environments that are thoughtfully designed and with teachers who receive professional development and support for using these alternative spaces for learning, emergent bilinguals can thrive academically (Condliffe et al., 2016).

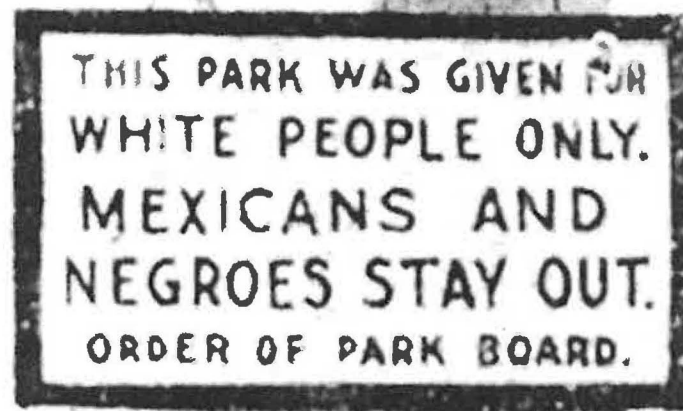
Teachers have reported that using collaborative online PBL enhances their instructional strategies for English learners. In a collective case study, Foulger and Jimenez-Silva (2007) describe how 14 classroom teachers received technology training and sustained support from a professional developer to implement project-based activities that involved writing. One of the teachers joined a global learning group called the International Education and Resource Network (iEARN)⁴ so that her class could participate in an online exchange with students in a school outside the United States. In selecting iEARN, the teacher had the benefit of a robust digital learning space with a long history of teacher-led interchanges. iEARN began in 1988 with a telecommunications project between teachers and students in New York State and Moscow and soon expanded in 1990 to nine countries. Since then, more than 140 countries have been involved in more than 150 international collaborative projects online in English and in 29 other languages. Its online platform allows teachers to connect with other teachers and their students around the world to *interact* with one another and to collaborate on meaningful projects and make contributions to local and/or global communities.

In another iEARN online project, which involved U.S. and Middle East and North African (MENA) classrooms, analyses were carried out of the online social interactions among teachers in iEARN's development workshops as well as the follow-up interactions between their students, who were collaborating on projects across languages and cultures. The findings indicated that participants—many of whom were emergent bilingual English learners from Yemen—through their online *interactions* gained ground in intercultural understanding, learned about different life worlds, and developed their communicative and technology skills in the online spaces (Kleifgen, 2017a, 2017b).

Creativity

To examine the notion of creativity as an affordance, we turn again to the work of Gunther Kress, who first introduced the concept of *design* for education in the early 1990s. For Kress, design implies that both teachers and learners exercise agency and freedom to become *creative* in their academic work. Arguing for a pedagogy of creativity, agency, and change in the curriculum, he states: "Curriculum is a design for the future" because such a curriculum has the potential to shape individuals' positive participation in society (Kress, 2000b, p. 161; see also Kress, 2000a). Design is also a way to demonstrate individual learners' agency, interests, and freedom to become creative in their academic pursuits "through the design of messages with the resources available to them in specific situations" (Kress, 2010, p. 23; see also Kress, 2003). In using the term *messages*, Kress is referring to "making" or "producing" new forms of content in today's digital age by assembling the meaning-making resources available to students in many modes. More than ever, learning is about drawing on multimodal resources to design something new.

Figure 9.2. Image of a Park Sign in the Segregationist South, Barring People of Color From Entry



Creativity occasioned by the support of technology is a process of design in environments that can range from the design of the smallest fragment of text to the construction of more extended multimodal discourse. We learn how a short note begins to be created in Ronan's (2015) work. She carried out a fine-grained analysis of two emergent bilinguals examining a multimodal resource in the digital library of a web-based system in order to take notes on the system's digital notepads. During a class lesson on the history of segregation in the United States, the two students collaboratively discuss and come to an interpretation of a historical photograph from the segregationist South showing a park sign barring people of color from entry (Figure 9.2).

Both students begin to take their own notes describing the photograph. At one point during their discussion and note-taking, one student asks her classmate in Spanish what she should write next. He suggests a reason for the discriminatory order posted on the sign: "*Porque ¿ellos son diferentes razas?*" [Because they are different races?]. She transforms the message written in English on the image along with her classmate's suggestion in spoken Spanish into a new written note in her developing English:

white people only (negros and Mexican) out. i think the white people not like that peoples of Mexican and negros because they different countrys and different color of skin.

The student, in this unfolding creative process of interaction with a peer and drawing on and reinterpreting multiple modes—including a multimodal image and spoken and written language in Spanish and English—has transformed those resources and begun her design of a new text in written English.

Another study (Pierson, Clark, & Brady, 2021) illustrates the student creation of complex multimodal scientific artifacts. Groups of students in a sixth-grade STEM class were invited to leverage their translanguaging practices—linguistic modes—while designing different types of scientific models to represent ecosystems by combining a broad range of additional modes for learning (diagrams, physical structures, images, gestures). In varying ways, the linguistic modes conjoined with other modes provided opportunities for communicative interaction and design. For example, students discussed the advantages of the more complex and dynamic computational model over the flat, diagrammatic model. Throughout the unit, students demonstrated their *creative* design of different types of multimodal scientific models—computational, diagrammatic, and physical.

Studies give evidence that, when struggling students are challenged to engage in their own content creation using new media, they are more likely to do well on competency tests. In one such study, so-called at-risk students who were designing projects in technology-rich classrooms, compared with students who were on level but not using these tools, outperformed their peers in state-mandated exams (Maninger, 2006). Maninger's research on ninth-grade English classrooms provides illustrations of teachers guiding students as they produced blogs about the literature they were studying, used online software to compose assigned papers, and created multimodal webpages for their projects.

Other studies show the benefits when underserved minoritized students are presented with the opportunity to engage in *creative* digital storytelling. Hull and Nelson (2005) examine one young man's multimodal composition, an ensemble of modes—language, image, and music—to tell an autobiographical story called "Lyfe-N-Rhyme." The author developed his digital story at a community technology center in an urban setting where many youths have little or no access to digital tools at school or at home. The researchers' detailed analysis of a digital artifact focuses on how the *semiotic relationships across the modes* progressively elaborate one another and eventually create a new form of meaning where the whole is greater than the sum of its parts. Nevertheless, as Iedema (2003) points out, studies of "finished" designs like these demonstrate "the complexity of texts or representations as they are, and less frequently how it is that such constructs [are elaborated]" (p. 30; see also Kleifgen, 2013).

Whereas Hull and Nelson's (2005) "Lyfe-N-Rhyme" analysis is a case study of a finished product, the work by Angay-Crowder, Choi, and Yi (2013) offers a play-by-play description of how teachers can open up opportunities for their emergent bilinguals' *creative storytelling*. They provide a blueprint of lessons grounded in the New London Group's theory of pedagogy and lay out in detail the process by which 12 middle school students, all children of immigrants, were instructed in the basics of digital storytelling and in strategies for constructing a story. Ten of the students came from Spanish-speaking homes, one spoke limited Bengali, and one spoke Tagalog. They were encouraged to consult with one another and with adults in their communities to verify their narratives as well as to explore their multiple languages and literacies in the process of applying both linguistic and other semiotic

modes to their stories. The students were also taught how to use the storytelling software, and they were guided in how to assess and select the different modes in order for their stories to have greater effect. The study demonstrates the importance of providing specific guidance and encouragement to emergent bilinguals to unleash their creativity throughout the process.

In Marshall and Toohey's (2010) study, Punjabi Sikh fourth- and fifth-grade students in Canada participated in a multimedia intergenerational stories project. The students took home MP3 players and recorded interviews with their grandparents in Punjabi, Malay, and Hindi about what it was like growing up in India. The students translated these spoken interviews into written English and produced the text on computers, leaving space for their illustrations. They then decided to translate their written work into the grandparents' home language (with the help of the grandparents or other adults who were literate in the language) so that they would have bilingual texts. Finally, they recorded their readings of the stories in English and Punjabi; the recordings were put on compact discs to accompany the books. In short, the students used multiple modes over time, both online and off, to complete their *creative work*.

Increasingly, learning is about drawing on multimodal resources to design something new, as these studies illustrating the affordances of creativity have shown. Although most of the examples we have given describe digital storytelling, other spaces on the internet are being used by young people for creative work. In a Pew internet survey, over half of the adolescents surveyed report that they have created web content (Lenhart & Madden, 2005). Further, emergent bilinguals can create as they learn computer science skills, as reported in a study of one sixth-grade classroom where students used translanguaging as they integrated computer code into their language arts projects (Ascenzi-Moreno, Güilamo, & Vogel, 2020). (For more, see the PiLa-CS project described later on in this chapter.) Young people today are also exploring wikis, video production, games, virtual worlds, and especially social media with YouTube, TikTok, Instagram, and Snapchat surpassing Facebook in daily use as reported by Pew Research Center (Vogels, Gelles-Watnick, & Massarat, 2022). And they are self-publishing zines with original or copied texts and images used in new ways. All of these digital spaces make use of multimodal resources, including multiple spoken and written languages.⁵

Taken together, the affordances for learning that new digital technologies can provide—*accessibility, retrievability, interactivity, and creativity*—demonstrate the potential that these new learning environments have for the equitable education of emergent bilinguals.

RESOURCING EMERGENT BILINGUALS' CLASSROOMS

We have argued that emergent bilinguals can benefit academically from high-quality digital tools and from teachers who have preparation, commitment, and experience in using these tools in their schools and classrooms. We know theoretically

and empirically that new media technologies are good for emergent bilinguals. So, what can we do to make this happen? Here, we refer again to the four affordances described in this chapter to address this question.

First, students need *access* to digital tools in their schools. Schools require the necessary infrastructure—servers, storage, and bandwidth—for fast and reliable connectivity and to avoid the frustration of breakdowns. We know that one-to-one *access*, one device per student, is beneficial for emergent bilinguals. This is especially the case if they do not have *access* to computers or other devices at home; they need more opportunities at school to *retrieve* online materials for study, note-taking, review, and the production of new knowledge artifacts.

Second, web-based and other software materials that are well-designed and *interactive* must be made available to students. Software designed for rote learning should not be the menu of options for emergent bilinguals; technologies designed for complex and collaborative learning-in-*interaction* must be part of the digital curriculum.

Third, teachers are students' best advocates in obtaining sustained and efficacious *access* to digital technologies. Students will learn appropriate and *creative* uses of new media with the guidance of teachers who are well prepared to integrate technology into their teaching. This means that teachers must be given the opportunity to explore the scholarship on multimodality, to consider the affordances and limitations of ICTs, including AI technology, and to experiment with implementation of multimodal learning using digital resources so that they can support students' *creative* designs.

In short, ICTs for learning must be intelligently designed and tested, schools must be supplied with adequate technical infrastructure, and educators must be given the professional preparation and ongoing support to be students' guides in these alternative learning spaces. One project that takes into account these requirements illustrates what can be done to support emergent bilinguals' literacy and educational attainment: The project, Participating in Literacies and Computer Science (PiLa-CS; <https://www.pila-cs.org/our-approach>) has been working with teachers specifically to support emergent bilinguals and all multilingual students in computing education. The PiLa-CS approach builds and sustains the language practices, identities, and communities of multilingual learners by rejecting deficit-based framings of these students (Vogel et al., 2020).

In terms of multimodal resources, the embodied modes and those in the environment (visual, audio, etc.) are not separate scaffolds for developing the spoken and written modes; instead, they are an essential part of all the meaning-making resources at emergent bilingual students' disposal (Grapin, 2019; Kleifgen & Kinzer, 2009). Foregrounding multimodality can transform educators' conceptions of how to leverage the students' meaning-making potential beyond accessing spoken and written linguistic modes alone. Students can draw on an ecology of modes, including linguistic—spoken and written—in the home language and the emergent language, embodied modes such as gesture and facial expressions, and modes in the physical environment and through ICT. But to draw on them creatively and naturally, educators must provide an accessible and enabling environment for learning.

EDUCATING EMERGENT BILINGUALS: THE IMPORTANT ROLE OF TECHNOLOGY

In this chapter, we have addressed the important role that digital technology has in the education of emergent bilinguals. Many studies like those reported in this chapter, which are based on multiliteracies pedagogy and the more recent thinking in social semiotics about multimodality, offer ideas for classroom instruction with technology—including the potential of AI-supported tools—that is engaging and meaningful for emergent bilingual students. The four affordances we discussed can serve as guidelines as teachers and other adults in students' lives provide motivating and educative digital materials and activities for students. Other excellent resources that suggest sensible technology implementation are available: Teachers can benefit from ideas in Cecilia Magadán's (2015, 2021) volumes (written in Spanish), which offer theoretically based, empirically demonstrated, and pedagogically effective ways of integrating technology into the classroom. Bruce, Bishop, and Budhathoki's (2014) work describes examples from a wide variety of settings that show how students use new media to support other people in their communities. A most important teacher resource to advance educational equity in computer science is the open-source textbook published by the Computer Science Education Justice Collective (in press). Written in clear language, this guide is important for any teacher who wants to implement equitable and relevant computer science instruction for diverse students taking into account issues of race, language, and ability. We conclude this chapter by calling upon leaders and school administrators to properly resource schools, classrooms, and communities with technologies for optimal learning in our increasingly diverse, digitized, and globalized world. But we also call upon educators to consider multiple modes of communication as part of students' meaning-making capacity and not as a simple scaffold. In particular, we call for a transformation of the *incomplete ways* in which schools often view emergent bilinguals' semiotic repertoire. Too often, "schooling takes place in a linguistic and digital straitjacket" (Kleifgen, 2022, p. 65). Schools many times consider only what emergent bilinguals are *missing*—English—instead of all the language features and practices that make up their existing language repertoire. When they leverage them, they often do so only as scaffolds. Likewise, when schools consider other modes, they sometimes think of them as a way to support the "language" that students do not have—again, what they are *missing*. For example, students are allowed to draw only when they can't write, or act only when they can't speak, or use technology only to contextualize tasks with images. But if we take a translanguaging view, we see *all of it—all linguistic features together with all other modes—as essential* affordances making up the students' meaning-making repertoire, transforming their capacity to learn and to be themselves.

Educators of emergent bilinguals need to remain "wide awake," as Maxine Greene (1995) tells us, as to why some students are given the opportunity to use all their meaning-making resources and others are not. And educators must remain vigilant about the reasons why emergent bilinguals often are not given equitable curricular opportunities and resources, as we have been suggesting throughout this book.

STUDY QUESTIONS

1. Discuss the concepts of multiliteracies, initiated by the New London Group; multimodality, as defined and elaborated by Gunther Kress; and social semiotics, the foundational theory proposed by M. A. K. Halliday.
2. What are some of the inequities that low-income and minoritized students face with regard to where and when they can use digital technologies?
3. What are some ways that generative AI might support emergent bilinguals? What do educators need to know about the opportunities and challenges that this tool presents?
4. Describe the four affordances offered by ICTs and give examples from the research of how they support emergent bilinguals' learning.
5. Select one or two of the practices described in the research and discuss how they illustrate more than one affordance for learning. For example, how might one technology implementation demonstrate both accessibility and retrievability? Interactivity and creativity? Other combinations?

Signposts

Conclusion and Recommendations

In this concluding chapter, we will:

- Summarize what we have learned about:
 - » Who emergent bilinguals are and what educational programs exist for them,
 - » Language theory and research,
 - » Bilingual programs and practices,
 - » Curriculum and other practices,
 - » Family and community engagement,
 - » Assessment, and
 - » Affordances of technology.
- Offer signposts: a set of detailed recommendations for advocates, policymakers, educators, and researchers to provide a more equitable education for emergent bilinguals.

Throughout this book, we have presented the case for reconceptualizing English language learners in American schools as *emergent bilinguals*. This concept recognizes the value of the students' home language practices as resources for learning and as markers of their identity as individuals who have creative ways of knowing, being, and communicating. The term *emergent* emphasizes the “loopiness” of bilingual development and the internal connectedness of the linguistic/multimodal, the cognitive, the social, the emotional, and the lived bodily experience as students do language in meaningful interactions. The term *bilingual* challenges the current silencing of bilingualism in education; it also links the present battle against deficit thinking and raciolinguistic ideologies to the historical antiracist struggles of language-minoritized communities during the civil rights era of the 1960s. In repositioning these students from English learners to emergent bilinguals, we have been able to expose the dissonance between research findings on the best ways to educate them and the current educational policies and practices that have disregarded them.