Understanding the Interaction between Technology and the Learner: The Case of DLL

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In our Keynote Article (henceforth KA) we outlined the DLL framework for using cutting-edge digital technologies to enhance second language (L2) learning and representation. L2 is an excellent example for illustrating how the development of emerging technologies may intersect with education due to the complexity and relevant instructional practices involved. Although our KA had much to say about the different types of technologies (e.g., mobile learning, virtual reality, and digital games) and the impacts that they bring to L2 learning in particular and to education in general, our goal was to understand how the features/affordances of these technologies could be better applied to enhance L2 learning effectiveness. At the outset we considered the gaps in the literature as the starting points of our discussion, specifically, the mismatch between technological features and learner-specific characteristics. Without understanding how the technologies may be relevant to a given task (L2 learning in this case), the application of a new technology will be blind. At the same time, without understanding how the learner characteristics fit a given technology, the use of a technology will be fruitless.

The two sides of digital learning

Mayer's (2021) commentary hits on a critical point that we wish to use to anchor our responses here, that is, the interaction between the available technologies and the characteristics of the learner or user. He points out two different approaches toward digital learning and suggests that we put instructional methodologies before instructional technologies, that is, to shift our focus from the specific media type (e.g., mobile phones, VR) to the design of digital learning environments based on our knowledge of how students learn. We agree wholeheartedly that we should ask the question of "how can we adapt today's technologies to design effective instructional methods for L2 learning?", aiming at evidence-based design principles for effective L2 learning and teaching. However, we believe that we need not shift from one end (understanding what features of the technology are relevant) to the other (understanding what methods are effective), but to study them together.

Indeed, the approach advocated by Mayer (2021) regarding instructional methods implies strongly that we must understand the learners, their characteristics, and their cognitive, affective, and neural differences that are brought to bear on the learning task. In our view, it is the understanding of both sides of digital learning and their *interactions* that will lead to the most productive and effective instructional design. We mentioned in several places of the KA the concept of 'affordances' of today's digital technologies, and how specific affordances may be leveraged for better learning. Take, for example, learner autonomy, according to which the digital tools can facilitate the learner's (rather than the teacher's) control in the learning environment, where the student can maximize learning as a discovery process. This is an example of the technology's affordance to move from traditional teacher-centered to student-centered method, which brings the media-based and method-based approaches together. Of particular interest to note here is Mayer's (2021) point regarding the utility of guided/directed activity versus total self-exploration, where the understanding of enhanced joint social attention and deep cognitive processing will be crucial for the effective use of technology (see further discussion below).

Increasingly more researchers are paying attention to the effects of motivation on learning, for both children and adults (e.g. Chik & Ho, 2017; Sha et al., 2016), and DLL tools and platforms are shown to enhance motivation and interest in learning and therefore increase cognitive processing. In this regard, Caldwell-Harris (2021) points out that VR creates learning environments that are inherently interesting for learners to explore, which helps to overcome boredom during sustained efforts of learning. For example, when being immersed in VR, learners' engagement is promoted through either person-to-person or environment-to-person interactions (Lan et al., 2013; Lan et al., 2015); real-world-like situations can provide the learner with hands-on experience through discovery explorations (see some examples illustrated in Figure 1 of KA). We also agree with Chien and colleagues (2021) that components of the IDC theory (Chan et al., 2006) may guide instructional designers to focus on the role of motivation. In addition, the use of DLL can occur anytime and anywhere, especially through mobile devices, consistent with the requirements of 'seamless learning' proposed by Chan et al. (2006).

Several commentators have echoed the exciting research avenues that the study of DLL and the brain can bring. As we elaborated in section 4.4 of the KA, understanding the neural substrates of DLL will not only provide further evidence on the impacts of DLL, but also a window into how brain changes might reflect the various cognitive and social dimensions of DLL. Chen (2021) further points out that understanding the brain's function and structure will have direct implications for building brain-computer interfaces to enable AI-driven DLL tools. Although our understanding in this regard remains rather limited, new exciting work is emerging rapidly. Chen (2021) also articulates the need, along with Godwin-Jones (2021) and MacWhinney (2021), to make DLL more complete by not only considering MALL, VR, and GBLL, but also RALL (robot-assisted language learning), social media tools, captioned videos, Google maps and so on (MacWhinney, 2017; Presson et al., 2013; Sykes, 2017). As mentioned by Chen, multiple language teaching approaches have been implemented by RALL, and it is attracting attention from language educators and researchers particularly because of its ability to integrate advanced AI technologies, including speech recognition, NLP, and machine learning (Cheng et al., 2021). RALL could further broaden our perspectives on the interaction between technology and the learner, with respect to both the cognitive, social, affective, and neural dimensions (Table 1 in Chen's commentary), and the interface between technology and instructional design (see Table 2 of Chen's commentary).

Personalized learning through DLL

In authentic DLL contexts, learners' learning logs accompanied by long-term portfolios can be automatically saved and analyzed in DLL, to provide the basis for constructing student models and precise and personalized progress indices. This is a promising direction for integrating DLL with AI and big data analytics (see section 5 of KA). MacWhinney (2021) paints a futuristic but highly plausible picture in which DLL could be implemented in this way to fully realize DLL's potential, particularly through large-scale shared platforms to promote personalized learning (see MacWhinney, 2017). To do so, it will require the storage and automatic analyses of hundreds or thousands of users' data in terms of the learner's first language (L1) background, history and habits of language use, cognitive abilities, social and cultural preferences, and different proficiency levels (e.g., variables or dimensions assessed by the LHQ3; Li et al., 2019). Only when such a shared platform is developed will we be able to construct meaningful student models that contain information about the profiles of variation of learning, background, motivation, and aptitudes, which will then allow us to track learner progress and performance in real time. This will also enable a wide range of personalized learning options that match with learners' needs, levels of knowledge, and available resources for learning. Further, such a shared platform will provide a solid empirical foundation to ask and answer theoretical questions such as whether there are fundamental differences in the mechanisms or principles of learning between child L1 and adult L2 – Han (2021) and Spector (2021) seem to suggest there are, while others debate this premise (e.g., Hernandez, MacWhinney, & Li, 2005; MacWhinney, 2012).

Ma and Yan (2021) raise a similar point regarding the need to integrate large-scale corpora of authentic language data with DLL tools and platforms for personalized learning. But for this to occur, as also pointed out by MacWhinney (2021), it will require joint efforts and collaborations among not only SLA researchers, linguists, and educators, but also efforts in open-science platform building, cross-lab and cross-disciplinary data sharing (see a recent call by Kriegeskorte & Douglas, 2018), along with online data collection and analytic tools which are especially important under today's climate when in-person learning and teaching are affected by the pandemic. A good example in this regard is the creation and expansion of the CHILDES data exchange system since the 1980s (see http://childes.talkbank.org/), which contains not just corpora and data, but also analytic frameworks, manuals, programs, scripts, tests, and metadata, setting a successful example for the emerging SLABank for adult L2 learning (MacWhinney, 2017). Finally, such large-scale joint projects require the collaboration of key players not only from academia but also instructional designers from the industry and policy makers from the government, as discussed in a recent manifesto by Luan et al. (2020) on challenges and future directions of big data and AI in education.

A continuum of contextualized student-centered learning

A number of scholars comment that 1) total self-exploratory or discovery learning may not be effective, at least not to some students (Lantolf, 2021; Mayer, 2021), and 2) exploratory and contextualized activities for learning are not uncommon in today's classrooms for learning L2 or other subjects. For example, Godwin-Jones (2021), Han (2021), and Lantolf (2021) all point out that today's language classrooms value interactive, sociocultural learning and are not necessarily based on teacher-centered, translation-focused learning pedagogies. We concur with these points and wish to note that DLL does not in any principled way deny the important role of directed instructions or the existence of interactive activities in L2 classrooms. Further, we wish to highlight the 'continuum' along which contextualization is established or realized on different learning platforms. In this regard, we argue that modern digital technologies have enabled new capabilities of contextualizing learning, in ways well beyond reading or acting out a story in the classroom. While no doubt adults can learn from other traditional media types and means (e.g., text reading remains the main medium of scientific knowledge acquisition; Hsu et al., 2019), ample evidence has accumulated that students acquire language better through contextualized learning, not only for children learning L1 (Kuhl et al., 2007; Lan et al., 2018) but also for adults learning L2 (Li & Jeong, 2020).

As we discussed in the KA (section 4), DLL-based contextualized learning involves embodiment and real-world social interaction, where physical or simulated bodily activities are integrated within the learning task, which will also create integrated brain networks that enhance memory retention and retrieval (see also Jeong et al., 2021; Lan, 2014; Li & Jeong., 2020). When the learner is immersed in VR and games, contextualization is at the higher end of the continuum (e.g., involving whole-body experience or physical simulation), as opposed to thinking about the relevant context while reading a story (e.g., involving no physical participation but imagination or mentalizing); in between, we have a variety of other media types that can provide different levels of contextualized learning, from videos to desktop animations to 3D IMAX cinemas (see Li et al., 2020). The best contextualized learning scenario is one that can enable adult L2 learning to occur like in child L1 learning, as we mentioned in the KA. Caldwell-Harris (2021) points out that this can be achieved through content-and-language integrated learning, including ‘learning by doing’ activities that target specific domains of interest (e.g., martial arts while learning Chinese, soccer while learning Spanish, and opera singing while learning Italian).

We agree with Han (2021) and Lantolf (2021) that “student-centered learning” is not new, but DLL provides a new way for implementing smartly guided student-centered learning, especially for immature or struggling learners. Han (2021) specifically mentions instructed second language acquisition (ISLA; Loewen & Sata, 2017) as a burgeoning field of study in this regard, and in our view, ISLA can indeed benefit from the use of advanced technologies in the digital era. This is particularly important if ISLA aims at catering to individual student needs and personalized learning, as discussed (see also Lan, 2020). Pushing the continuum of contextualized learning further, if the teachers are to use DLL to provide precise feedback and suggestions based on real-time data and model, and the learning history and process, then task-based language teaching can become more effective (see, for example, discussion on the role of feedback in section 5 of KA). Going back to the central point in this article, contextualized learning is only one side of the story; without understanding how variations of individual learners and teachers may fit the context, it is not possible to answer the question of whether VR is definitely better than organized classroom settings (to answer Lantolf). Empirical studies do indicate that, other things being equal, adult learners are more willing to generate oral output and interpersonal interactions in VR comparing to organized classroom settings, especially concerning pragmatic skills (e.g. Lan, 2014, 2020; Liaw, 2019).

Learner characteristics and individual differences

It goes without saying that every learner is unique and different from others. How DLL takes into consideration different learner characteristics and leverages technological affordances for personalized learning is a topic of research with great future promises. Although the technological advances in AI and big data are important as discussed in our KA (section 5), whether and how DLL tools can lead to effective personalized learning will depend largely on the degree to which we understand learners and their individual differences. As Godwin-Jones (2021) correctly points out, without considering individual learner trajectories (e.g., proficiency, learning style), generalizations about learning effectiveness can be dangerous.

With respect to individual differences we singled out cognitive abilities in working memory and executive function in our KA discussion, given the prominent role that these components have been implicated in L2 learning and representation in the literature (see Li, 2015; Wen et al, 2017). Further, not all students will benefit equally from the same technology or even the same feature of a given technology, because different students may select, organize, and integrate available information differently during learning. Our own studies showed that it is the struggling learners rather than the successful learners who benefit more from VR platforms for L2 learning (Legault et al., 2019), suggesting that technology-enhanced multimodal information may differentially affect learners with different aptitude and capacity. In this regard, Ma and Yan (2021) also call for better design of DLL tools and platforms for more advanced in addition to beginning or novice learners. They further highlight the importance of teacher training and education on adopting DLL technologies in their pedagogies and curricula.

Other important learner factors with regard to the four dimensions outlined in our KA could include the learner's age, gender, and cultural background and predispositions toward technology. Puebla et al. (2021) showed that because of the cognitive and physical changes (e.g., declines in memory and vision), older adults are more resistant to the use of DLL tools, especially mobile applications. Puebla and Garcia (2021) further comment on the need of tech companies as well as instructional designers to develop DLL products that accommodate older learners' abilities, attitudes, needs, preferences, expectations, and learning practices. We agree completely with this call for attention to an increasingly large and important population, especially given the rapid pace of aging in our societies (e.g., by United Nations' estimate, the population aged 65 or older will grow to over 300 million by 2040 in China). To design DLL tools that target older adults' learning experiences and demands will not only expand the student-centered learning approach, but also help to realize the great potential of DLL for lifelong learning for all.

Finally, although not between technology and the learner (a central focus of this article), the dynamic interaction between the learner's L1 and the target L2 should also be taken into consideration in designing DLL tools. As Spector (2021) points out, linguistic differences (e.g., tonality) that are specific to the L2 but not the L1 (or vice versa) should be carefully examined so that DLL can be made adaptive to learners from different L1 backgrounds. A large amount of psycholinguistic and neurolinguistic work has already examined how the overlapping L1 and L2 systems interact with each other in a dynamic system, especially with regard to the cascading effects of L1 on L2 as a function of age, time, and linguistic overlap (Li, 2009, 2015; Tsao, Liu, & Li, 2020; Yu et al., 2019), and the effects of transfer of learning from L1 to L2, both positively and negatively (e.g., Kato, 2018; Yang et al., 2017). There have also been several influential theoretical frameworks on how L2 speech learning may be impacted by L1 features, such as the Speech Learning theory (Flege, 1995) and the Native Language Magnet theory (Kuhl, 2004). DLL tools and platforms should aim at incorporating these theories and practices into their future designs.

In conclusion, we acknowledge and appreciate the excellent points that the eleven commentators have provided regarding the current and future promises of DLL (and the pitfalls), and embrace their perspectives and proposed methods for fully realizing the DLL's potential. We believe that the following statement from our KA article most accurately summarizes our main point of view in this article: "We need a greater synergy between technology and human characteristics – nowhere more than in education – and we must make our technologies be adaptive to individuals' cognitive, social, affective, and linguistic abilities and profiles."

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