Indulging interactivity: a learning management system as a facilitative boundary object

Sharon Chang¹ · Annie Camey Kuo²

Received: 25 October 2020 / Accepted: 24 January 2021 / Published online: 1 March 2021

© The Author(s), under exclusive licence to Springer Nature Switzerland AG part of Springer Nature 2021

Abstract

With the recent global pandemic, education institutions including higher education have shifted to offering online instruction for a prolonged period of time. Faculty and instructors have had to transform the content of face-to-face instruction into a format fit for distance education. In the virtual space, understanding or facilitating interactivity is a key component of online teaching for sustaining engagement and social interactions; promoting active learning between participants; and providing resources, tasks, and activities. The learning management system as a facilitative boundary object makes pivoting to online classes more tactical when adopting cultural-historical activity theory as an analytical lens, which can be used as a guide to re-envision how interactions can be implemented in e-learning or online courses and how instructors can repurpose resources and tools to maximize their instructional practices. Examples of interactivity and the implications for practitioners are synthesized, and the multiple components at play in the online and hybrid space are characterized in order to promote the exchange of practices and knowledge mobilization.

Keywords Interactivity · Learning management system · Cultural-historical activity theory · Boundary objects · Digital learning · Online teaching · Distance education

Introduction

After the World Health Organization (WHO) officially declared the spread of the coronavirus (COVID-19) a global pandemic on Wednesday, March 11, 2020, many educational institutions around the world had to rapidly transform their in-person classes due to on-site campus closures. One way higher education has pivoted is by using a learning management system (LMS). An LMS is an online platform that

✉ Sharon Chang
scc2168@tc.columbia.edu

¹ Teachers College, Columbia University, 525 West 120th Street, Box 122, New York City, NY 10027, USA

² Stanford University, Stanford, CA, USA

integrates digital tools to facilitate e-learning delivery and the co-construction of knowledge, such as the Canvas course system. Using online platforms during remote teaching presents two challenges in distance learning: (1) issues of equity become salient especially when proper software subscriptions and selective hardware equipment are not available, such as the most crucial internet connectivity, for the most vulnerable populations; (2) not everyone is a proponent of distance education and digital learning—some students prefer face-to-face courses, and some instructors think online education is less optimal than in-person teaching. To assist faculty members and instructors in meeting their objectives of transitioning to online teaching, this article offers sociocultural approaches in using an LMS as a facilitative boundary object to promote interactivity in online teaching/learning. While the examples we provide in this article are focused on graduate education, this approach can be used in other online classrooms such as community college courses and in undergraduate programs.

A boundary object, first introduced by Star and Griesemer (1989), is a tool that has the capacity to be understood by different people in various settings. In online and hybrid learning, the boundary object is a shared web space that both instructors and course participants use to explore their information filters, communication, and work requirements as locally perceived while working together (Griesemer 2015; Star and Griesemer 1989). A boundary object facilitates boundary crossing, through which knowledge is co-constructed rather than being linearly developed by the course instructor. A boundary object, therefore, “allow[s] the different groups to share meaning [and] to learn about each other’s perspectives” (Fox 2011, p. 72). Fox further argues that a boundary object can be “facilitative” or “inhibitory.” Facilitative boundary objects leverage a community of practices and promote knowledge to be mobilized among the course participants and instructors, whereas inhibitory boundary objects fail to “ensure such objects can be generated, established and sustained during the process of innovation or translation” (Fox 2011, p. 73). Thus, we regard an LMS as a positive boundary object in relation to the underlying objective of facilitating interactivity for online teaching and learning within the context of unique challenges during a global pandemic.

However, this assumption of the role of an LMS requires some understanding and unpacking of the elements and principles in the cultural-historical activity theory (CHAT); specifically, boundary objects must be understood as they relate to the notions of mediating artifacts and interactivity. According to Vygotsky (1978), the idea of semiotic mediation in CHAT offers an account of how consciousness emerges from human activity as mediated by tools (i.e., material forms) and signs (i.e., conceptual forms). These artifacts/tools and signs are co-constructed by different online participants—instructional designers, instructors, and students—to mediate the distant learning experiences in an LMS, which serves as the facilitative boundary object for increasing interactivity.

Fox (2011) concludes that “what is re-introduced to the boundary object conceptualization—by recognizing the significance of an object’s meaning—is an acknowledgment of the social and power relations that a technology or a technological object mediates. The success or failure of an innovation depends on the reception of this meaning and these social relations” (p. 82). In what follows, we first use CHAT principles to lay

the groundwork for understanding interactivity in boundary crossing, as this theoretical understanding can help instructors to approach online teaching and learning more dynamically during the distance education. Next, we focus on using an LMS as a facilitative boundary object to encourage knowledge to be mobilized among the course participants and instructors with low-stakes innovations, which we refer to as knowledge mobilization.

Cultural-Historical activity theory (CHAT)

CHAT uses the interactions among six major elements—tools, divisions of labor, rules, subjects, communities, and objects—to analyze structurally and historically constructed tensions to facilitate boundary crossing (Akkerman and Bakker 2011). CHAT requires a minimum of two activity systems coming together to work toward the partially shared goals with a motive that draws both subjects together. For instance, when students take the initiative to share their screens or documents on their desktops on Zoom, they become the subject of their own activity system, reversing the participating roles and class rules to engage other members in the virtual learning environment in a different way. From the CHAT perspective, the LMS can then be proposed as a facilitative boundary object that promotes interactivity to leverage communities of practices and knowledge mobilization. With the LMS-integrated tools, the division of labor of the online participants could be technologically delineated, such as the assignment of discussion forums for peer-reviewing and how peer reviews can be conducted in the e-course.

Examining the LMS through the CHAT analytical lens can be reconceptualized using the six major elements that promote interactivity. The *object*, or the motive of this activity, is the reconfiguring of a web space in which a facilitative boundary object emerges to actively combine synchronous and asynchronous learning, so that the expected outcome of new e-course implementation can best serve both instructors' and students' needs and foster a positive teaching/learning experience. The *rules*, aside from institutional technology policy, refer to when and how to conduct synchronous and asynchronous sessions online. The *community* consists of both individual students and the virtual smaller groups they form. The *division of labor* is the role each participant plays in their online course engagement, including collaboration, discussion, and peer review. Lastly, envisioning the repurposing of *tools* helps the *subjects* (both instructors and students) to reimagine possible reconfigurations of interactivity within the LMS, especially when it comes to providing access and engaging a diverse array of students located in different time zones and geographical locations.

Interactions and interactivity

To promote interactivity, instructors need to become aware of how it works as a mediator, and how it is best curated and interspersed (Farber 2013). Equally important are instructors' beliefs about interactivity (Bolldén 2016). These beliefs guide pedagogical decisions across all e-learning contexts but are particularly important

for the sudden transition to online courses, as everyone is immersed in a hybrid environment as they generate new learning. In these contexts, instructors must be aware of multiple modes of communication, practices, and the principles of multimodality (Kress et al. 2004; Latour 2005; Leeuwen 2015).

In discussions of interactivity, Wagner (1994) defines the term as consisting of “reciprocal events that require at least two objects and two actions. Interactions occur when these objects and events mutually influence one another” (p. 8). For instance, the concept of a module is a sub-unit of learning composed of asynchronous and synchronous class sessions. Modules organize the sequence of learning throughout the course regardless of which LMS is adopted. If we couple Wagner’s viewpoint with a CHAT perspective (Bharosa et al. 2012; Engeström 1987, 2001), instructional interactivity then becomes an event containing a mediating process between a learner and the learning environment, including the learning materials, with an intended learning or performance outcome. Specifically, modules may include a series of instructional videos, reading assignments, practical exercises, and class discussions that focus on a particular topic for each session. Moreover, Smuts (2009) states that “interaction [is] best described [as] a kind of behavior one engages in” (p. 63). Instructors most often regard face-to-face classes as having the strongest degree of interaction among course participants (Ishii et al. 2019).

As Smuts (2009) argues, “interactivity must be a relational, not an intrinsic, property; it is only in relation to our ability to control something that it is interactive *for us*” (p. 65, italics in original). Therefore, instructors can decide how interactivity will be incorporated in their own LMS. It is important to note that Smuts distinguishes “interactive” from “interactivity.” According to Smuts (2009), interactivity “must be responsive in a way that is neither completely controllable nor completely random” (p. 54). In other words, when engaging in interactivity, “the type of responsiveness is more important than the degree” (Smuts 2009, p. 64). The responsiveness of interactivity could be understood in relation to one or more types of online learning interaction, such as learner–content interaction or learner–technology interaction.

When it comes to types of responsiveness of learner–content interaction and learner–technology interaction, technology is not merely a tool but also a set of rules from a CHAT perspective. Perhaps the most productive way to engage and indulge interactivity is to think of technology as a kind of division of labor (Chang and Martínez-Roldán 2018) that can be used to its full potential in some formal learning settings. Divisions of labor are roles in the human activity system that participants assume or assign. Socioculturally speaking, learning is mediated by tools. In terms of substance, these tools are mostly tangible in face-to-face classrooms, for instance, a hardcopy of a worksheet that students can write in, or Play-Doh for students to make sculptures with in their groups.

However, in online teaching, these tools become largely semiotically mediated. For instance, graphic interchange format (GIF) files support both animated and static images, and emoji icons notated in distance learning share a semiotic importance equal to the spoken text. Depending on how online teaching is materialized, semiotic mediation plays an even more critical role in engaging and indulging interactivity as instructors cross disciplinary boundaries in a virtual collaborative space

to maintain academic integrity, continuity, and even authenticity (Marull and Kumar 2020). Hence, it is more generative to begin to rethink the roles of technologies that would allow instructors to engage course participants in different capacities.

Furthermore, online instructional interactivity is regarded as a “dialogue between learners and e-Learning tools through which learners become engaged and involved in the e-Learning process” (Pappas 2015, n.p.). This dialogical definition fits the purpose of this article in identifying the types of responsiveness in interactivity (Juwah 2006). Also of significance is that interactivity can be embodied with on-site learning materials and thus transferred from online platforms to face-to-face teaching in a post-COVID-19 environment, which is especially important since some schools have decided to reopen their campuses using blended learning formats. The repurposing of tools can make them more advantageous compared to what would have been used only for in-person learning as we cross the boundaries between the two contexts, such as a flipped method (Voss and Kostka 2019). In fact, based on our empirical experiences, there is more transfer from online teaching to face-to-face teaching than there is the other way around.

This theoretical extension of instructional interactivity allows online instructors to embody themselves even when they are not physically present with students. In short, how instructors approach instructional interactivity has important implications for online teaching: *How can course instructors make teaching visually, pedagogically, and technologically interactive online?* One way to approach online teaching is to avoid restricting collaborative conversations to verbal or face-to-face formats. There is an increasing amount of in-depth and insightful conversations taking place in online classes, whether on the default discussion forums on an LMS or through the integrated tools that are embedded on the LMS page. The blessing in disguise here is that trying to reimagine one’s instructional interactivity online requires risk-taking to retune the content delivery and make each unit (session or module) more visually, pedagogically, and technologically interactive. Such a risk-taking ability may vary according to the individual instructor’s training, motivation and interest in online education, which can affect their conceptualizations of an LMS as a facilitative boundary object. While this is beyond the scope of the article to address instructors’ conceptualization of an LMS as a facilitative boundary object, some studies have shown that reimaged instructional interactivity has positively impacted students’ learning outcomes.

In a study conducted by Zhang et al. (2006), groups working with interactive video content, as opposed to groups presented with linear video or no video content, were shown to exhibit “higher achievement of learning outcomes in post-gain tests” (p. 23). The test scores of the students in the interactive video group were on average nearly 20% higher than those of the linear video group and approximately 22% higher than those of the group with no video. The students in the interactive video group had test scores that were approximately 30% higher than those in the traditional classroom group. Zhang et al. (2006, p. 22) found that video/audio learning tools are beneficial for students in engaging and indulging interactivity as the types of responsiveness are diversified. Semiotic mediating artifacts can also be used for a face-to-face course through flipped classroom teaching methods (Johnson and Lester 2016; Knapp 2018). All in all, video/audio learning tools can enhance and improve

group dynamics when meaningfully embedded and integrated in the facilitative boundary object, which helps students transcend their current state of learning and rethink online engagement.

Much of the LMS functionality relies heavily on interweaving and interacting with different versatile tools, which, broadly speaking, are the artifacts used to mediate the learning in action—be it software, hardware, cloud-based services, digitized physical objects, or a combination of different artifacts. Therefore, instructors are in greater need of a dynamic tool system for deeper and more active digital learning. For example, instructors in higher education conventionally regard teaching face-to-face courses as more engaging and effective than online courses due to perceived physical interactions (Ishii et al. 2019; Kenzig 2015; Sun and Cheng 2007). In a time in which learning and teaching must be done remotely, faculty and online instructors without professional training in the technology field face tremendous challenges in adopting and adapting tools to use LMS as a facilitative boundary object in the digital professional learning space. One starting point is to allow the lesson objectives and learning content to help instructors to curate the tools, rather than beginning with the selections of tools first.

At the institutional policy level, an LMS is usually vetted in compliance with institutional regulations. The supported and compatible external software and hardware are typically weighted in the cost–benefit analysis, which inadvertently reinforces monopolization in higher education. Such rules of restriction are in conflict with the future-oriented vision to “break through the predefinition,” coined by Greene (2000) in her seminal work on social imagination. In considering these issues from the CHAT and materialist points of view, philosophically and epistemologically speaking, more generative questions to ask would be the following: When are tools *tools*? How are tools *tools*?

Envisioning the repurposing of LMS-integrated tools

As we begin to consider when and how tools serve their purposive instrumentality, we must look at how online instructors start to envision the repurposing of tools. Using CHAT as an analytical lens reconceptualizes the usage and roles of tools. In thinking of transforming face-to-face coursework and assignments into online sessions, instructors can begin by making synchronous modules more personalized for the class participants with video/audio learning tools (Lohr and Haley 2018). For instance, the Zoom video conferencing tool can be used for synchronous teaching, with the option of opening breakout rooms for small group discussions or think-pair-share activities where instructors can e-circulate and join each private web space. Moreover, Zoom can be used for holding online office hours with a waiting room enabled.

At the same time, Zoom can also be used as a screen recording device to prepare shorter lectures, content videos with hyperlinks, and audio transcripts generated for asynchronous learning. If the institution has a Zoom account, instructors do not necessarily have to use separate screencasting tools to record their screens or slides. These screencasting tools are free alternatives if no other video

conferencing tools are available at the institution. Video conferencing tools can also be used for screencasting to create an aesthetically animated and graphically attractive instructional video. This interpersonal aspect of the video/audio learning tool affords greater opportunities to further subdivide the course content into shorter chunks of video/audio-based interactions to create a more flexible learning pace.

In terms of enhancing online learning engagement and re-imagining interactivity, the repurposing of tools allows online instructors to embed visual directions, verbal hints, and pre- and post-assessments. For instance, we can use Google Docs as a substitute for K–W–L charts, Google Forms for exit tickets or bonuses, Google Slides for gallery walk, and Google Jamboard for digital whiteboard with sticky notes. These Google applications can be easily repurposed by making a copy as a separate file for the next class or for future iterations of courses. Repurposing the tools not only aids instructors in templating their semiotic mediating tools but also helps class participants to move their learning goals from familiarity to sophistication by generating case studies, deliberate annotation, and peer reviews. The video/audio learning tool helps instructors to combine the actual tasks to reduce the amount of time spent going back and forth on the discussions or email chains; it also allows them to reuse the first part of the presentation to extend the video discussion as a formative assessment and to create a feedback loop by developing individual exercises and small group assignments that are either graded or ungraded.

Interactivity in online teaching and learning is a conceptual tool for online instructors to provide educational content to facilitate multimodal communication so students can “benefit from and optimally initiate dialogue” (Adams 2016, n.p.). Essentially, interactivity is dialoguing through semiotic mediation. There are many video/audio learning tools to facilitate this line of synergy. It is crucial to understand, however, that these video/audio learning tools offer semiotic mediation through “visually-represented human-like entities within software systems” (Craig and Schroeder 2018, p. 128). Furthermore, these video/audio learning tools allow instructors to *pre-teach* the foundational elements of some content by using the video/audio-based feature in assessments.

These LMS-integrated tools serve as an “embodied agent” (Kim et al. 2017, p. 219) when instructors are in a realm of non-being (David Hansen, March 25, 2020, personal communication in breakout room on Zoom), which promotes more active learning and reduces learning anxiety while differentiating. In other words, embodied agents act as teachers in an alternative mode of interaction. When the instructors are not in the same physical space as the students, they may need to seek alternative embodied agents to co-facilitate learning. Moreover, the LMS-integrated tools also allow instructors of online courses to integrate multimodal methods into the process of chunking the content (Hicks and Bose 2019). Admittedly, the video/audio learning tools challenge instructors to reframe teaching (and learning as well) in synchronous and asynchronous spaces. By creating connections between the smaller chunks while staging, story-ing, and sequencing the content for the learners, the instructor cultivates a stronger and more active relationship with the class members (i.e., students) to become genuine co-constructors of knowledge at the post-secondary level.

Another way of repurposing the tool is through opening remarks, wherein instructors can audio record themselves using the PowerPoint files and make a quick walk-through of the module overview to frontload the learning objectives in the agenda or foreshadow the outcomes of a particular activity or unit. In this case, the PowerPoint files or Google slides themselves can be repurposed for future courses. The instructors can be creative in curating the learning experiences with contemporary features (i.e., stretch sidebars on the left/right) that can promote deep and active learning. Using a video/audio learning tool embedded in the facilitative boundary object also helps the class participants to navigate all the nuances in one interface rather than having to process information in separate modalities. Practically, a video/audio learning tool creates a positive line of synergy between the flipped, virtual classroom and the online class participants (Knapp 2018; Voss and Kostka 2019) in any given LMS and semiotically promotes boundary crossing. With this boundary-crossing challenge in mind, we seek to examine how the facilitative boundary object can be used to engage and indulge interactivity in the LMS (Ross 2019).

LMS as a facilitative boundary object

In the push for online teaching, stakeholders sometimes castigate instructors whose forte is not technology for their unwitting reluctance and resistance, which may be based on their lack of technological pedagogical content knowledge (TPACK, formerly known as TPCK) skill sets. TPACK focuses on what instructors need to know in order to effectively teach with the use of technology (Voogt et al. 2013), and it is primarily operationalized through a linear transmission model in which instructors need to first learn the technology application and then the principle of learning by design (Koehler and Mishra 2005). Such an approach highlights the importance of “content knowledge (CK), pedagogical knowledge (PK), and technological knowledge (TK)” (Harris et al. 2009, p. 397). This knowledge-based orientation not only demands that instructors be avid learners to pivot from in-person to online teaching in a remarkably short turnaround, but it also produces anxiety from their transition to online learning in a challenging time of developing TPACK. Professional development for faculty members and instructors is key in providing and extending knowledge of technology, especially the LMS system, engagement and participation strategies, and accommodations to be provided during online learning.

LMS could either be an inhibitory boundary object or a facilitative boundary object, depending on the theory used. The relationships between TPACK and the community of practices make knowledge mobilization difficult in designing online learning that engages and indulges interactivity. It is not viable to assume that instructors have the same TPACK digital literacy as instructional designers or students. Hence, Costa et al. (2019) encourage instructors to engage in the theorizing of technological tools in education as a more reflective practice. Conceivably, the tools used in virtual spaces are dramatically different in terms of the modes and means of communication from those available in face-to-face scenarios (Voss and Kostka 2019). With the reformatting of courses for the online space, many are concerned about the loss of in-person interactions (Kenzig 2015). For instance, instructors in

art education programs can no longer engage their students in the same way as they typically would in the ceramic studio with wheels and clay in hand. Rather than focusing on the one-to-one replication and the institutionalized knowledge-based TPACK skill sets instructors need to acquire, the LMS could be better approached as a facilitative boundary object.

As we reconceptualize the usage of tools in shared web spaces to reimagine interactivity, we can also use the LMS to teach online in a time of need. E-courses have been delivered and implemented in conventional distance education, through which course instruction is conducted entirely online with asynchronous and/or synchronous sessions. Some e-courses have been developed with a blended method where course participants meet physically at a work site or on campus for a certain period of time for student teaching, a practicum, or a clinical internship, and meet online for other segments of learning. This option is currently limited for educators and students impacted by COVID-19. Other e-courses, prior to the COVID-19 outbreak, have been offered in a hybridization space, with face-to-face participants meeting on campus and online participants meeting at the same time in a physical classroom that is technologically enhanced (i.e., having a wireless internet connection, cameras, microphones, and speakers ready). After the demand for instructors to move classes online to ensure academic continuity, the new e-course format involves a stronger level of boundary crossing of two or more learning communities coming together in a shared web space.

Viewing the LMS as a facilitative boundary object allows course participants to increase multidirectional interactivity in the web space. According to Star and Griesemer (1989), boundary objects “enabl[e] access by people from differing communities of knowledge or practice” and serve as a prototype “that is ‘good enough’ to serve different communities” because they have “a standardized form that can be completed by actors within differing knowledge communities” (pp. 410–411). At its sociological conception, Star (2010) proposed that boundary objects are “shared spaces” (p. 602), or “a set of work arrangements that are at once material and processual [...] something that people [...] act toward and with” (p. 603). In other words, boundary objects are meta-artifacts shared by a community working together to reach their individual goals (Kreijns et al. 2014).

Over the last ten years, universities have begun to offer more courses online; initially, such an approach was introduced for non-credit bearing courses, but it was eventually extended to courses that would culminate in an accredited degree (Johnson and Lester 2016). Currently, much of the professional development for faculty regarding online design focuses on accessibility and formats without accounting for the underlying awareness and beliefs about interactivity that govern faculty and course instructors’ decisions and practices. In the domain of digital learning and online teaching, it would be beneficial to contextualize the LMS within the scope and scale of a facilitative boundary object to seek additional possibilities to curate course participants’ learning experiences online and retool the modules. Focusing on how course participants and instructors take form and shape to co-construct and negotiate knowledge in light of multimodality further aids in engaging and indulging interactivity, as has been argued in this article. There are three ways instructors can view the LMS as a facilitative boundary object: (1) by noticing web spaces

and simulation, (2) by renegotiating orientations and attitudes, and (3) by comparing personal learning and collaboration. These examples were drawn largely from online courses offered through a US graduate-level teacher education preparation program on the West Coast (Hicks and Bose 2019).

Noticing web spaces and simulation

Digital learning is multi-spatial (Hubard 2020), and examples from theory and practice suggest that learning unfolds not only within the established infrastructure, but also across multiple spaces of teaching and learning beyond the physical classroom (Bolldén 2016; Craig and Schroeder 2018; Griesemer 2015). The LMS as a facilitative boundary object encompasses external and internal tools and digitized resources in web spaces. These web spaces form a virtual social world, extending the course duration and its physical boundary. Interactivity as a concept is not equivalent to interactive experiences in the gaming industry but is in this case mediated by tools and divisions of labor, as understood through the CHAT approach. Thus, interactivity occurs as a result of meeting information and communication needs, the demands of teaching arrangements, and the requirements of course participants and instructors positioned as learners. While online course instructors typically assume the role of primary facilitators in web spaces for the purpose of community building, they also serve as the curators of syllabi at the beginning of the coursework. To engage and indulge interactivity, the divisions of labor will need to be gradually rotated among the course participants in order to co-construct knowledge and mediate learning semiotically.

Using an example regarding space, in a graduate teacher education course that was transformed for the online environment, students were asked to find, explore, and connect with a community-based organization that provides support for students designated as English learners and immigrant students. Through this assignment, students had the opportunity to go into the community they will be teaching to research and connect with organizations. The assignment did not explicitly require students to visit the organization but instead encouraged them to reach out to staff by phone or email to establish a connection. This type of interactivity involves multiple types of engagement, from an authentic research experience to building community connections and again synthesizing the information collected into a coherent deliverable. The important thing to keep in mind is how the online course assignments enhance course participants' remote learning experiences. As Hubbard (2020) shared, in her museum-inspired online course, "students came to understand the significance of art experiences to global competence around six interrelated themes: (a) feeling others' experience, sharing humanity, (b) gaining fluency in and valuing different ways of knowing, (c) considering multiple perspectives, (d) nurturing self-awareness about one's situation, (e) dwelling in ambiguity, and (f) motivation to continue to learn about global issues and different ways of life" (p. 119).

In another example regarding simulation, instructors would encourage interactions with a range of tools (e.g., from readings to websites) and the creation of deliverables through experimentation in person-to-person interactions. For example, in

the same graduate teacher education course mentioned above, students were asked to read academic journal articles, state and federal policy briefs, and practitioner tools on a weekly basis and to synthesize their takeaways. Instead of composing discussion board posts, students created an infographic either by hand (and digitize it for online display) or use a cloud-based program. Students were also expected to provide a brief description of their infographic and comment or ask questions of a few colleagues. Allowing the option of creating a visual representation of information supports various learning and reflection methodologies and models student choice and the inclusion of tools (technology and non-technology) as part of good instructional practice. Asking students to create an infographic also breaks up the monotony of weekly discussion board participation and engages students' creativity.

(Re)negotiating orientations and attitudes

Pedagogical decisions and research applications to practice are profoundly shaped by how one is oriented toward technology, media, and other forms of digital learning. In other words, course participants become the mediators in this boundary-crossing process. The LMS as a facilitative boundary object insinuates non-linear movement, as the course participants cross their own socially defined boundaries of learning. The LMS is conceptualized as a facilitative boundary object because it is where the new expanded, informed beliefs about e-learning are formed and recreated via reconciliation, reconstruction, reconceptualization, renegotiation, and re-mediation within the discourses of course participants and instructors. These non-linear movements provide a common meaning-making ground for the higher education community to extrapolate its disturbances and tensions in digital learning and online teaching in a time of need and in the wake of COVID-19.

Hence, instead of a traditional view of training premised on a knowledge transmission model, online instructors can infiltrate the web space by bringing the embodiment of interactivity into the semiotic mediation process, inviting all course participants from different social worlds to engage in thinking about the roles of educational technology and digital tools from boundary-crossing perspectives. Proposing the LMS as a facilitative boundary object has instantiated the possibility of shaping learning non-linearly and the move to expand on creating shared web spaces that further probe boundary crossing as the digital tools are constantly repurposed among two or more learning contexts (Akkerman and Bakker 2011).

For instance, the final project in the online graduate teacher education course described previously presented students with the opportunity to deeply explore a topic of their choice through research and the synthesis of findings that relate to supporting students designated as English learners (ELs). Students were able to explore a wide range of topics, including instructional strategies for supporting ELs in math and science to understand the research around EL policy and accessibility resources for large-scale testing. The final project components were broken down into smaller chunks throughout the quarter to allow for multiple interactions between the student, the materials, and the instructor. The project started with the topic selection that was discussed and refined and then moved to resource selection and summaries. At each

stage, students were expected to check in with the instructor through a short assignment and feedback, a conversation, or both. The instructor's role became that of a facilitator of the process instead of the center of learning. In this case, the instructor simultaneously supported the acquisition of research and academic skills and also built the student's capacity to problem solve and engage with the resources in the shared web spaces. The project culminated with a paper and presentation at the end of the course. This was done through Canvas and Zoom, where participants would be able to share their screens and present the resources they have created to enhance their presentations, and could be replicated with other LMS and communication technologies.

Comparing personal learning and collaboration

From self-identified novice users of digital tools to more experienced digital learners, all users can grow and develop their skills when the divisions of labor are redistributed as a result of semiotic mediation. The LMS as a facilitative boundary object is a shared web space for two online communities—online instructors, such as faculty in higher education, and the course participants from their physical locations. Both groups are jointly learning for concerted purposes, and being positioned in this way allows the instructors to reflect on the use of technological tools in digital learning and associated online teaching strategies. To further understand how the LMS as a facilitative boundary object could encourage new forms of interactivity, it is critical to base further discussion on boundary crossing between the two online communities (Marheineke et al. 2016).

In this time of need, the two communities are sharing a web space in which immersive communities of practices and non-linear knowledge construction are reified and translated across socioculturally and historically defined boundaries (Star 2010; Star and Griesemer 1989). Within these culturally defined boundaries, productive questions to ask include if, when, and how the new symbolic meanings are (re)negotiated digitally as the course participants engage mutually in the shared temporal space (e.g., the LMS) to reformulate the forms of interactivity. To that end, CHAT as an analytical lens offers some insights into reconceptualizing the usage of educational technology and the role of digital tools in shared web spaces while using the LMS to teach online and reimagine interactivity.

Another assignment from the same graduate teacher education course offered online that illustrates this was a culturally and linguistically diverse (CLD) case study, where students were asked to have a conversation with a friend or someone in their network who has immigrated to the United States. The interactions with the person and learning firsthand from their reflections contributed to building empathy for the range of challenges that immigrant students face. An alternative to learning from another person could be reading about an experience in a book or watching a film or documentary; however, purposeful engagement provides a back and forth for deeper learning and understanding. For the CLD case study, students were provided with a list of questions to choose from for the semi-structured interview with a specific lens on the immigration experience, learning

inside and outside of school, and challenges during the transition. In addition to expanding the awareness of the heterogeneity of students designated as EL and immigrant students, the assignment also emphasized the importance of getting to know your students to be able to build appropriate and targeted supports based on their prior knowledge, experiences, and backgrounds.

Conclusion

Using LMS as a facilitative boundary object through the CHAT analytical framework helps online instructors in higher education and other educational settings engage in interactivity with a focus on crossing the boundaries of knowledge production between two learning communities. The LMS as a facilitative boundary object aids both course instructors and students in positioning themselves in a redefined online and hybrid learning environment. With an analytical lens, CHAT characterizes the multiple components at play in the online and hybrid space. In providing courses online, participants who are usually constrained by distance from the institution are now able to acquire resources and tools to improve their instructional practice.

When using CHAT as an analytical lens, the coursework and all of its activities, tools, and interactions are viewed as part of the activity system, through which the LMS as a boundary object emerges. Opportunities for interactivity are not limited to engagement with resources. Interactivity also extends engagement with resources outside of the syllabi. Engaging and indulging interactivity can be used as a guide to re-envision how tools could be repurposed and how the LMS can be utilized as a facilitative boundary object through which more non-linear learning occurs. This article contributes to the existing literature promoting the use of CHAT as an analytical lens in conceptually addressing the interactivity problem for designing interactive online instruction.

Acknowledgements The first author would like to thank the Office of Digital Learning at Teachers College for their instrumental insights and hands-on support for online course transformation.

Funding Not applicable.

Compliance with ethical standards

Conflict of interest The authors have no conflicts of interest to declare.

Availability of data and material Not applicable.

References

- Adams T (2016) Distance education. In: Danver S (ed) The SAGE encyclopedia of online education. SAGE, Thousand Oaks, pp 338–347. <https://doi.org/10.4135/9781483318332.n112>

- Akkerman S, Bakker A (2011) Boundary crossing and boundary objects. *Rev Educ Res* 81(2):132–169. <https://doi.org/10.3102/0034654311404435>
- Bharosa N, Lee J, Janssen M, Rao R (2012) An activity theory analysis of boundary objects in cross-border information systems development for disaster management. *Secur Inform* 1(15):1–17. <https://doi.org/10.1186/2190-8532-1-15>
- Bolldén K (2016) Teachers' embodied presence in online teaching practices. *Stud Contin Educ* 38(1):1–15. <https://doi.org/10.1080/0158037X.2014.988701>
- Chang S, Martínez-Roldán C (2018) Multicultural lessons learned from a Chinese bilingual after-school program: Using technology to support ethnolinguistic children's cultural production. *Multicult Educ J* 25(2):36–41
- Costa C, Hammond M, Younie S (2019) Theorising technology in education: An introduction. *Technol Pedagog Educ* 28(4):395–399. <https://doi.org/10.1080/1475939X.2019.1660089>
- Craig SD, Schroeder NL (2018) Design principles for virtual humans in educational technology environments. In: Millis K, Magliano J, Long D, Wiemer K (eds) *Deep learning: multi-disciplinary approaches*. Routledge/Taylor and Francis, New York, pp 128–139
- Engeström Y (1987) Learning by expanding: An activity-theoretical approach to developmental research. *Orienta-Konsultit, Helsinki*
- Engeström Y (2001) Expansive learning at work: toward an activity-theoretical reconceptualization. *J Educ Work* 14(1):136–156
- Fox N (2011) Boundary objects, social meanings and the success of new technologies. *Sociol* 45(1):70–85. <https://doi.org/10.1177/0038038510387196>
- Greene M (2000) Imagination, breakthroughs, and the unexpected. In *Releasing the imagination: essays on education, arts, and social change*. Jossey-Bass, San Francisco, pp 17–31
- Griesemer J (2015) Sharing spaces, crossing boundaries. In: Bowker GC, Timmermans S, Clarke A, Balka E (eds) *Boundary objects and beyond: working with Leigh star*. MIT, Cambridge, pp 201–218
- Harris J, Mishra P, Koehler M (2009) Teachers' technological pedagogical content knowledge and learning activity types: Curriculum-based technology integration reframed. *J Res Technol Educ* 41(4):393–416
- Hicks S, Bose D (2019) Designing teacher preparation courses: integrating mobile technology, program standards, and course outcomes. *TechTrends* 63(6):734–740. <https://doi.org/10.1007/s11528-019-00416-z>
- Hubard O (2020) Aesthetic experience and global competence: a museum-inspired online course. *Arts Educ Policy Rev* 121(3):119–123. <https://doi.org/10.1080/10632913.2019.1658249>
- Ishii K, Lyons MM, Carr SA (2019) Revisiting media richness theory for today and future. *Hum Behav Emerg Technol* 1:124–131. <https://doi.org/10.1002/hbe2.138>
- Johnson WL, Lester JC (2016) Face-to-face interaction with pedagogical agents, twenty years later. *Int J Artif Intell Educ* 26(1):25–36
- Juwah C (2006) (eds) *Interactions in online education: implications for theory and practice*. Routledge, New York
- Kenzig MJ (2015) Lost in translation: adapting a face-to-face course into an online learning experience. *Health Promot Pract* 16(5):625–628. <https://doi.org/10.1177/1524839915588295>
- Kim Y, Thayne J, Wei Q (2017) An embodied agent helps anxious students in mathematics learning. *Educ Technol Res Dev* 65(1):219–235
- Knapp NF (2018) Increasing interaction in a flipped online classroom through video conferencing. *TechTrends* 62(6):618–624. <https://doi.org/10.1007/s11528-018-0336-z>
- Koehler MJ, Mishra P (2005) What happens when teachers design educational technology? The development of technological pedagogical content knowledge. *J Educ Comput Res* 32(2):131–152. <https://doi.org/10.2190/OEW7-01WB-BKHL-QDYV>
- Kreijns K, Van Acker F, Vermeulen M, Van Buuren H (2014) Community of inquiry: social presence revisited. *E-Learn Digit Media* 11(1):5–18. <https://doi.org/10.2304/elea.2014.11.1.5>
- Kress G, Jewitt C, Bourne J, Franks A, Hardcastle J, Jones K, Reid E (2004) *Urban classrooms, subject English: multimodal perspectives on teaching and learning*. Routledge Falmer, London
- Latour B (2005) *Reassembling the social: an introduction to actor–network theory*. Oxford University Press, Oxford
- Leeuwen T (2015) Multimodality in education: some directions and some questions. *TESOL Q* 49(3):582–589

- Lohr KD, Haley KJ (2018) Using biographical prompts to build community in an online graduate course: an adult learning perspective. *Adult Learn* 29(1):11–19. <https://doi.org/10.1177/1045159517735597>
- Marheineke M, Velamuri VK, Möslin KM (2016) On the importance of boundary objects for virtual collaboration: a review of the literature. *Technol Anal Strateg Manag* 28(9):1108–1122. <https://doi.org/10.1080/09537325.2016.1181744>
- Marull C, Kumar S (2020) Authentic language learning through telecollaboration in online courses. *TechTrends (Online First)*. <https://doi.org/10.1007/s11528-020-00488-2>
- Pappas C (2015) eLearning interactivity: the ultimate guide for elearning professionals. <http://elearningindustry.com/elearning-interactivity-the-ultimate-guide-for-elearning-professionals>
- Ross SM (2019) Slack it to me: Complementing LMS with student-centric communications for the millennial/post-millennial student. *J Mark Educ* 41(2):91–108. <https://doi.org/10.1177/0273475319833113>
- Smuts A (2009) What is interactivity? *J Aesthet Educ* 43(4):53–73
- Star SL (2010) That is not a boundary object: reflections on the origin of a concept. *Sci Technol Hum Values* 35(5):601–617. <https://doi.org/10.1177/0162243910377624>
- Star SL, Griesemer JR (1989) Institutional ecology, “translations” and boundary objects: amateurs and professionals in Berkeley’s Museum of Vertebrate Zoology, 1907–39. *Soc Stud Sci* 19:387–420. <https://doi.org/10.1177/030631289019003001>
- Sun PC, Cheng HK (2007) The design of instructional multimedia in e-learning: a media richness theory-based approach. *Comput Educ* 49(3):662–676. <https://doi.org/10.1016/j.compedu.2005.11.016>
- Voogt J, Fisser P, Pareja Roblin N, Tondeur J, van Braak J (2013) Technological pedagogical content knowledge—a review of the literature. *J Comput Assist Learn* 29(2):109–121. <https://doi.org/10.1111/j.1365-2729.2012.00487.x>
- Voss E, Kostka I (2019) Flipping academic English language learning: experiences from an American university. Springer, Singapore. <https://doi.org/10.1007/978-981-13-8657-2>
- Vygotsky LS (1978) *Mind in society: the development of higher psychological processes*. Harvard University Press, Cambridge
- Wagner ED (1994) In support of a functional definition of interaction. *Am J Distance Educ* 8(2):6–26
- Zhang D, Zhou L, Briggs RO, Nunamaker JF (2006) Instructional video in e-learning: assessing the impact of interactive video on learning effectiveness. *Inf Manag* 43(1):15–27