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Role of Epistemic Artifacts for Engaging in Collaborative Learning

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Abstract: Active learning (AL) instructional pedagogies involve collaborative activities that engage students in creating artifacts. Active Learning Classrooms (ALCs) are physical spaces designed to facilitate AL pedagogies. This study examined the artifacts produced within ALCs, which included physical affordances for collaboration and digital/analog technologies for sharing. By focusing on artifacts, the study analyzed the different practices that emerged based on the type of ALCs. Results showed that group-generated artifacts mediated within-group collaboration, regardless of ALC type. In high-tech ALCs that incorporate digital technologies, in addition, group artifacts mediated between-group interactions and generated new classroom practices including innovative AL pedagogical patterns and forms of communal knowledge building practices.

Introduction

Active learning (AL) pedagogies are student-centered approaches to teaching, that draw from social constructivist theories of learning. Growing in popularity, its instructional patterns range from evidence-based curricular approaches (e.g., Problem Based Learning), to simple group-work strategies (e.g., jigsaw, think-pair-share). AL pedagogy appears pragmatic in nature and, to date, research on the topic reveals that its main characteristic is the extent to which it prioritizes group work and collaboration (Charles et al., 2019).

Learners collaborate by generating joint problem spaces for building shared understanding (Teasley & Roschelle, 1993); frequently this results in the production of physical or material artifacts — e.g., worked problem solutions, annotated documents. While the act of creating artifacts anchors learners' collaborative efforts, the generated artifacts themselves act to mediate activity (Paavola & Hakkarainen, 2014). Artifacts can change the very nature of the ways students participate in a learning activity, as well as define the goals and means of said activity (Stahl, 2002). Moreover, when shared, artifacts play an important role in knowledge building by allowing groups of learners to coordinate and take up each other's ideas and view their ideas as communal (Hewitt & Scardamalia,1998).

Shared artifacts can be built through the use of computer-supported collaborative learning environments (Stahl, 2002). New digital fabrication makerspaces, accompanied by maker-centered pedagogy, also generate shared artifacts and expose socio-material aspects of collaboration as both process and practice. For instance, Riikonen et al. (2020) explore how artifact creation impacts the practices of the teacher and student groups within a makerspace, while Kajamaa and Kumpulainen (2020) examine how material artifacts mediate students' collaborative knowledge-building practices.

Active Learning Classrooms (ALCs) are other learning spaces in which artifacts are produced through material and embodied means and, therefore, should also be explored through a similar lens. In contrast to makerspaces, where a goal is to promote novelty (Riikonen et al., 2020), the goals of most ALCs are constrained by the course objectives, which often involve negotiating and refining shared norms and standards. As such, the artifacts produced in these two environments, and the way they mediate collaboration, are likely to differ. Thus, examining the practices emerging from the interactions between space, technology, people, and the artifacts they produce, offers opportunities to contribute to CSCL's understanding of collaborative learning.

Background

Stahl and Hakkarainen (2021), in writing about CSCL theories of cognition, suggest that new digital fabrication technology environments are moving us to consider factors such as how collective knowledge "is socially and materially distributed, temporally and socially emergent, and embodied, enactive, embedded and extended" (p. 5). These reflections posit that technology can be positioned as the mediator or actor of the learning — i.e., learning happens "through" the technology (e.g., Hewitt & Scardamalia, 1998) or happens "around" the technology (e.g., Kajamaa & Kumpulainen, 2020). Furthermore, these scholars propose we focus on the "enacted practices" that

evolve around the use of CSCL technologies, including innovations such as new pedagogical frameworks and associated guidelines. Our study does this by looking at ALC technologies.

Active learning classrooms definition and affordances

Extending on the definition of ALCs, such spaces promote the key aspects of AL pedagogies through the selection of furnishings. For instance, tables or clustered seating that create pods to facilitate discussion. Critically, the socio-material potential of the ALCs rests on whether they allow the co-creation of material artifacts, which typically involves group writable surfaces. These surfaces, in most cases wall-mounted, can be analog (what we call *low-tech*), or digital and interactive (what we call *high-tech*). However, the capacity for embodied actions, allowable through the devices for interacting with the boards (e.g., pens, multi-user touch, keyboards), may be an important factor in determining the practices that emerge in ALCs and were examined.

Orchestration involves the real-time management of resources and the situational awareness required to guide the students' learning in computer-mediated classrooms (Dillenbourg & Jermann, 2010). Classroom orchestration aptly describes the work done by AL teachers (Charles et al., 2019). Alavi and Dillenbourg (2012), extending on this concept, explored the use of a physical device, *Lantern*, to increase awareness of the information that is ambient within such classroom environments; and the role played by the device to provide timely feedback to both teacher and students. They show that Latern appeared to mediate the interactions and change the practices of the classroom; in particular, it promoted greater "intrateam" (i.e., within group) collaboration while facilitating "interteam" (i.e., between group) communication. But do other devices do this work of managing and regulating the ambient dimensions of knowledge in classrooms?

This study examined the interactions between space, technology, artifact, students, and teacher within the ecosystem of ALCs, and how these interactions change learning and instructional practices, keeping the above question in mind. In total we investigated three questions and used three methods.

Methods and analysis

This study was part of a two-year project examining AL pedagogy and the use of ALCs. The setting involved three large public junior colleges in Quebec, Canada. Nine ALCs in total were used, categorized broadly by their embedded technologies: (1) *high-tech* and (2) *low-tech.* Participants were 19 instructors from eight disciplinary fields, both teachers and students gave informed consent. This was a purposeful sample, with the selection of instructor participants contingent on their having prior experience teaching in ALCs.

Ethnographic methods were used for data collection of classroom observations — class recordings, field notes, student artifacts — as well as surveys and participant interviews. Each teacher was observed multiple times at different points in the 15-week semesters (~5 times/semester). A total of 157 observations were made from 33 course sections covering 13 courses from eight disciplines: physics, chemistry, biology, mathematics, psychology, history, humanities, and English.

Our data analysis involved (1) qualitative coding, followed by (2) a Latent Class Analysis (LCA; Vermunt, 2010) to explore the covariance of the coded observations, and (3) an interaction analysis of a specific case study. We start with the description of the qualitative coding and the LCA methods.

Analysis

The unit of analysis was the "collection" of activities (lectures, individual quizzes, and group problem solving, etc.) carried out over a class period (approximately 90 minutes). The artifact produced during these activities were classified using an *a priori* schema: (1) *Source*; (2) *Access*; (3) *Technology*; and (4) *Use*. Source described who generated the artifact, options were: individual vs. group. Access described the setting and whether the artifact was visible and accessible during its creation, options were: private vs. public. In particular, private artifacts were accessible (visible) only to its creators but not necessarily a personal object. Public artifacts were visible and physically accessible to both their creator and others. Technology described the media that produced the artifact, options were: analog vs. digital. Use described the temporal and functional nature of the artifact, when and why was it created; often this was confirmed only after the fact or in the teacher interview. New, artifacts typically were temporary, created in situ during the class period. Reused, artifacts typically were modified over time and produced in two phases: (1) drafts or information gathering; (2) expansions or refinements. Such artifacts were typically digital in nature. Finally, the entire observation was coded along these four categories based on the artifacts produced. This added a category level of *both* to describe class periods in which artifacts of different natures (e.g., an individual, analog, paper-and-pencil quiz followed by a public problem-solving activity on an interactive whiteboard) were collected during a single class period.

Results

Results show the following, for *Source* (individual/group/both), the majority of class activity produced artifacts classified as Group (62.5%); with Both (33%) and Individual (5%). For *Access* (public/private/both), half were classified as Both (50%); with Public (30%), and Private (20%). For *Technology* (analog/digital/both), the classifications were equally divided between the three modalities, Both (36%), Digital (34%), and Analog (30%). For *Use* (new/reuse/both), the clear majority are New (83%), with Both (10.5%), and Reused (6.5%). These artifact types reveal the practices used in the ALCs, and something about the pedagogical patterns.

LCA identified three dominant categories of observations (class periods), which made exploring the findings of the qualitative coding more intuitive —i.e., providing meaning to the patterns. Category A observations (41.2% of low-tech ALC observations, 11.5% of high-tech ALC observations) involved the production of artifacts classed as individual, private, analog, and not reused. Category C observations (25.5% of low-tech ALC observations, 46.2% of high-tech ALC observations) produced artifacts that were mostly group, public, digital, and reused. Category B observations (29.4% of low-tech ALC observations, 39.4% of high-tech ALC observations) involved the production of a mixture of different artifact classifications. Category C described an important finding that suggests something special about the high-tech ALCs, namely, its interaction with the instructor's practice of engaging students in group work using digital and public modalities. To elaborate on this significance, next, we provide a narrative of a typical observation (case study) that fell within the Category C.

Case study narrative

An example of Category C orchestrational pedagogical practice is shown in Figure 1 (a, b, c), a typical course taught in the high-tech ALC: a horseshoe design with six tables, each including an interactive board (T1 to T6). The content (generated artifacts) of each board is within a clear sightline of every group and access to the artifacts is unimpeded by the tables and other furnishings—i.e., the artifacts are public. In (a) and (b), all students are up at their respective board engaged in a problem-solving activity. Each group has one or more students writing on the multitouch surface with multiple pens, which allow for simultaneous inputs. Others from the group are pointing to the artifact, while others are looking on attentively—see students in the lower right of (a).

Turning to the teacher (green arrow in a, b, c), we describe a typical class sequence. Starting with (1a), the teacher watches the artifact generation of students at the board T2. He makes a few comments about their problem solution decisions, which initiates a debate among the group that ends with modification to the artifact. The teacher, seemingly satisfied with the new trajectory of the artifact, turns, scans the boards, and, within a few seconds, identifies his next move. He crosses the room and even before he arrives (1b), his finger is already pointing to the artifact on T6. He has a verbal exchange with those students who, like the T2, become animated as they modify their artifact. He lingers a while longer, then repeats this pattern, moving to another group.

Figure 1

Example of the pedagogical and artifact production practices that emerge in a high-tech ALC

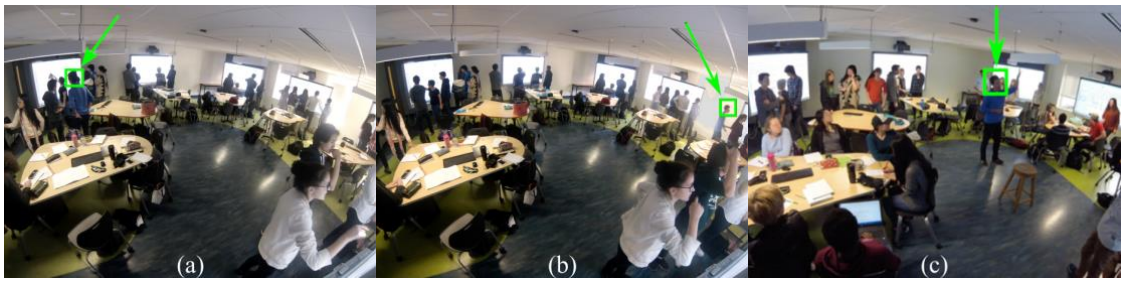

Figure 1c illustrates another enacted practice—orchestrating the activity by moving to the center of the room. Sometimes this would result in the teacher giving a just-in-time mini-lecture. More often, he would use this to engage in one of the practices of his repertoire. For instance, he might single out one or more of the artifacts and ask students to check those out. This would create a wave with students moving *en masse* to the boards in question; followed by between-group discourse patterns that included several instances of pointing to the artifacts and embodied gesturing of concepts. This modified "gallery walk" acknowledged the shared knowledge environment. Still other times, this same move (1c), would involve in another planned activity. For instance, a new strategy that looked a lot like "musical tables" and involved each group moving to the board of a neighboring group to complete their problem-solving work. Our post-class interviews confirmed that the teacher was aware of the public affordances and was deliberate in his designs that leveraged the distributed knowledge environment.

Discussion

This study explored three broad topics: the characteristics of artifacts produced in the ALCs observed; the impact of space and technology (ALC-type) on the types of artifacts created; and the implications of these interactions on the practices that emerge within the classroom ecosystem. We paid particular attention to a class of artifact-generating activities (category C) that were strongly associated with high-tech ALCs and argue that these appear to change the very nature of the ways students and teachers participated in the activity.

In these classroom environments, knowledge was distributed both socially and materially, and the "enacted practices" emerged around the use of technologies. Students in these environments took on new practices, demonstrating a new sense of agency by taking permission to learn from groups — interpreted as "cheating" in traditional instruction — similar to findings of Alavi and Dillenbourg (2012). This was mediated through the public artifacts that, while not persistent, emerged from social interactions and seemed to have a persistent impact on conceptual knowledge building between the students within their groups and, importantly, between the groups forming a knowledge ecosystem. This aligns with Hewitt and Scardamalia's (1998) observation that physical artifacts facilitate communal knowledge building in their computer supported environment. Shared public artifacts, created "around" technology, expand the zone of proximal development for students, enabling them to attend to other groups and the teacher as well as to receive just-in-time explanations. Technology affordances, such as reworkable shapes, text size, and color on interactive surfaces, enhance these practices by making information visible, manipulable, and reusable.

In this study, we also observed that public artifacts in high-tech ALCs change the ways in which teachers engaged in their AL pedagogies: releasing authority and giving students permission to learn from peers. The public artifact changed the class practice by changing the teacher's discourse — e.g., "You should check this out," that encourages between-group communication. At other times, it changed the instructor's orchestration and pedagogical pattern, adding explicit and invented strategies such as *musical tables*, and other forms of distributed problem solving. CSCL has often focused on how artifacts mediate student-to-student interactions. This study showed how public artifacts can also mediate group-to-group interactions, which in turn mediate group and whole-class knowledge building practices. Finally, these were all mediated by the unique affordances of high-tech ALCs.

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