Teachers as designers in computer-supported communities of practice

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ABSTRACT: School classes can be conceptualized as bounded communities of practice made up of teachers and students working together to build knowledge. Teachers make design decisions about physical and virtual spaces supported by information and communications technologies, and about curriculum. Design influences how students go about their work, and their learning outcomes, but its processes are rarely observed. This paper, based on observations and conversations in schools, explores how teachers engage in designing learning environments. It argues that while most teachers display leadership in design decisions for their classes, they should build on this experience to influence policy and become more involved in designing beyond the classroom walls.

Keywords
Communities of practice, computers in schools, teachers' roles, design

Introduction

Teachers in schools are often said to work in isolation, and if we consider their peers only to be other teachers, this is generally the case. Therefore, unlike other workplaces, it is sometimes unclear how the notion of a community of practice applies within the school setting. This paper conceptualizes each class as a community of practice in which experts and novices, all learners, work together to build knowledge across various domains. Community of practice is not a term to be used lightly. Practice, according to Wenger (1998), is the social production of meaning, and the source of coherence of a community. The specific practice that goes on in schools can be viewed as building knowledge, and through the learning process necessary for this practice, the community of practice emerges, with complex boundaries and peripheries. Wenger suggests that indicators of such a community include sustained mutual relationships, shared ways of engaging in doing things together, rapid flow of information and propagation of innovation, and knowing what others can do. Although each class is the potential site of a community of practice, it should not be considered in isolation but in relation to the rest of the world, including other parts of the school and beyond.

Within these communities, numerous design decisions are made by teachers. Discussing leadership roles in building learning organizations, (Senge, 1990) argues that the most important role is that of designer. While the functions of design are often invisible, he suggests that they must include clear purpose and vision, policies, strategies and structures, and effective learning processes. Social constructivist approaches to teaching and learning (Brooks & Brooks, 1993), and the access to information afforded by computers, require that teachers act as facilitators of student learning, rather than experts dispensing knowledge in a top-down fashion. Constructivism suggests that teachers and students interact with their context, so that they also contribute to designing the learning environment in which they operate. These learning environments comprise two broad arenas: the curriculum and the physical or virtual space.

This paper is based on research undertaken with classes using computers in schools in Victoria, Australia, between 2000 and 2003.

Designing Curriculum Activities

In a climate of increasing accountability for schools, many education systems provide curriculum standards and frameworks to guide the learning tasks set by teachers. In this study these were augmented by charts of suggested activities using computers (Board of Studies, 2000). Some critics believe that such frameworks allow teachers little control over curriculum content (Cuban, 1984; De Marrais & LeCompte, 1999), while others see them as flexible design spaces that can be filled with a wide range of learning activities devised by teachers and students (Hill & Russell, 1999; Petraglia, 1998; Scardamalia & Bereiter, 1999). In essence, the constructivist approach challenges teachers to create contexts that seem empty and open, but are in fact the result of a great deal of analysis,

organization and planning of possible interactions (Cuttance & Innovation and Best Practice Consortium, 2001; Zucchermaglio, 1992).

Having decided on appropriate tasks within the curriculum framework, teachers make further design decisions when choosing resources such as software. From a teaching and learning perspective, Leask and Pachler (2001) argue that generic software for word-processing, databases, and spreadsheets — which helps users to process information, engage in abstract thinking, make knowledge construction processes apparent, and build classification systems — is desirable because its emptiness allows space for thinking and learning, thereby encouraging creation of knowledge rather than merely consumption. However, Bednar, Cunningham, Duffy and Perry (1992) claim that much computer software is based on a behaviorist model incompatible with constructivist learning. In addition, Petraglia (1998) argues that educational software designers misunderstand constructivism if they do not involve the learners.

Designing Physical Space

The physical context in which teaching and learning takes place is frequently ignored in much of the literature on learning, according to Jamieson, Fisher, Gilding, Taylor, & Trevitt (2000). However an awareness of the interaction between people and space should be a consideration when designing the learning environment. On one hand, Pouler (1994) focuses on power relations, arguing that:

Space is neither innocent nor neutral: it is an instrument of the political; it has a performative aspect whoever inhabits it; it works on its occupants. At the micro level, space prohibits, decides what may occur, lays down the law, implies a certain order, commands and locates bodies (Pouler, 1994, p.175).

However Wenger suggests that while the context impacts upon the activities of teachers and students, their activities also act upon that context, in a "systematic, planned and reflexive colonisation of time and space" (Wenger, 1998, p. 228). This is his definition of design. But in relation to using and integrating computers, a non-participatory, top-down approach from outside the community could account for their lower than expected use in many schools.

In some education systems, the design of learning spaces is undertaken centrally. During the course of this study, the Department of Education and Training announced funding for schools to install computer 'pods', comprising five to six workstations in separate spaces but closely associated with teaching areas, so that students could have access to computers, overseen through viewing windows from a number of different classrooms. However, Pouler's argument regarding power was reflected in the Department's language of control and surveillance rather than an open approach to learning. It was reinforced by the funding requirements, which created a tension as school committees converted hallways and storerooms into pods (in the belief that their students deserved the computer resources) often with little consideration of, and little design support for, their particular space or learning needs.

Designing for a Learning Community

Wenger (1998) argues that designing education means creating an architecture that allows the formation of identities: a mutual development process between communities and individuals. He suggests that a learning community must do four things: push past its boundaries and interact with other communities of practice in a purposeful way; link participation inside with that outside the community; use the styles and discourses of the areas it wants to affect; and become involved in the organizational arrangements of its own institution. To encourage knowledge building in communities of practice, such as exist in the classrooms of a school, Wenger — like many constructivists — argues for a minimalist design: a framework bounded by shared language, expertise or rules, but with considerable internal space allowing for learning. Through two types of connections: boundary objects (artefacts, documents, terms, and concepts) and brokering (connections made by people) practices can influence each other.

While school classrooms are clearly physical communities that can be supported by online activity, once they start crossing boundaries the proportion of their activity conducted online increases, raising issues, according to Preece (2001) of sociability (how members interact with each other) and usability (how they interact with the technology). Sociability, she suggests, has three components: purpose, people, and policies, while usability refers to concerns such as support for dialogue, information design, navigation, and access.

Since teachers' daily work is not well-known, it can be difficult for designers to develop appropriate support for their needs. In their research, Carroll, Chin, Rosson, & Neale (2000) showed that considering teachers in classrooms as the users of technology, and involving them in its design in a long-term project, had the benefit of personal development for the teachers. They found that teachers moved through stages in their ability to contribute to the design of educational applications, from practitioner-informant to analyst stage.

The research reported here sought to better understand teachers' work, asking under what conditions, and how, teachers design an architecture that actively contributes to learning? Or, stated another way, how do teachers design and develop communities of practice in their current contexts? After a brief discussion of the research methods, some findings are presented, followed by a case study of a teacher-driven project that crossed community boundaries.

Method

Thirty-two teachers and principals from twelve schools (seven primary/elementary, five secondary) participated in this qualitative research over three years. All participants had a personal laptop computer subsidized by the Department, and all classrooms contained at least one computer for teacher and student use. In primary schools most rooms had four to six computers, and in some cases, particularly in secondary schools, there was one computer per student in the classes observed. A pilot study using classroom observations identified four roles — designing learning environments, managing people and resources, mediating learning and improving practice — but the focus in this paper is on the designing role, one which teachers reported requires considerable time and thought.

The research design included teachers as partners in the process, where the resulting knowledge was the output of a collective enterprise, to be shared (Freire, 1993; Thomas, 1993). As Carroll et al. (2000) suggest, an ethnographic method based on observation alone cannot reveal the perspectives and insights that users bring to development and design. In this study, regular observations focused on the teachers in a range of classroom types, and were enhanced by video recording which prompted later reflection, as a means of joint learning. Underlying this reflection is the notion of conversational constructivism, where reflection on personal experience becomes a learning opportunity and conversation itself is seen as a learning space (Baker, Jensen, & Kolb, 2002). Participants were therefore encouraged to join in group — rather than individual — conversations, wherever possible. Digital transcripts of conversations were returned to participants for further reflection, and this sometimes prompted email dialogue, while one group of teachers established an email list that included researchers. Some teachers kept electronic journals that they contributed to the research, and curriculum and school policy documents were also collected. Many photographs were taken.

Over 100,000 words of text and visual data were coded to identify emerging themes, of which several related to the teachers' role in designing learning environments. These were then held up to the scrutiny of Wenger's description of the characteristics of communities of practice. At this point some conclusions were drawn about the development of school-based communities of practice.

Findings

The teachers' role as designers was strongly influenced by the existence of structured physical environments — the design of which has changed little over one hundred years — and mandated curriculum frameworks that drove their daily interaction with students. They were, in effect, interpreters of these structures, and carried out this task to varying degrees. For most of the teachers in this study, the purpose of their work was expressed as teaching students how to learn. Yet, since the introduction of new technologies has changed the balance of power in the classroom community, teachers all expressed the view that they too were learners.

Designing the classroom learning environment

Most teachers were concerned with the on-site facilities available to them, and some were experimenting with communication links to parents, classes in other schools, and experts in industry. They had generally inherited traditional classrooms into which computers had been introduced, and their main concerns were to make this physical space suit the type of learning activities which they and their students wished to engage in. The classrooms ranged from the most flexible: those allocated to the teacher and class for most of their work, with one to six computers; to the least flexible: labs with up to thirty computers arranged for a whole class at one time. The latter generally had to be booked, often weeks in advance. In the middle of the flexibility range, some of the schools had created computer 'pods'. Figure 1 shows two typical pod settings: "A" shows three monitors in a windowless room between two classrooms, while "B" is a larger space with eight monitors between two classrooms with overlooking windows.
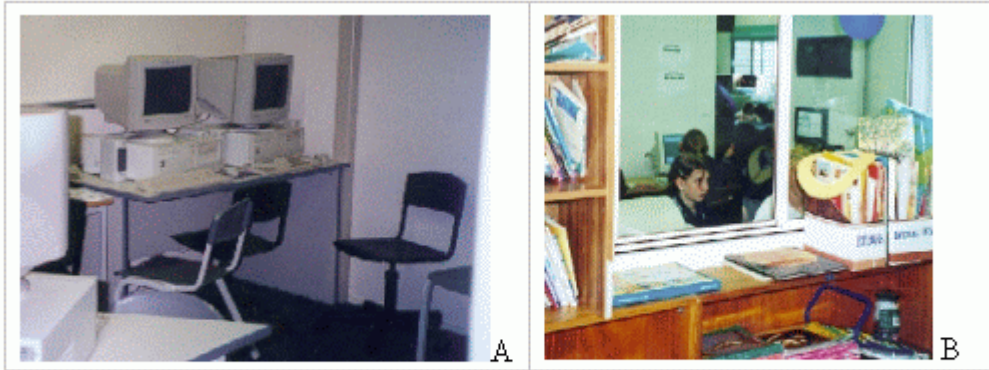
Figure 1: Two versions of the computer pod in primary schools. A: converted storeroom; B: space between two classrooms.

Students were generally able to move in and out of these pods as they needed to complete tasks. However dialogue and interaction between students and teachers, considered as an important aspect of the learning process, was affected. The space was not designed by the teachers and students who were to use it, but rather by a principal or a committee. Hence the teachers who were asked to work with pod "B" commented:

Female teacher: I don't like that situation; (looking at the small room) I'd rather be in a [class]room.

Male teacher: Being separate from that room you have to leave one room to go into another, so you lose contact with one room while you're in the other room and vice versa. And because it's so small and it echoes…

Others were frustrated by a failure to influence school decisions. Comments like this were frequently heard:

I still haven't got any technology down in the junior site, which was promised three years ago, and every time we consult someone, 'yes, it's coming, it's coming' or 'it's too expensive to change the wires'. (secondary teacher)

In all classroom types, teachers took advantage of the Internet and local area networks. This allowed for multiple perspectives and flexible learning, and a means of crossing the boundaries of classroom walls, home/school, and school/industry, among others. One teacher commented:

The classroom doesn't exist anymore. The four-walled classroom that is your domain has gone. It's an open access space that kids need to be able to access at most times (secondary teacher).

This attitude was supported by flexibility in school organization and timetable expectations. Technology allowed new ways of managing time and space, such as using networked computers to allow students and teachers access via password to material on shared drives from numerous points, and enabling home access to school Intranets. One teacher described this:

Having them networked so that you know if [the teacher] has got three kids in another classroom and they are wanting to access their file, they can do that through the network. So it doesn't particularly matter where the children are or who they are working with; they can access their information (primary teacher)

Collaboration is recommended in social constructivism, but there was no evidence that students in either primary or secondary settings were involved in collaborating with teachers in designing (rather than decorating) the physical space. In many cases, teachers themselves could make only modest changes to assist student collaboration in learning activities, as shown in Figure 2.

Figure 2: Computer labs in secondary settings

In "A", a lab space designed by the teacher to encourage collaboration away from the computers contrasts with "B", a lab of twelve computers created in a former storeroom, where students have little room to place the paper they are using to write answers to on-screen questions.

In many primary schools in this study, the walls were covered with colorful posters about learning and thinking, multiple intelligences, project steps, and questions students should remember to ask themselves about their work, such as "what have I discovered today that's new" and "what would I like to learn more about tomorrow?" The teachers and students displayed a sense of ownership and shared discourse. Often computers were placed on tables throughout the room, easily accessible on a just-in-time basis, as shown in Figure 3 (where the teacher is sitting on the floor surrounded by students).

Figure 3: Teacher- and student-designed classroom space in primary school

However, in spite of Wenger's suggestion that communities of practice should influence the organization of their institution, there was little evidence that teachers made an impact on the design of the physical environment except at the level of their own classroom.

Designing the curriculum

Curriculum frameworks can provide a clear structure for developing learning tasks and the opportunity for a common discourse that can support communities of practice. Teachers in this study frequently shared talk as they designed

class activities together. Those who used a constructivist approach had implicit guidelines for choosing appropriate software for building knowledge. A primary teacher articulated the argument of Leask and Pachler (2001) regarding the constructivist possibilities of generic software, naming programs that are relatively empty until manipulated by users:

In my mind, Years 5 to 8 — the middle years—are begging for four basic programs [Excel, Microworlds Pro, Front Page, Legodacta]. If our educators across Victoria could become expert with these four pieces of software I think we could move mountains (primary teacher).

Teachers used a range of methods to involve students in designing learning activities, from brainstorming topics of interest to negotiating contract tasks. They encouraged students to reflect on their skills and their learning needs to varying degrees, to give feedback to teachers, and to share their knowledge to benefit others by creating "a pool". Student comments were generally taken as important feedback in the teachers' design process, as one teacher described:

The children have been very active participants. We'll put something to them and they'll say 'that doesn't work, but this does.' So they've been very proactive, they always are (primary teacher).

In their efforts to design for authentic tasks, some teacher-brokers set up online relationships with outside experts as mentors, while in one primary school students designed web pages for external clients. A teacher reflected:

We wanted to boost [a student]'s confidence. The guy from the Rotary club was emailing him telling him what he wanted to do. So it was those two connecting, not me, so he had to do it and he thought 'Well someone else is depending on me now' (primary teacher).

In spite of physical difficulties and a lack of knowledge, teacher-brokers persevered with technologies such as video-conferencing because of the potential benefits to learning:

We could communicate with ourselves, with other schools, but we couldn't communicate with people in industry and we didn't know why. Now it took weeks, because of the security and the size of the bandwidth. I think with all technology, there's going to be things you come up against, but you don't think about first, and that's probably one of the difficulties. You're looking into the future, you're not sure of the specifications, how it runs, and even the technicians here hadn't used them before (secondary teacher).

Designing across communities of practice

As each classroom becomes a community of practice, in Wenger's (1998) terms it pushes past the boundaries to relate to other communities. In both primary and secondary settings in this study, teachers planned, but rarely taught, together, so that the traditional isolation appeared to be maintained. However, some who were experimenting with computers reorganized timetables to allow for two teachers within a school to work with one group, or for roving teachers to provide particular expertise. On a broader scale, teachers appreciated the online communities developed through web portals or through teacher-generated email lists that allowed peer-to-peer problem-solving: Where teachers saw a purpose for connecting outside the community, as Preece (2001) suggests, they were enthusiastic in doing so. One of the most highly-developed, 'joined-up' communities of practice in the study emerged as teachers in two primary schools, 150 kilometres apart, worked online to share curricula and professional development, as described below.

City to Surf: A Community of Practice

Teachers in two of the schools involved in the study initiated and implemented an integrated curriculum project that made use of their technology resources for student projects, while linking teachers in professional development. One school, in a suburb of Melbourne (City) had a long history of computer use, while the other, on the coast (Surf) had the necessary computer resources and the motivation to use them purposefully. Both had enthusiastic teachers and principals, and a general belief that the state-mandated curriculum frameworks provided a springboard, rather than a constraint, for their work (Hartnell-Young, 2004). Sociability was enhanced as the participants, encouraged by teacher-brokers in each school, had developed a model for their own learning based on social constructivism: encompassing experimentation, documentation, reflection and collaboration, and were ready to develop new ways of working. They therefore had a shared purpose.

The City to Surf model created a community of practice by crossing both horizontal and vertical boundaries within and between the two schools. Focusing on a curriculum topic such as Space, the principals of the two schools acted as brokers, communicating regularly by email and video-conference to plan, manage, and evaluate within a strategic framework, opening themselves to new ideas from outside. Similarly, teachers from both schools worked together to plan a unit of inquiry which could be undertaken collaboratively by students, and maintained a peer mentoring relationship throughout. The boundary objects that supported this practice include the statewide curriculum frameworks with their common language, the telecommunications infrastructure that supported voice and data transfer, and the schools' selection of open software such as Microworlds and NetMeeting. As novices (teachers and students) became more expert, they were encouraged to share particular skills and knowledge at the periphery. This purpose was articulated:

What we're attempting to do is move the learner from being a reader of that community to becoming a full speaker within it, and how they speak and how they act is different for each person (primary teacher).

Usability was more problematic than sociability for this community. Although each school had sufficient computers in classrooms, managing the use of resources was always an issue. Students were formed into teams consisting of three students from each school, and researched locally using a range of digital and print resources as well as linking regularly via email and video-conference with their counterparts in the other school. By creating time and space for action and reflection as time went on, teachers found that the quality of interactions increased. Students had been accustomed to participating in decision-making about project content, appropriate software, collaborative processes, production values and assessment of finished products, and needed time to discuss with the online team members. Video-conferences were therefore lengthened to allow for more dialogue, questioning, and feedback on the pieces of work presented by members of the distributed team. The share/collaborate function of NetMeeting software allowed students to view each other's developing products prior to merging them into one seamless presentation. Scheduling these conferences and making good use of the time available was crucial as bandwidth capacity was limited. One teacher described how the student video-conferences were managed:

The students have their information prepared, they're ready to get online and they've revised their questions, so one of the students is operating the mouse, one is operating the keyboard, and the mouse driver will also have the headphones on and be doing the speaking. The third participant observes and is involved as an information gatherer, reflector: a number of different roles (primary teacher).

Figure 4 shows this arrangement as students in the two schools communicated about their project, using the share/collaborate function of NetMeeting to complete the research tasks they set for the team.

Figure 4: Video-conferencing between two primary schools

Teachers discussed on-screen projects with students face-to-face, and at times, via the video-conference to the partner school. Students also used their experience to contribute to design, as this teacher described:
We wanted to create a student multimedia project evaluation rubric, so we kept putting information out to the kids, 'does this make sense, is this what you mean?'. Rephrasing the questions. And they've been responding to it the

whole time. The children have been very active participants in how we run a video-conference. They'll say 'that doesn't work, but this does' (primary teacher).

Wenger (1998) suggests that technology deepens relationships within a community of practice, and rather than replacing personal contact, facilitates written and verbal dialogue and connections to other communities. School-level support for sociability included the video-conferences, reflective journal-writing, and an email distribution list intended for sharing ideas and administrative messages. One school made regular time for journal-writing, which was a more private activity, and the resulting journals showed participants' varying comfort levels with the mode of reflection, as well as differing levels of reflection on substantive issues. Both schools had Intranets and websites for sharing school policies, events, and completed student work. Teachers believed that the video-conference was very successful, as it acted as a conduit for discussion with a peer and a window into each other's classrooms, thereby crossing a boundary and reducing the isolation between the individual classroom communities. As one teacher said:

The closed-door syndrome is really out there. Let's leave the door closed and get into the room. Teachers feel most comfortable in their own environment (primary teacher).

However, the interactions on the distribution list were often one-way information-giving, with replies returned to individuals, rather than to the group. One teacher suggested a reason for this:

Once you write on the distribution list, they know that you have to revise, edit, and make sure that what you've said is clear and accurate, so people avoid it if they can (primary teacher).
This tension between spontaneous and reflective comments in formal online environments has been previously identified by Sorensen & Takle (2001), and can inhibit knowledge building in a community. Nevertheless, the emergent City to Surf community of practice developed in other ways as members took advantage of the infrastructure provide by the Department, in the form of hardware and software, email and Internet connections, and professional development opportunities, but it was continually overstretching bandwidth allocations as teachers and students alike eagerly took up videoconferencing. In addition, both teachers and students requested face-to-face meetings where they literally met halfway to get to know each other, so several bus trips were required. One of the principals observed that flexibility in timetabling, time release, recognition of achievement, and ensuring of good hardware and technical support were costs in sustaining the community. The benefits included the opportunity for teachers to observe and communicate regularly with other teachers without leaving their school.

The City to Surf community existed in the Victorian state system, with similar technical infrastructure to other schools, and subject to the same accountabilities, but it took on design in a learning-centred way. The conditions that appear to support this approach include teachers' sound understanding of curriculum design frameworks, which allowed for shared discourse; involving students in design; shared purpose and active experimentation at all levels from students to principals; and working with researchers to reflect on and document practice. By bringing together classroom communities in two schools, they were able to push past boundaries and interact in a purposeful way, linking participation inside with that outside the community. Further, the teachers became involved in the organizational arrangements of their institution (Wenger, 1998). One teacher even commented that the "teachers build their rooms as they see fit", which while not literal, reflects a sense of the autonomy they felt. They were clearly moving through the stages noted by Carroll et al. (2000), albeit with little connection to designers. In Preece's (2001) terms, the sociability of the City to Surf community was high due to its clear and shared purpose, active involvement of people, and the influence of social norms ingrained in the culture of teaching. Usability was very much a work in progress, as teachers, inexperienced in designing for technology use, experimented with various configurations.

Conclusions

Teachers in this study spent a great deal of time planning for learning through curriculum activities and resources, and were confident of their expertise in the processes of teaching and learning. They were generally confident that, given space, they could work with students to build knowledge. They took on a role as designers within the constraints of space, as noted by Pouler (1994). The examples discussed here show teachers working in physical environments generally designed by others with very little consultation, limiting their scope to implement the constructivist approach that so many of them espoused. While they collaborated to design the curriculum, they were less likely to join forces to influence the design of the physical environment. Students were rarely involved in

curriculum design, and there was no evidence of students influencing the physical design of the school or classroom However, classrooms were bases for a wide range of connections to other resources, whether by telephone, Intranet, Internet, or physical movement. The furniture was often rearranged to suit different purposes and student movement was common. While teachers in this study used proprietary software and local networks to meet their purposes, they did not design their own software, nor was there evidence that they collaborated with designers of software or systems.

One of the strongest influences on the level of sociability (Preece, 2001) was the difference in culture and lack of connection between primary and secondary schools, raised by most teachers in this study. Although a broad view of collaboration in education would include links between teachers in primary and secondary schools, and this is an area of concern at both school and system level, there were few instances of this. Primary teachers had made more progress than their secondary counterparts in developing school-based communities that crossed classroom boundaries, as teachers and students made flexible use of time and space.

In both primary and secondary settings teacher-brokers made links with industry and the wider community. There was, however, little evidence of the teachers' practical experience and their reflections being documented within schools to inform design, and in some cases teachers felt that their experience was not valued.

Implications

The range of ways in which teachers interpret their roles and the influence of constructivism mean that a 'one size fits all' approach to designing learning environments is not appropriate. There is a clearly a rich resource in teachers' knowledge of, and experience in, using computers for learning, and that of their students, which needs to be available to influence future design. School- and system-level mechanisms to record this knowledge should be developed, so that decision-makers can draw on it to improve design policy and practice in its broadest sense. Design that supports teachers working in communities of practice appears to have potential to support both teacher and student learning, as in the City to Surf example.

Collaboration between teachers and designers as part of professional learning also has the potential to inform and improve student learning. This might involve architects, interior designers, and designers of systems, devices, and software. Further research that crosses the boundaries between the teaching and design communities in the pursuit of student learning is called for. A research model that also crosses boundaries, involving teachers, researchers, and designers in action and learning together, is appropriate for this task. Through this, new communities of practice may well emerge, focused on the shared purpose of designing learning environments.

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