Redesigning Classroom Learning Spaces: When technology meets pedagogy and when they clash

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Abstract: As educational institutions look to the future, there is growing interest in constructing technology-rich classrooms. Using a three-part study, this research examined the relationship between pedagogy and socio-technological spaces in a college-level physics course. The first part looked at the effect of implementing socio-technological environments on students’ conceptual change, while comparing implementations made with different pedagogies (active learning vs. ‘enabled-traditional’ instruction). The second looked at the students’ perceptions of this new learning space. The last examined the effect of the instructors’ perception of their instructional approach (teacher-centered versus student-centered) on students’ conceptual learning. Findings show that active instructional approaches are an essential condition for success of socio-technological spaces. Students who received an active learning pedagogy achieved greater conceptual gains and were more able to take up the affordances for learning of the environment.

Introduction
Interest in redesigning traditional learning spaces to promote greater student engagement and deeper learning has reached the science classrooms of institutions for higher education. Heralding this commitment to change are projects such as the Peer Instruction at Harvard, and Student-Centered Activities for Large Enrollment Undergraduate Programs (SCALE-UP) at North Carolina State University. Adoption of educational innovations is not without challenge particularly in regard to greater student engagement, i.e., active learning (e.g., Dori & Herscovitz, 2005). But with increasing interest in these socially-based technologically-rich classroom learning environments, new questions arise.

We examine the effect of designed technology-rich learning spaces on students’ conceptual change, comparing the impact of different instructional approaches — i.e., structured student-centered active learning instruction vs. enabled-traditional instruction (defined in the upcoming section). Second, we examine how students’ perceptions of the new learning spaces differed depending on the treatment condition. Third, we examine the effect of teachers’ perception of their instructional approach (teacher-centered vs. student-centered) on students’ conceptual knowledge.

Background
Student-centered active learning (referred to as AL hereon) has become a way to describe the type of pedagogy that is derived from both principles in constructivist and social constructivist theories of learning and knowing. It runs counter to traditional views of learners as passive recipients, and instructors as transmitters of information (Keyser, 2000). AL can be summarized as a pedagogical approach that engages students in the process of purposefully thinking, questioning and reflecting on specific aspects of their understanding while engaged in authentic activities that are domain-specific.

AL pedagogy acknowledges that it is important to consider the key ideas and practices described above when designing learning activities for a specific domain or field. For instance, in physics it is important for teachers to design activities that account for the difficulties students have when faced with conflicting models of the world, and promote the process of conceptual change (e.g., Chi, 2005).

Empirical studies of implementations of AL approaches in physics instruction show benefits such as more meaningful construction of knowledge and deeper understanding (e.g., Dori & Belcher, 2005). Research shows that AL approaches encourage students to take on more meaningful ways of learning, with implications on strategies used in the process of knowledge construction — i.e., deep approaches versus surface approaches (e.g., Marton, Hounsell & Entwistle, 1997).

Technology and Learning Spaces
When social constructivist theories inform educational reform not only do classroom activities change, but often, so too do the physical environments. Instead of rows of desks facing the front of the class, students sit and work together in circular pod-like groupings while the teacher circulates around the class, thereby providing students with easy opportunities of collaboration and group work. Such environments are generally rich in
technology thereby allowing for knowledge sharing, distribution and visualization – e.g., simulations, web access, online collaboration and sharing of notes. In the current study, the condition described as active learning in the socio-technology environment follows the above description.

It has long been argued that technology itself is not a substitute for good pedagogy (e.g., Clark, 2001). Recent meta-analyses, however, show that technology can be an effective tool when used in support of learners’ effort to achieve and not merely to present content (Tamim, Bernard, Borokhovski, Abrami, & Schmid, 2011). So what happens to learners when technology-rich learning spaces are used by teachers whose pedagogical approaches are best characterized as low to moderate in its student-centeredness? (We characterize this type of pedagogy as “enabled-traditional” because these teachers are willing to use new environments but still mainly use teacher-centered strategies). One possibility is that affordances for different forms of group work (e.g., cooperative or collaborative activities), created by the designed layouts of these new spaces, may of themselves improve learning outcomes. Another possibility is that the new environments can be either under-used or possibly misused if instructors are not fully committed to social constructivist pedagogical approaches - e.g., limited know-how, simultaneously holding opposing views on teaching and learning (more teacher-centered than student-centered beliefs). The current research also looked at teachers with different views of learning to determine whether the affordances provided by socio-tech environments enable them to promote students’ conceptual change.

**Connection Between Teaching and Learning**

There is a growing body of evidence suggesting a strong relationship between teaching and learning (Trigwell, 2010). These studies show that the approach to teaching and the design of the learning environment can substantially impact learning outcomes by influencing student’s approach to learning. Students who perceived their teachers as using a transmission approach (teacher-centered) often use a surface approach, while those who perceived their teachers as using a facilitator (student centered) use a deep approach to learning. The result of these studies was the production of the Approaches to Teaching Inventory (ATI; Trigwell & Prosser, 2004). The inventory is composed of 22-items on two scales – (1) conceptual change/student focused (CCSF) and (2) information transmission/teacher focused (ITTF) – represented by 11 items each.

Studies that have used the ATI show a correlation between the approach to teaching and a teacher’s repertoire of teaching methods (Gibbs & Coffey, 2004). Those results suggest that to change teacher’s approach to teaching may mean that we need to change how they understand teaching and learning and depends on how they see their role in the classroom. In the current study we used the ATI to establish where teachers might be positioned along a continuum in their approach to teaching and learning. This allowed us to examine the relationship between these self-reported perceptions and students’ conceptual learning.

**Methods**

This three-part study used a mix-method design described below. For simplicity, we refer to the enabled-traditional instruction simply as “Traditional” instruction and the socially-based technology-rich environment as “socio-tech.”

**Research Designs**

Part 1 was a quasi-experimental design assessing conceptual change in introductory physics students using the Force Concept Inventory (FCI; Hestenes, Wells, & Swackhamer, 1992). The FCI is a 30-item multiple-choice test made up of questions designed to reveal levels of conceptual understanding, and non-normative understanding, of Newtonian physics. It is arguably one of the most widely used assessment instrument in physics, which assesses conceptual change on the topic of kinematics and Newton’s Laws (McDermott & Redish, 1999). Students were given the FCI at the beginning and at the end of the semester. Pretest-posttest differences on the FCI allowed us to compare between the four groups in a 2x2 comparison: pedagogical approach (Active Learning vs. Traditional) by classroom settings (Socio-tech vs. Conventional). Summary of the research design is shown in Table 1.

<table>
<thead>
<tr>
<th>Classroom Setting</th>
<th>Pedagogical Approach</th>
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<tbody>
<tr>
<td></td>
<td>Active-Learning Instruction</td>
<td>Traditional Instruction</td>
<td></td>
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<tr>
<td>Socio-Tech classroom</td>
<td>Soc-Tech_AL (n=56)</td>
<td>Soc-Tech_Trad (n=51)</td>
<td></td>
</tr>
<tr>
<td>Conventional classroom</td>
<td>Conv_AL (n=49)</td>
<td>Conv_Trad (n=58)</td>
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Part 2 was a qualitative investigation based on focus group interviews. We conducted focus group sessions with students during their semester using a semi-structured interview format. Part 3 was a post hoc examination of whether or not there was a correlation between a teacher’s view of instruction (i.e., student-
centeredness or teacher-centeredness as assessed by the ATI) and their students’ average conceptual gain on the FCI.

Participants and Setting
Participants in Part 1 were first-year science majors at an urban Anglophone college in Quebec. They were generally between the ages of 17 – 19 years. The ratio of males to females was roughly 50-50. Intact sections of the introductory physics course were the focus of the study – from the Fall 2010 and Fall 2008.1

Part 2, we recruited 34 students to take part in focus group interviews in the Fall 2010. Approximately half of the students were from the AL treatment group, the other half made up of students from the classes of the other comparison group teachers – i.e., Traditional instruction. The gender spread was near equal with 16 males and 18 females in total.

Part 3 participants were six physics instructors. They form a representative sample of the physics faculty. Their teaching experiences ranged from 2.5 to 15 years.

Setting
In all cases, the research setting was the physics classroom – the socio-tech or the conventional classrooms. The socio-tech environment used in this study facilitates group work by organizing worktables into pod-like configuration seating four students, with one computer for every two students; and two interactive white boards that allow for knowledge visualizations. Note that in Part 1 the intact section, and its teacher, was assigned based on conditions described in footnote 1. For Part 2, all sections, and the respective teachers, were assigned to the same soc-tech environment.

Analysis and Results
Part 1 – environment and conceptual gains
Students’ end-of-semester FCI scores were compared between groups using an ANCOVA, taking the students’ beginning of semester FCI scores as a covariate. Results from these analyses allow for comparisons between groups while accounting for prior knowledge differences (i.e., what students know before instruction). In contrast, simple conceptual knowledge gains are calculated as the differences between pre-test and post-test scores. Given that such absolute change is constrained by ceiling effects, this study also used a normalized gain (Hake, 1998; normalized gain is calculated as: \( g = (\text{Post-test%} - \text{Pre-test%}) / (100\% - \text{pre-test%}) \)).

In the analysis of the FCI we address whether the affordances provided by socio-tech environments enable teachers with different views of learning to equally promote students’ conceptual change. Figure 1 shows the interaction of pedagogy and technology on students’ conceptual change. We found a significant between subject effects for Pedagogy (F value 28.808, p<0.001)]. That is, students in AL pedagogies achieve greater conceptual change, as gauged by their FCI gains, than students in traditional pedagogies. However, the socio-tech environment on its own had little impact on conceptual learning. Indeed, there is no significant difference between subject effects for Classroom (F=0.201, p=0.7). Our data therefore suggests that students have increased conceptual gains only when taught with a student-centered AL pedagogy.

The salient result is that without the accompanying student-center active pedagogy, the socio-tech environment failed to show improvement in learning (see Figure 1). Furthermore, students participating in the student centered AL pedagogy within the socio-tech environment were those that benefitted the most. Hence, the potential affordances to improve learning outcomes, provided by socio-tech environment, were realized only by teachers who adopted socio-constructivists views of learning to promote students’ conceptual change. Lastly, there is a non-significant trend suggesting that socio-tech environments, when not used with an appropriate pedagogy may be less productive than conventional classrooms. This needs further exploration.

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1 In an effort to maintain authenticity of the design we collected data over the course of several years. Data collection started with the AL teacher before there was a Socio-tech classroom (Fall 2008). It continued with teachers who could genuinely be categorized as unaffected by the zeitgeist of change (Fall 2009), when the room was first in use and there was little talk of pedagogical change. Lastly, data was collected from teachers who had had a couple of semesters to teach in the room.
Part 2 – student perceptions of socio-tech environment

In total 34 students who were taught in the new socio-tech environment were interviewed in groupings of 3-4 students. Of those interviewed 19 were taught by a teacher identified as using a high student-centered approach (high CCSF – AL group); while the others 15 were taught by teachers identified as using a medium to low student-centered approach (low CCSF – comparison group). This classification of teachers was made based on the results of the ATI questionnaire.

The interviews were video recorded, transcribed and coded by two raters using a grounded method (Glaser & Strauss, 1967). The unit of analysis was the student’s unique contribution (i.e., repeating the same statement/sentiment was not counted). Two categories emerged: (1) student’s perception of the classroom authority structure and role of the teacher (authority), and (2) perception of learning in physics (epistemic perceptions/beliefs). The latter category was composed of three sub-components of perceptions/beliefs about how one learns or uses what is learned in physics: (a) relates to real world phenomena (real world), (b) takes additional work outside of class (requires effort), and (c) requires access to a variety of experiences in the classroom (experientially mediated).

Both main categories revealed differences between the AL and comparison groups. Looking at category 1 (Authority), students in the AL group were twice as likely to view themselves as essential to the learning process (29% vs. 15%). These differences are also consistent with our characterization of teachers, which was based on their self-reports using the ATI. Category 2 (Epistemic beliefs) results showed larger differences between the AL groups and comparison groups (see Figure 2). While the AL groups were at least twice as likely to hold these sophisticated views of knowledge construction (epistemic views), these differences were not statistically significant.

Part 3 – teaching approach and conceptual gains

We also analyzed the correlation between ATI subscales (CCSF and ITTF scales) as self-reported by instructors and their students’ FCI gains. Our results show that the ATI scale of an instructor’s self-reported student-centeredness (CCSF scale) is very highly correlated with students’ conceptual knowledge gains on the FCI ($R^2 = 0.83$). By comparison, an instructor’s teacher-centeredness (ITTF scale) is poorly correlated with gains on the FCI ($R^2 = 0.11$). These results suggest that the greater the instructor’s degree of student-centeredness, the greater
the likelihood that students will achieve higher conceptual gains. However, instructors’ degree of teacher-centeredness does not impact (neither positively nor negatively) students’ conceptual change.

**Discussion**

Recent studies have reopened the issue of the role of technology in learning (Tamim, et al., 2011). The current study supports findings that show differences in learning is related to how technology is used, which appears to be influenced by a teacher’s approach to instruction. This approach also has an impact on what students learn and how they perceive their learning experience. Though all students in the Part 2 were taught in a new socio-tech environment only those in the high student-centered AL instruction showed significant increases in their conceptual knowledge, compared to those taught by teachers with medium to low student-centered approach. Providing students with opportunities and technological tools for engaging with each other is not enough to promote conceptual change if the teaching itself does not change.

Given that student-centered teaching was more effective at using new socio-tech environments, as shown in Part 2 of this study, it may be that teachers who use such approaches may also be more interested in using technology to support and create learning opportunities rather than using it to transmit content. Therefore, while there is still a lot to learn about effective design of these new technology-rich learning environments, that leverage social engagement, one thing stands out, investments in teachers’ pedagogical knowledge should go hand in hand with investments in these new spaces. Their interest in learning how to use the technology affectively will follow (i.e., techno-pedagogical knowledge). Additionally, the ATI may be an effective and easy way to assess teacher’s readiness to take on the challenges of teaching in such spaces.

**References**


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