THE ADOPTION OF SOCIO-TECHNOLOGICAL ENVIRONMENTS TO DRIVE CLASSROOM CHANGE

In 2006, the Ministère de l'Éducation, du Loisir et du Sport (MELS) [Department of Education, Recreation and Sport] launched its efforts to change the face of science instruction in Quebec. On the basis of years of research in educational psychology and the learning sciences, the MELS implemented the Programme de formation de l'école québécoise (PFEQ) [Quebec Education Program], the main goal of which was to reframe teaching as a process of engaging students in instructional activities including providing opportunities to learn through inquiry-based projects and collaboration with their peers. This type of approach, often referred to as "active learning", is informed by social-constructivist theories of instruction.[1]

At the same time, there has been a growing trend toward redesigning classrooms to optimize the advantages of the pedagogical changes inspired by this expanding understanding of how to improve learning. As teaching moves to a student-centered approach, instead of a teacher-centered process, traditional classroom designs are called into question. New designs, which we refer to as "socio-technological" environments, eliminate the teacher's podium at the "front" of the classroom and students work together in small groups; often around circular tables. Furthermore, these environments often use new technologies that support students' engagement and increase their involvement in the learning process – for example, computer-based simulations, interactive technologies. Here in Quebec, as elsewhere, we have observed a growing interest to replace conventional learning spaces with socio-technological environments. An article in the *New York Times*, entitled "At M.I.T., Large Lectures are Going the Way of Blackboard", was an early indicator of this trend going mainstream when they discussed the technological remodeling of classrooms and conference rooms in various major U.S. universities (Rimer, January 13, 2009). The best known examples include Harvard's Peer Instruction project (headed up by Professor Eric Mazur), M.I.T.'s Technology Enabled Active Learning (TEAL) project (directed by Professor John Belcher), and the Student-Centered Activities for Large Enrollment Undergraduate Programs (SCALE-UP)[2] project (presided over by Robert J. Beichner from North Carolina State University and Jeffery M. Saul from the University of Central Florida).

Considerable evidence now exists supporting the effectiveness of active-learning as a pedagogical approach, though there is still much to learn in regards to optimization of this new way of instruction and how its implementation affects the learning outcome. When it comes to the topic of innovations in classroom design – i.e., the socio-technological environments – many questions are yet to be answered. In particular, questions about their impact on learning and teaching. The objective of the research project[3] described in this article was therefore twofold:

- **To determine whether (and how) active-learning pedagogies and socio-technological environments influence students' conceptual understanding of an introduction to physics; and**
- **To examine how teachers have adopted active-learning pedagogies and socio-technological environments.**

[1] Active learning includes activities related to the various ways in which this approach is implemented: Think- Pair-Share (peer instruction) activities; problem analysis and solving (problem- or project-based learning (PBL), learning by design (LBD), inquiry-based instruction); and less structured activities (Just-in-Time Teaching, reflective journals, and other writing exercises).

[2] In connection with the SCALE-UP project, see KINGSBURY. F. 2012. "The SCALE-UP Project: A Teaching Revolution from the South," *Pédagogie collégiale* 25.3 (Spring): 37-44 [aqpc.qc.ca/en/journal/article/scale-project-teaching-revolution-south].

[3] The study in question is available at [cdc.qc.ca/parea/787902-charles-et-al-tic-pedagogie-active-dawson-john-abbott-vanier-PAREA-2011.pdf].



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PROBLEM STATEMENT

In studying how active-learning techniques and new socio-technological environments, we identified two distinct perspectives: that of the student, and that of the teacher.

THE STUDENT'S PERSPECTIVE

Until recently, student-centered active pedagogies have been used primarily at the elementary level and secondary level (Blumenfeld *et al.*, 2000). At the post-secondary level, however, there have been only a few large scale implementations. One such case is the project at Harvard in the physics classrooms of Professor Eric Mazur (Crouch and Mazur, 2001). His experimentation with active learning involves high achieving and highly motivated students who may or may not be typical. Other trails of active learning at the post secondary levels have involved small groups that had been carefully selected or identified in accordance with specific criteria. Therefore, we need to know more about when active learning works and for whom. Yet to be addressed are questions such as: What are the effects of these techniques if applied to different segments of the student population? Does their effectiveness depend, for example, on differing levels of prior knowledge? Does it vary with gender?

One of the major characteristics of this new pedagogy is that it has been accompanied by a reconceptualization of the learning environment and the use of technology aimed at facilitating collaboration among students. While these new environments appear extremely attractive, to date there has been little formal research to support their effectiveness. Importantly, such new spaces raise questions that older studies on the effectiveness of technology cannot answer. In particular, those studies stressed the fact that technology alone does not ensure improvements in learning (Clark, 2001). Socio-technological environments constitute spaces in which technology and classroom design are inter-dependent. In as much, there is likely to be an interaction between these two last factors, which will raise new issues not dealt with by older studies.

Accordingly, we need to learn more about the effect of active-learning approaches and socio-technological environments at the post-secondary level. In so doing, we will be able to develop learning environments that promote greater engagement among students and reflection on what is being learnt thereby fostering deep and meaningful learning

THE TEACHER'S PERSPECTIVE

Preparing teachers and supporting them in their efforts to adopt new pedagogies and to use new technologies constitutes a major challenge, especially as these changes require a redefinition of their role as professionals. According to Dillenbourg and Fischer (2007), in the transition to student-centered education, it would be simplistic for teachers to see their role as changing from that of "sage on the stage" to that of "guide on the side". With re-conceptualized classroom design, teachers are no longer simply "saying" that their courses are active, but rather "showing" the kind of thinking and reflection students need to demonstrate in order to learn. In this model, students are at the heart of socio-cognitive processes: they are seen as "cognitive apprentices" (Collins, Brown, and Newman, 1987).

> *The role of teachers is to orchestrate classroom activities, a responsibility they must assume without being at the centre of the instruction.*

The role of teachers is thus to *orchestrate* classroom activities, a responsibility they must assume without being at the centre of the instruction (Fischer and Dillenbourg, 2006). Teachers must create opportunities for learning that encourage student participation and the use of the related tools and artifacts.[4] In a physics course, for example, students could be asked to establish the causes of an automobile accident, using mathematical tools and measuring instruments to stage the appropriate scientific demonstrations.

Successfully implementing such changes raises a number of important questions, and answers are urgently needed. In order to effectively launch active-learning pedagogies, what skills must teachers master? What do such methods mean to them?

Because the question of how teachers view their classroom role is closely tied to the cultural traditions to which they

[4] This term, which is more often used in the field of anthropology, refers to a cultural product and, in the present context, designates scientific-culture objects (cognitive or other) produced by students.

belong, those traditions are extremely significant. The world of education is steeped in cultural traditions that have convinced many that the teacher-centered method is best. Yet, several recent students clearly show that this approach may impede deeper learning (Biggs, Kember, and Leung, 2001; Kek, 2006; Kim and Branch, 2002; Trigwell, Prosser, and Waterhouse, 1999). (These findings stem from classroom-based data, not from data collected from individual students.) In addition, teachers wishing to modify their instructional approach are often confronted by systemic and personal obstacles (Laferrière and Gervais, 2008), and may end up wondering: "If teacher-centered methods helped me learn when I was at school, why wouldn't they work with my students?". The problem, however, is that students do not necessarily have similar learning styles to those who have been successful in an academic career. In short, the model of success in school relies more on having similar learning styles to those of the teacher, which often involves high levels of self-regulation and knowing how to learn on one's own. But, it's the point of education to help those who do not have these skills. The point of active learning to exactly that, to help demonstrate how to learn not just what to learn. This tension between teachers' personal learning experiences and the new pedagogical paradigm – i.e., active learning – constitutes a so-called "epistemic" contradiction.

The questions raised by the portion of our study focusing on teachers are related to the process involved in preparing and supporting these professionals while they acquire the skills, experience, and expertise needed to effectively adopt active-learning pedagogies and socio-technological environments.

How teachers view their classroom role is closely tied to the cultural traditions to which they belong.

A TWO-PART STUDY

Because we were interested in both the students' and the teachers' perspective, our study was divided into two parts. The first part was aimed at verifying if the learning of scientific concepts was influenced by the adoption of student-centered active learning. We asked the question, what role do socio-technological environments play in this type of learning? In addition, what is more important: technology or pedagogy?

The second part explored teaching practices, in order to answer such questions as: How are teachers implementing active-learning techniques? In what ways have they embraced socio-technological environments? We also examined the factors that allow teachers to use the latter effectively.

PART ONE STUDENT LEARNING

This aspect of our research also involved two parts. First, was a quantitative study, which compared the conceptual learning[5] produced by two competing educational approaches: student-centered active (AL) pedagogies, which, as the name suggests, help students play an active role in the learning process versus traditional teacher-centered didactic pedagogies. The study consisted of 407 first-year science students[6], approximately half in each of the two comparison groups. All participants in this study were enrolled in an introductory-physics course[7]. They were between the ages of 17 to 19 and the two groups contained approximately the same number of males as females.

Next, we conducted a qualitative case study to analyze if students' perceptions of the socio-technological environment depended on the teaching approach adopted (i.e., AL or traditional). We conducted two targeted interviews with 34 students (16 males and 18 females) in the two groups (AL and traditional).

PART TWO EDUCATIONAL PRACTICES

To understand the teachers' educational practices, in addition to a series of qualitative interviews, we carried out a case study involving six physics teachers and studied their pedagogical practices in the new socio-technological environment – i.e., how did it change or how did it stay the same. Importantly, all six teachers were keen to incorporate aspects of active learning into their courses, even if most had never taken part in formal professional-development activities.

This research involved the observation of these teachers' classroom practices and interviews. In addition, we asked them to fill out the Approaches to Teaching Inventory (ATI) (Trigwell and Prosser, 2004). This tool, which helped us analyze the relationship between teaching and learning, involves two scales—one that enables teachers to assess the extent

[5] Conceptual learning was assessed using the Force Concept Inventory (FCI) (Hestenes *et al.*, 1992). This test is composed of 30 conceptual physics questions requiring no calculations. In the teaching of physics, the FCI is viewed as a valid, reliable instrument (Lasry *et al.*, 2011) and the "most widely used and thoroughly tested assessment instrument" (McDermott and Redish, 1999).

[6] Fall students for 2008, 2009, and 2010.

[7] "Physics NYA: Mechanics".

to which their practices are student-centered, and another designed to help them evaluate the degree to which their approach is teacher-centered. The results of the questionnaire allowed us to establish all six teachers' perception of their practices.

We found that, regardless of classroom design, conceptual gains were greater for students whose teachers used an active-learning approach than for students whose teachers preferred a traditional approach.

RESULTS

PEDAGOGY IS MORE IMPORTANT THAN TECHNOLOGY

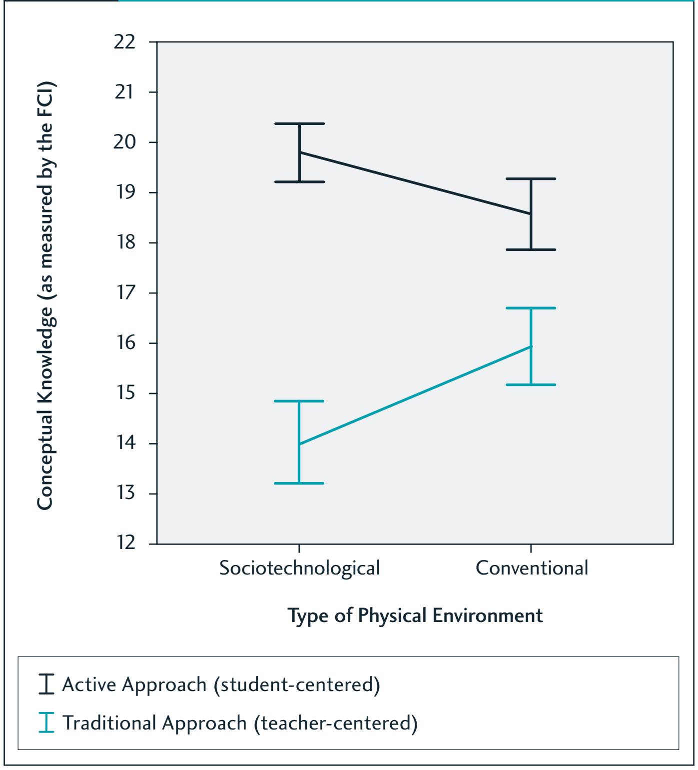
Figure 1 below shows that the relationship between the extent of conceptual learning (FCI conceptual gains, y axis) depends on classroom design (socio-technological or conventional, x axis) and learning type (AL (black) or conventional (orange)). We found that, regardless of classroom design, conceptual gains were greater for students whose teachers used an active-learning approach than for students whose teachers preferred a traditional approach.

The adoption of a socio-technological environment had no impact on conceptual learning when used outside an active-learning context. Even more importantly, Figure 1 indicates that, in the absence of student-centered active learning, the adoption of a socio-technological environment may even be counterproductive. An in-depth analysis shows that this is particularly true for students with less prior knowledge, as well as suggesting that socio-technological environments may represent a greater "cognitive load" for these students. This issue must therefore be examined more closely in order to offset possible cognitive-load problems in such environments.

Another significant result was that students who benefit most from student-centered active learning did not, as one might have expected, have a high degree of prior knowledge (like those from Harvard or MIT)—an argument contradicting statements to the effect that student-centered techniques are most effective with high-achieving students from elite institutions.

Our findings showed that pedagogy is more important than classroom design. The biggest impact a teacher can have on his or her students is via student-centered active learning. Once this approach has been adopted, reconfiguring the physical environment can be productive.

FIGURE 1 — IMPACT OF PEDAGOGY AND PHYSICAL ENVIRONMENT ON CONCEPTUAL LEARNING*



* Margin of Error: +/– 1 SE

CAPTION FOR FIGURE 1

AL (black line) makes for more conceptual gains than conventional techniques (orange line). The use of a socio-technological environment produces optimum conceptual gains only when used jointly with AL. In the presence of traditional approaches, the socio-technological environment is less effective than conventional environments.

TEACHING APPROACH RESULTS IN MAJOR DIFFERENCES

Turning to the qualitative case study involving students who had been exposed to socio-technological environments. This study highlighted several major differences between students who had been taught via a student-centered active-learning approach and those who had received a "traditional" education. These differences can be divided into three categories: perceptions of classroom learning, perceptions of physics instruction, and perceptions of the teacher's role.

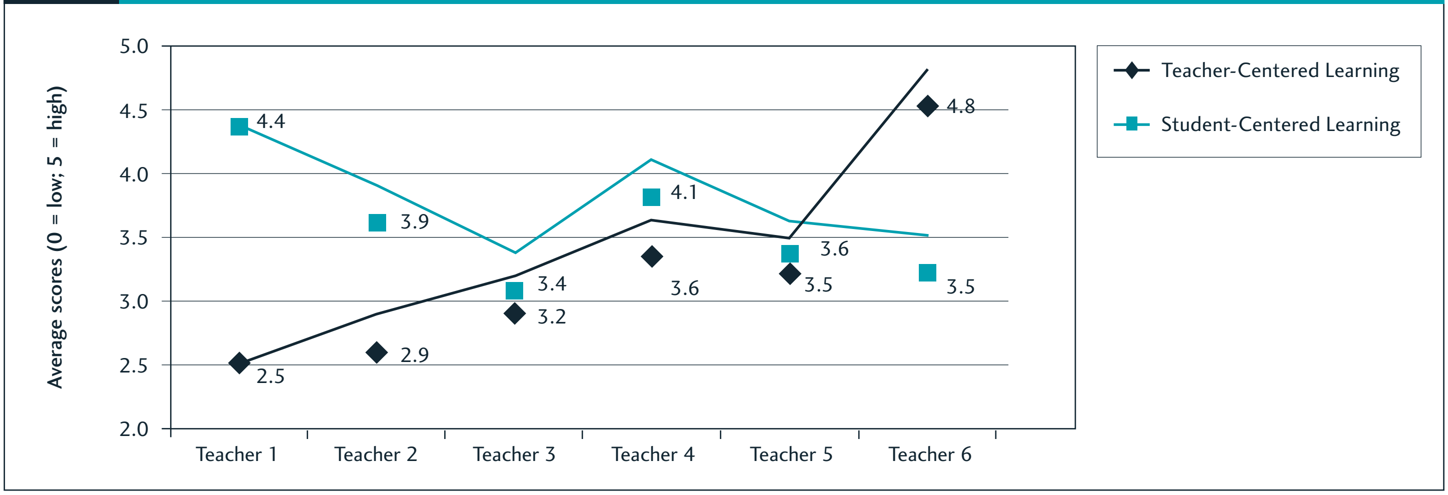
— Perceptions of Learning in a Socio-Technological Classroom

Our results showed that students who had been exposed to the student-centered active-learning approach have a concept of in-class learning that differs from that held by students whose education had been traditional and teacher-centered. The latter reported four times more often that classroom participation did not contribute significantly to the learning process, and felt the teacher was responsible for what they did learn in class. The former, however, were twice as likely to consider learning a process requiring their participation and interaction with peers. In other words, those taught with active learning pedagogy felt they were responsible for working with others, and appreciated learning and peer instruction. For example, one student said the experience of having to explain a physics concept to his classmates and defend his point of view proved crucial to his learning experience. Another stated that the student-centered course had helped him develop interactive skills within a group, and that these skills would be an advantage in other circumstances.

— Perceptions of Physics Instruction

With respect to physics instruction, there were also differences between the two groups of students. Those who had been exposed to the student-centered active learning approach spontaneously mentioned having had the chance to apply what they had learned in class to other "real-world" situations. However, this type of anecdote was lacking in the second group – i.e., the teacher-centered pedagogy. These results are consistent with those of other studies that show that, with traditional pedagogies, students generally tend to separate what they learn in their science courses from their day-to-day lives (Entwistle, 2010). Students from the active learning pedagogy also mentioned having learned a great deal from various classroom activities requiring more effort on their part, a fact that might suggest they had become aware of the importance of "effort" in the learning process. Students in the second group, however, made no such comments in their interviews. Lastly, students in the active learning group said that frequent demonstrations—i.e., the fact of participating actively in such endeavours by making predictions and discussing findings—had had a major impact on their comprehension. In this regard, they were referring directly to the value of the socio-technological environment, and how that environment facilitates demonstrations and interaction. The "traditional" group made no such comments.

FIGURE 2 TEACHER SELF-ASSESSMENT OF DEGREE OF STUDENT- OR TEACHER-CENTEREDNESS



CAPTION FOR FIGURE 2

The more the teacher feels his or her instruction is student-centered (in black), the less he or she sees that instruction as teacher-centered (in blue).

— Perceptions of the Teacher's Role

This factor was mentioned twice as often by the active-learning students than their traditional counterparts. The former more frequently mentioned the importance of having an enthusiastic teacher able to provide follow-up and take students' personal and academic success to heart. They realized the importance of efforts made in demonstrations, and appreciated the impact of these activities on learning, commenting that demonstrations helped give the subject matter a visual dimension and involved an educational objective other than entertainment. The students also enjoyed it when the teacher divided the course into different segments in order to make it more interesting.

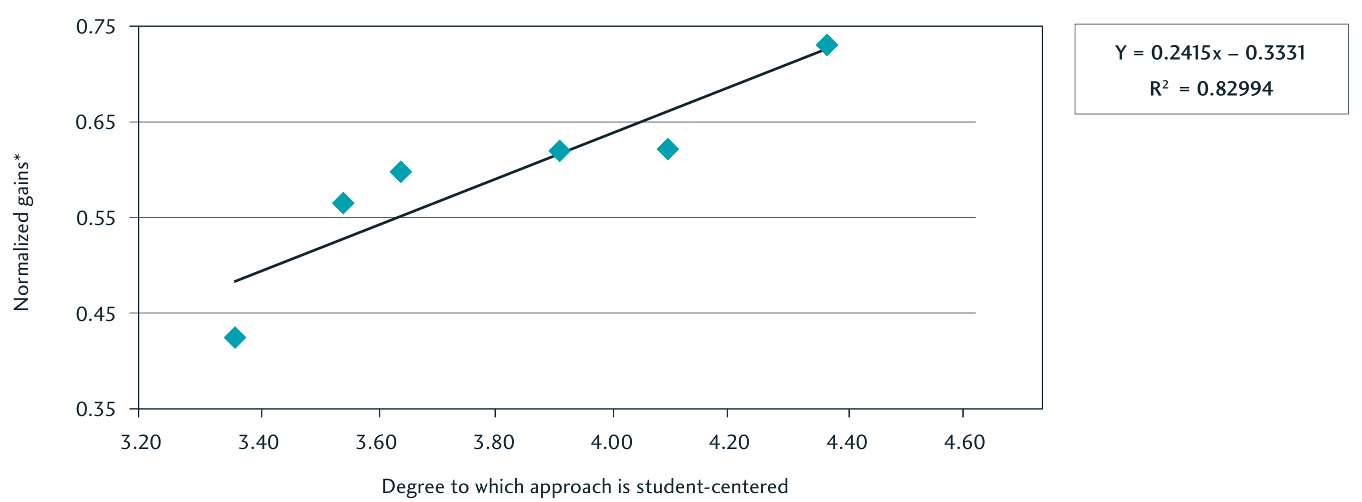
We also collected ATI data, which show the degree to which each teacher saw his or her approach as student-centered or teacher-centered. The results enabled us to classify the teachers on a continuum, from least to most student-centered. Independent of the teachers' perceptions as measured by the ATI, our research team also assessed the teachers and placed them on the same continuum. The ranking produced by the ATI displayed a clear correlation between this instrument and the qualitative observations made during the classroom observation of the teachers' educational practices, thereby corroborating the validity of the ATI as a method for evaluating their approach.

As concerns the ATI data, we found a high correlation between the results of the inventory and students' conceptual gains as measured by the FCI (Figure 3). In other words, the more teachers described their approach as student-centered, the greater the conceptual gains noted in their classes. This finding is surprising, as it reflects teachers' perceptions on one hand, and students' conceptual learning on the other.

The results in Figure 3 indicate that 83% of the variance in conceptual gains was apparently attributable to the degree to which teachers perceived their instruction as student-centered. These results lead us to ask the questions: Does this mean an impact on conceptual learning could be produced simply by modifying teacher perceptions? Would helping teachers realize the importance of focusing their instruction on students be enough to enhance conceptual learning?

While unexpected, this finding does corroborate an ever-increasing number of observations to the effect that student-centered pedagogies produce greater conceptual gains (see

FIGURE 3 — CORRELATION BETWEEN CONCEPTUAL GAINS AND TYPE OF PEDAGOGY (STUDENT OR TEACHER-CENTERED)



* The higher the score, the higher the degree of student-centeredness.

CAPTION FOR FIGURE 3

There is a high correlation between student conceptual gains (y axis) and teacher self-evaluation (x axis) as to the degree of student centeredness.

Trigwell, 2010). Lastly, we should mention that the socio-technological environment has had a positive impact on many teachers, seeming to support them in their efforts to modify their approach.

Students who had been exposed to the student-centered active-learning approach more frequently mentioned the importance of having an enthusiastic teacher, one who was able to provide follow-up and take students' personal and academic success to heart.

CONCLUSION

We studied the impact of active learning and the adoption of socio-technological environments on students' conceptual learning and their teachers' perceptions. Our main finding is that the pedagogical approach used is paramount and if teachers hope to improve their students' learning then an active learning pedagogy is recommended. The adoption of new socio-technological environments absolutely must be accompanied by the adoption of active learning techniques, if all the advantages offered by this approach are to be realized.

While these new environments in themselves cannot improve learning, they may facilitate the achievement of other benefits when accompanied by student-centered active learning. Moreover, socio-technological environments support the efforts of teachers who hope to modify their approach. Investing in educational technologies could therefore prove useful, if only to encourage teachers to re-examine their methods and adopt student-centered active learning.

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