

Changing Classroom Designs: Easy; Changing Instructors' Pedagogies: Not So Easy...

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Abstract. Technology-rich student-centered classrooms such as SCALE-UP and TEAL are designed to actively engage students. We examine what happens when instructors adopt the classroom but not the pedagogy that goes with it. We measure the effect of using socio-technological spaces on students' conceptual change and compare learning gains made in groups using different pedagogies (active learning vs. conventional instruction). We also correlate instructors' self-reported instructional approach (teacher-centered, student-centered) with their classes' normalized FCI gains. We find that technology-rich spaces are only effective when implemented with student-centered active pedagogies. In their absence, the technology-rich classroom is not significantly different from conventional teacher-centered classrooms. We also find that instructors' self-reported perception of student-centeredness accounts for a large fraction of the variance ($r^2=0.83$) in their class' average normalized gain. Adopting student-centered pedagogies appears to be a necessary condition for the effective use of technology-rich spaces. However, adopting a new pedagogy seems more difficult than adopting new technology.

Keywords: Classroom design, architecture, SCALE-UP, TEAL, technology, pedagogy.

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INTRODUCTION

Traditional classroom settings are teacher-centered. They place instructors at the front of the classroom with all students facing the instructor. This traditional classroom architecture is implicitly based on a 'transmission' model of learning: an expert transmits knowledge to attentive novices. Much of the physics education literature has been devoted to developing student-centered pedagogies¹ that are shown to be more effective than traditional teacher-centered approaches such as lecturing^{2, 3}. Classroom lectures have been particularly criticized, at least since Blight's 1972 book: *What's the use of Lectures?*⁴ Initially constrained to teacher-centered class architectures, pedagogical approaches were developed to enable student-centered learning in these settings. For instance, approaches such as Peer Instruction^{3, 5-7} were developed to engage students in a lecture hall and enable them to co-construct knowledge by pairing and sharing their conceptions. These student-centered

active-learning approaches are quite effective, despite being constrained to teacher-centered classroom architectures. Classrooms can be redesigned to fully support student-centered active collaboration. Among designs that have been well documented to support student centered pedagogies are *Student-Centered Activities for Large Enrollment Undergraduate Programs* (SCALE-UP)^{8, 9} at North Carolina State University and Technology Enabled Active Learning (TEAL) at MIT^{10, 11}. We choose not to distinguish between SCALE-UP, TEAL and the implementation of the classroom design that we studied. We focus on the similarities between these architectures and collectively call these designs *socio-technological spaces* because the technology facilitates social collaboration and the co-construction of knowledge.

In this study, a socio-technological space was presented to instructors as a classroom architecture

that facilitates collaborative approaches and more generally student-centered pedagogies. However, a number of instructors that adopted the socio-technological classroom did not effectively adopt the pedagogy it was designed to support. We examine what happens when instructors adopt the technology-rich classroom but not the student-centered pedagogy it supports.

STUDY DESIGN

We compare two classroom architectures used with two types of pedagogy. Classrooms were either redesigned socio-technological spaces (e.g. TEAL) or traditional teacher-centered classrooms. Pedagogies were either student-centered or conventional teacher-centered. Researchers assisted a few classes from each of the six participating instructors to determine whether the pedagogies used were conventional or student-centered. The six participating instructors were also asked to complete a self-report instrument on how teacher-centered or student-centered their instruction was. This instrument, the *Approaches to Teaching Inventory* (ATI)¹² is composed of 22-items that can be broken down into two sub-scales – (1) conceptual change/student focused (CCSF) and (2) information transmission/teacher focused (ITTF). Each subscale comprises 11 items. ATI results were used along with researchers’ observations to establish where teachers might be positioned along a continuum of teacher-centered to student-centered.

Students participating in this study were enrolled in a first semester introductory mechanics course. Students’ conceptual learning was assessed using the *Force Concept Inventory*¹³ during the first and last week of the term. We then calculated average normalized gains for each section². We also performed a complementary analysis of covariance (ANCOVA) to determine whether groups differed in FCI scores at the end of the semester (post-test), taking their incoming (pre-test) scores as a covariate. FCI data from three years were aggregated - F08, F09 and F10. In total we collected data from 214 students in the four groups examined (see Table 1). Finally, we examine the relationship between the ATI (instructors’ self-reported student-centeredness and teacher-centeredness) and the normalized gain for each instructor’s group.

TABLE 1. Number of students in four groups studied

	Socio-Tech Classroom	Conventional Classroom
StudentCentered ActiveLearning	56	49
Teacher-centered Instruction	51	58

RESULTS

We begin by comparing the average normalized gains obtained by students in Active Learning versus traditional teacher-centered instruction. As expected², we find that Active Learning pedagogies produce statistically greater learning gains than traditional teacher-centered pedagogies. When comparing classroom designs, we find no statistical difference between the average normalized gains obtained by students in socio-technological classrooms and the gains obtained in conventional classrooms settings. However, an interaction seems to be present. Socio-technological classrooms architectures yield both the greatest and smallest average normalized gains. Indeed, the largest normalized gains are found in socio-technological classrooms that use Active Learning pedagogies; The smallest normalized gains are found in socio-technological spaces that use traditional teacher-centered instruction. Socio-technological spaces are not effective in of themselves. They effectively support Active Learning pedagogies but are ineffective at best when used with traditional teacher-centered instruction.

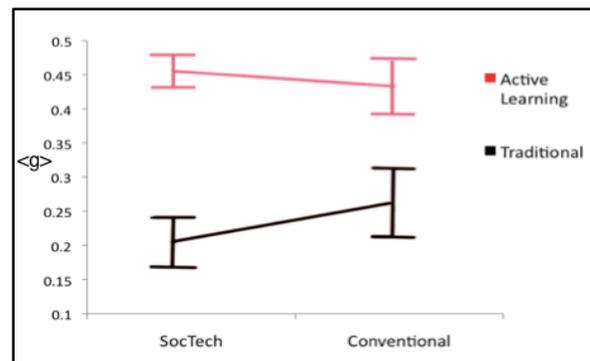


FIGURE 1. Active Learning pedagogies produce larger normalized gains, regardless of classroom design. Classroom designs do not significantly differ from each other. Largest gains are found in socio-technological designs that use Active Learning. Smallest normalized gains are found in socio-technological designs that use traditional teacher-centered pedagogies.

We also analyze the correlation between instructors' self-reported ATI subscales (CCSF and ITTF scales) and the average FCI gain for their class. We find a surprisingly high correlation between the student-centeredness scale (CCSF) and the average FCI normalized gain for their class ($r = 0.91$). In contrast, instructors' perceived teacher-centeredness (ITTF scale) correlates weakly with FCI gains ($r = 0.33$). These results suggest that a large part of the variance ($R^2=0.83$) in average FCI gain for a class can be explained by the instructor's perception of student-centeredness.

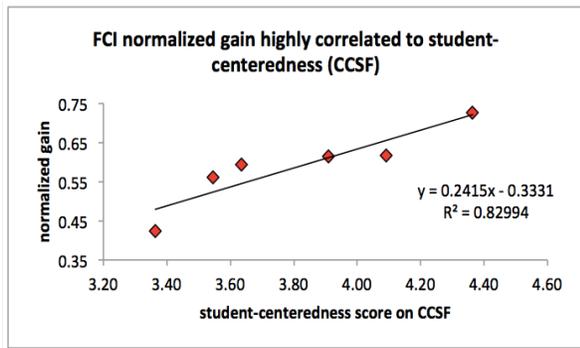


FIGURE 2. Instructors' self-reported student-centeredness (CCSF) is strongly correlated ($r = 0.91$) to their class' average FCI gain.

However, the instructors' degree of teacher-centeredness does not seem to impact students' conceptual change. Indeed, the instructors (self-reported) ITTF score accounts for a small amount of variance ($r^2 = 0.11$) in their class' average FCI normalized gain.

DISCUSSION

When designing technology-rich classrooms, teachers and administrators often assume that the technology will enhance students' learning. Empirical studies of technology-rich student-centered spaces have shown benefits such as more meaningful construction of knowledge and deeper understanding^{8, 10}. These studies document the use of technology-rich classrooms with the student-centered pedagogies they have been designed to support. To our knowledge, no studies have explored the use of socio-technological spaces in the absence of the student-centered pedagogy they are designed to support.

Our results show the primacy of pedagogy: active learning pedagogies produce larger normalized gains than teacher-centered pedagogies, regardless of the classroom architecture. Socio-technological classroom

architectures are designed to enhance the effect of student-centered pedagogies. Hence, the effective use of these socio-technological environments requires the adoption of student-centered active learning approaches. Instructors and administrators interested in adopting technology-rich spaces must be aware of the need to adopt active learning pedagogies. This finding can be viewed in light of past findings on educational technology, namely that technology itself is not a surrogate for good pedagogy^{14, 15}. For instance, Peer Instruction has been implicitly associated with the use of wireless clickers in classrooms. Yet, Peer Instruction works equally well without clickers, using flashcards for instance¹⁴. When used in support of learners' effort and not merely to present content, recent meta-analyses show that technology can be an effective learning tool¹⁶.

When used with a teacher-centered pedagogy, socio-technological environments yield the smallest normalized gains of all four groups. This result might be explained by the mismatch between the classroom architecture and the implicit instructional model it supports. Lecture-halls are designed to support teacher-centered lecturing. Socio-technological spaces are designed to support student-centered pedagogies. One may have expected that socio-technological spaces would be more effective than lecture halls *even for lectures* because of the many affordances offered by the technology. We find that traditional classrooms are better suited (albeit marginally) for lectures. This somewhat counter-intuitive result can be explained by the uncanny observation made by one of the researchers. Our socio-technological spaces feature workstations organized in round pod-like configuration seating four students, with one computer for every two students. Being seated in circular arrangements, students are no longer facing the 'front' of the classroom. On one occasion, a researcher was observing a student asking a teacher-centered instructor a question. Although the question was pertinent to the entire group, the instructor moved to the former front of the classroom and began to address the group as a whole. However, being seated in circular arrangements, most of the students were no longer facing the instructor and were therefore unaware of a possible learning opportunity. Together with the data shown in Figure 1, this suggests that socio-technological environment may hurt students if used with teacher-centered pedagogies.

Survey results for the six participating instructors on the ATI¹² revealed interesting findings concerning their self-reported perceptions of how information transmission/teacher focused (ITTF) and how conceptual change/student focused (CCSF) their

instruction was. We find a surprisingly high correlation ($r = 0.91$) between normalized gain and self-reported student-centeredness (CCSF) but not so large ($r = 0.33$) with teacher-centeredness (ITTF). Our first surprise is that instructors do not view teacher-centeredness and information-transfer as orthogonal to being student-centered conceptually-focused. What is more striking is the finding that a self-reported instrument correlates with a measure, not of the teachers themselves but of their students' learning. We find this result interesting and would welcome replications.

CONCLUSION

Instructors and administrators are often attracted to the newest educational technologies. However, for an educational technology to be adopted effectively, the pedagogical model it supports should also be adopted. Our results show that socio-technological classroom architectures are only effective when implemented with student-centered active-learning pedagogies. Much support should be offered to instructors adopting new socio-technological environments because adopting the newest educational technology may be easier than adopting the pedagogy it is designed to facilitate.

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