Moving Innovative Classroom Design Forward: Features that impact instructor's orchestration

Abstract: Popularization of *active learning* pedagogies has led to a burgeoning number of innovative learning spaces in higher education institutions. The architecture and technologies in these classrooms privilege group work and collaborative problem-solving. *Classroom orchestration* research is beginning to examine how space and technology interact to afford and/or constrain what teachers do (and can do) to manage and support students' learning. Technology tools can provide ambient awareness by making learning progress public. Using ethnographic methods, we document and compare orchestrational moves of three college-level instructors teaching in differently designed active learning classrooms. Results show that while these teachers have similar pedagogical routines, their orchestration was impacted differentially by their respective space-technology ecosystem and task-content. Findings suggest a rethinking of the current *design language* to better reflect the interdependence of space and technologies in these new classrooms. It also raises questions about the equity of students' access to teachers.

A*ctive learning* pedagogies has led to a burgeoning in the number of innovative classrooms. These new spaces are intended to leverage key aspects of active learning instruction, notably by creating a student-centered environment that privileges collaboration and communication. The teacher is often repositioned to the center of the room, and rows of desks are replaced with group tables. On a very organic level, learning is distributed across the classroom space because there is no definite "front" to the classroom. Other common and important features of these new spaces are the embedded (or brought in) technologies that facilitate the joint work and sharing of collaborative activities. Examples include networked computers and group displays such as whiteboards and tabletop surfaces. Interestingly, effective implementations of such interactive spaces can involve digital (interactive whiteboards) or analog (conventional white board, or white paint on walls) devices. To date, only a handful of studies has examined how the physical layout, and technologies used, in these innovative learning spaces might impact classroom management. Fewer yet have investigated how the interaction between space and technology affords and/or constrains how and what teachers do (and can do) to support students' learning experiences in these new environments. As students drive the learning agenda, teachers no longer fully control what will happen in class. The management of constraints arising from these interactive classroom designs can be characterized as the *orchestrational* decision-making associated with such implementations.

In this study we examine three simple yet fundamental questions about active learning room design as mediated by consideration of orchestration. First, how do teachers manage their time, space and technology resources in active learning classrooms? Specifically, we document how teachers use the space they are in—some monitor from a central location while some go to the students' boards, etc. Second, what features and/or factors mediate the enactments of their pedagogical routines? Here we compare the orchestrational moves of instructors <u>in different environments</u>—some rooms have interactive whiteboards that act as ambient awareness tools, while others do not. Third, how do the architecture and technologies interact to afford and constrain how the teachers interact with the groups, individually? In essence, this question is about equity of access to the teacher and whether or not there is something to be said about how this might be improved.

Background

In the last decade there has been increasing interest in building technology-rich collaborative learning environments, what we refer to as active learning classrooms (ALCs). Examples include the SCALE-UP project at North Carolina State University (Beichner, Saul, Abbott, Morse, Deardorff, Allain, Bonham, Dancy, & Risley, 2007) and the TEAL project at MIT (Dori & Belcher, 2004), University of Minnesota (Brooks, 2011). These innovative teaching and learning environments are designed to support the enactment of active learning pedagogies. Frequently their layout reshapes the traditional authority structures of classrooms. Instead of the teacher-centric single focal point "front" to the room, the layout and seating focuses on students working in groups. Another important difference between these new spaces and traditional classrooms is the ubiquitous availability of technologies that promote visualization, connectivity, artifact creation and sharing. Many include group-dedicated writable surfaces—wall-based or tabletop, analog or digital—as common features. While others include networked personal computing devices and projection screens upon which the contents of one or many devices can be displayed around the room. With no more "back" of the classroom and with teachers forced to circulate the room attending to students in groups, these new layouts hold the promise of democratizing access to the teacher. But is this the case?

Active learning pedagogies

Active learning is a pedagogical approach based on constructivist and social constructivist theories of learning (e.g., Vygotsky, 1978). It is student-centered and redistributes the authority structures of the classroom, demanding new roles for students and teachers. Students are asked to take on more prominent roles during class time—debating with peers, engaging in discussion, initiating inquiry activities, etc. (e.g., Engle & Conant, 2002). Teachers are also asked to take on new responsibilities both during class and outside of class—preparing activities, managing the progression of learning, etc. In this respect, active learning is much like CSCL scripts and scenarios, inasmuch as they both require instruction (and instructors) to purposefully plan tasks in sequence (workflows) that aim to promote specific learning objectives.

Classroom orchestration

This real-time management of activity, along with the management of resources of these new active learning spaces, can be considered *orchestration* (Dillenbourg, 2011; Fischer & Dillenbourg (2006)). As a research topic, orchestration has garnered much interest in the CSCL and technology enhanced learning (TEL) communities (Dimitriadis, Prieto & Asensio-Pérez, 2013; Stellar, 2010). Growing consensus defines it as the work done by teachers to manage, in real time, the constraints systems of the classroom setting that typically include technologies of one form or another (Dillenbourg & Jermann, 2010; Roschelle, Dimitriadis & Hoppe, 2013). This includes marshalling learning processes across time, spaces and multiple social levels—i.e., inside and outside of the classroom; physical and virtual spaces; and, the individual, group and whole class levels. Of particular note is recognizing physical space and layout as orchestrational considerations (Dillenbourg & Jermann, 2010).

Summary of orchestration-related issues and our research questions

Orchestration presupposes that instruction is not teacher-centered but neither is it without structure and constraints (Dillenbourg & Jermann, 2010). If this is so, then more than "guide on the side" is expected of the teacher in new pedagogies and new environments. But what are these needs? What types of decisions and management issues does the teacher face when they adopt pedagogies such as active learning? And, if physical space consideration is part of the orchestration, then what types of designs might impede or facilitate the management and flow of actors and activity within these new learning environments? In essence, what are the implications of space on the orchestrational decisions of the teacher? Lastly, understanding how teachers make monitoring decisions of group work is an essential issue in active learning that typically relies on collaborative activities. Specifically, knowing whether or not a group is making progress and knowing which individuals need specific help at specific times. Solutions to issues of orchestrating the progress of group work often look to tools such as dashboards and the like (e.g., Wang, Tchounikine & Quignard, 2011). But what about the technologies embedded in active learning classrooms, can they themselves be used as feedback? What roles do such technology play in supporting or constraining orchestration? In the remainder of this paper we describe research that aims to shed light on these growing questions.

Methods

This research consists of three case studies, which allows for cross-case comparisons. An ethnographic approach was used to collect classroom observations, which includes observer fields notes, video and audio recordings, as well as post-instruction teacher interviews. These cases are part of a larger research project examining issues related to active learning classrooms, including student engagement and learning objects. In this current study we look only at the teacher data.

Participants were three instructors, each from different post-secondary institutions in a major North American city. The selection of these data was based on the following considerations: each instructor had at least three years using an active learning pedagogy; they had taught previously in an active learning environment; and, mostly importantly, each had a strong track record of successful instruction and student outcomes. Teacher T1 and T2 are physics instructors—the course observed was Introduction to Physics (Mechanics). Meanwhile, T3 is a biology instructor—course observed was Introduction to Biology. Both are courses taught in the first year of a science program. All three teachers had similar class sizes, ranging from 34 to 41 students.

Context

The research settings consisted of three different active learning classrooms (see Figure 1). Each room contained group tables and technologies, including various wall-mounted writable surfaces—digital and interactive (in blue) and analog (in solid grey). Classroom A, teacher T1's room, consists of six specially designed tables and seven interactive whiteboards—six dedicated to groups with one for the teacher and sometimes offered to students to create seven working groups. Its design was based on a DBR project (citation authors). Classroom B, teacher T2's room, consists of flexibly arranged tables that generally make up nine workspaces. This room has three interactive whiteboards for the students and an additional one for the teacher; in addition, there are nine analog whiteboards. In this room interactive whiteboards are not dedicated to a group but assigned by the teacher to groups, on rotating basis. Classroom C, teacher T3's room, consists of five large circular tables, each having its own dedicated interactive whiteboard—there is also an interactive whiteboard for the teacher. Each table also has three desktop computers one of which is hardwired to network with the interactive whiteboard. The design of this room is based on the SCALE-UP model (citation). Other notable differences between these rooms was their "central area". Classrooms B and C both have a physical teacher podium set-up in the center of the room (note Classroom C's podium is small and designed to hold handouts, etc. It can be removed but wasn't when we observed). Classroom C's podium is fixed and contains the network system that controls the students' interactive boards—i.e., giving over control or taking away control. Classroom A's central area is completely open, the teacher has a small movable podium that is kept off to the side of the right side of the teacher workspace—in the empty corner. In our coding, described below, we consider the tables as one type of working space (group or non-ambient public) and the wall-mounted boards as another type of space (ambient public).

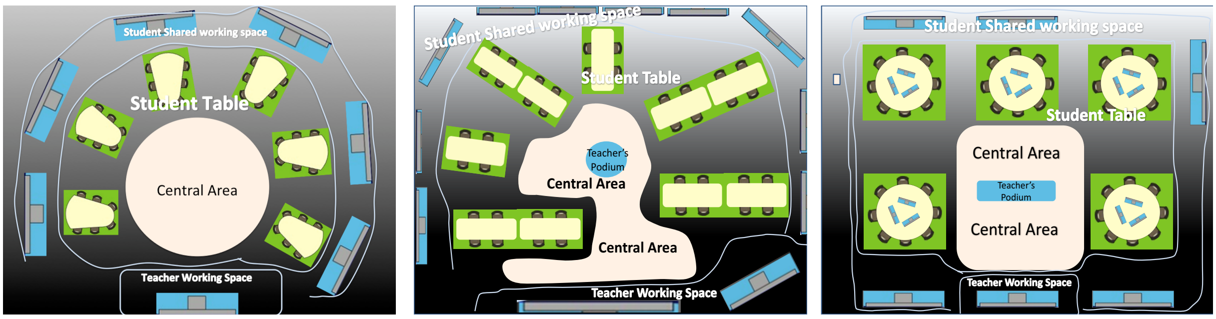

Figure 1. Layouts of the 3 ALCs – Classroom A-T1 (left), Classroom B-T2 (middle), Classroom C-T3 (right).

Data collection and analysis

Data for each case study were collected by the same member of the research team over the course of six sequential classroom visits. These sequential visits reduced possible misinterpretations of the instructor's pedagogical routines as well as possible differences in student engagement patterns. Field notes for all six sessions were documented using a modified COPUS coding schema (citation). These observation data were coded into the five main activities teachers engaged in in these rooms: (1) *lecture presentations*; (2) *group*; (3) *individual*, generally mini-quizzes; (4) *whole class*; and (5) *management* and other. These were aggregated across the six sessions.

Collection of the video data followed a set protocol: two micro cameras (GO-PROs) mounted on the front and back walls of the classroom. For this current study, we selected one video recording for each teacher. Choosing from the six sessions, a representative example of each teacher's enactment of active learning was selected for analysis. These data were analyzed using *Studio Code*, a specialized qualitative video data analysis software that allows for moment by moment accuracy in coding. Our protocol consists of two coding phases: (1) identifies the *teacher physical location*; and (2) identifies the *teacher awareness* during group activity. To code teacher location the room was divided into 4 zones: (1) teacher workspace (at the board), (2) central monitoring stations (3) student tables, and (4) student-shared workspace (wall-mounted boards). Teacher awareness was coded as follows: (1) surveying whole class; (2) monitoring group without interacting; (3) interacting with group; (4) interacting with individual. Interacting involves physical and gestural indicators.

Tracker coding

The positions of the teachers in the classrooms were also coded using their physical position in the room as a function of time on the video clips using *Tracker* software. This software is an open source video analysis and modelling tool. It was designed to be used in physics education, but was repurposed here to track the position of the teacher every five seconds. It was necessary to track two vertical points on the teacher, in order to get an estimate of the perspective (how far from the camera the teacher is, after calibrating for the room size). One point was the top of the teacher's head, and the other the teacher's waist. This, together with the angle on the video relative to the camera, gives a good indication of where the teacher is located in the room to within ~1m.

Results

Helping to answer our first research question, we looked at how teachers spend their time—i.e., what are they and their students doing during class? Table 1 shows the results of the six aggregated observations for each teacher. In this we see that all three teachers spent a greater percentage of class time engaging students, either in group or individual or whole class activity—(T1 [62%], T2 [55%] and T3 [49%]), than lecturing. Though teacher T3 is somewhat low compared to the others, his low percentage of time spent lecturing (46%) is a clear indication that his pedagogical routine is consistent with active learning pedagogies.

Table 1: Percentage of time T1, T2 & T3 spend in different modalities of classroom activities.

Activity Modality	T1_Class A (%)	T2_Class B (%)	T3_Class C (%)
Lecture	32	40	46
Group activity	57	52	44
Individual activity	2	3	5
Whole class activity	3	1	1
Administrative	4	4	4
Total time	100	100	100

The next part of the first question asks how teachers manage the physical spaces and resources of the room. To answer this question, we documented the position of the teacher and used it as a surrogate (indicator) of their management of the spaces and the technologies available in those spaces. Figure 2 normalizes the time that each teacher engages their students in group activity and shows where in the classroom they physically orchestrate this activity. These results clearly show that all three teachers spend nearly the same percentage of time at the shared spaces—i.e., the wall-mounted writable technologies—73.4%, 72.8% and 69.9% respectively. Teachers T1 and T2 also spend nearly equal percentages of time at the students' tables (24.8% and 20.6%, respectively). Meanwhile teacher T3 shows a slight preference for the central area of the room with 13.2% of his time spent there compared to 17% spend at the tables. Recall that T3's classroom has desktop computers on the tables. We will discuss the possible reasons for this later.

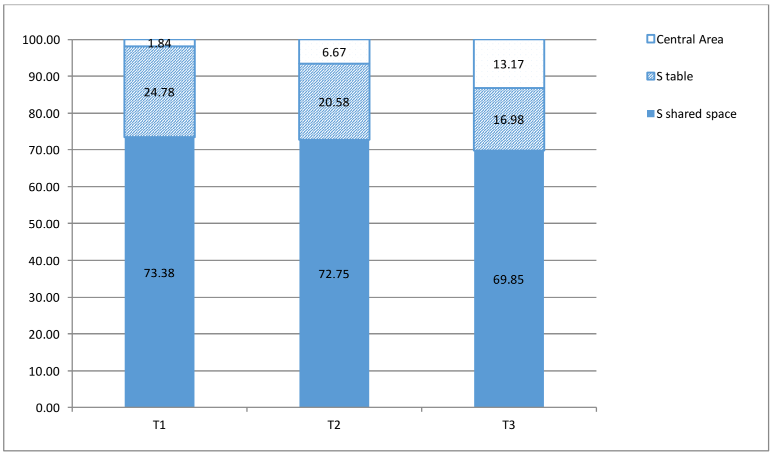

Figure 2. Percentage of time T1, T2 & T3 spent in the three physical locations within the classrooms.

Our second research question asks what features and or factors might mediate the orchestrational moves of the teachers. In other words, what is the flow of the teacher as he navigates the physical spaces? We answer this question by looking at the tracker diagrams in Figures 3 (parts a & b) and 4. In these Figures we see the path that the teachers took and the dots indicate their locations, based on a sampling rate of one sample every five seconds. An overview of the three classrooms and the flow of the teachers' tracking tells us immediately that the classrooms of T1 (classroom A) and T2 (classroom B) are more alike because of the number of groups and because perhaps because of the amount of space between groups. The teacher's flow in both rooms clearly gravitates towards the boards. In fact, T2 seems to be drawn to the corners of the room, which also are where the interactive whiteboards are located (G2, G4 and G7) and spends considerably more time there. Note also in some instances he moves across the room within the time of two tracking periods (10 sec)—example movement between G8 and G4. This pattern even more pronounced for T1 who moves across the space between G1 and G4 several times and between G4 and G7, also several times. What is also clearly different for T1 is that there is more flow at the periphery of the room, so much so that the tracking almost forms an arc—note movement from G4, G5, G6.

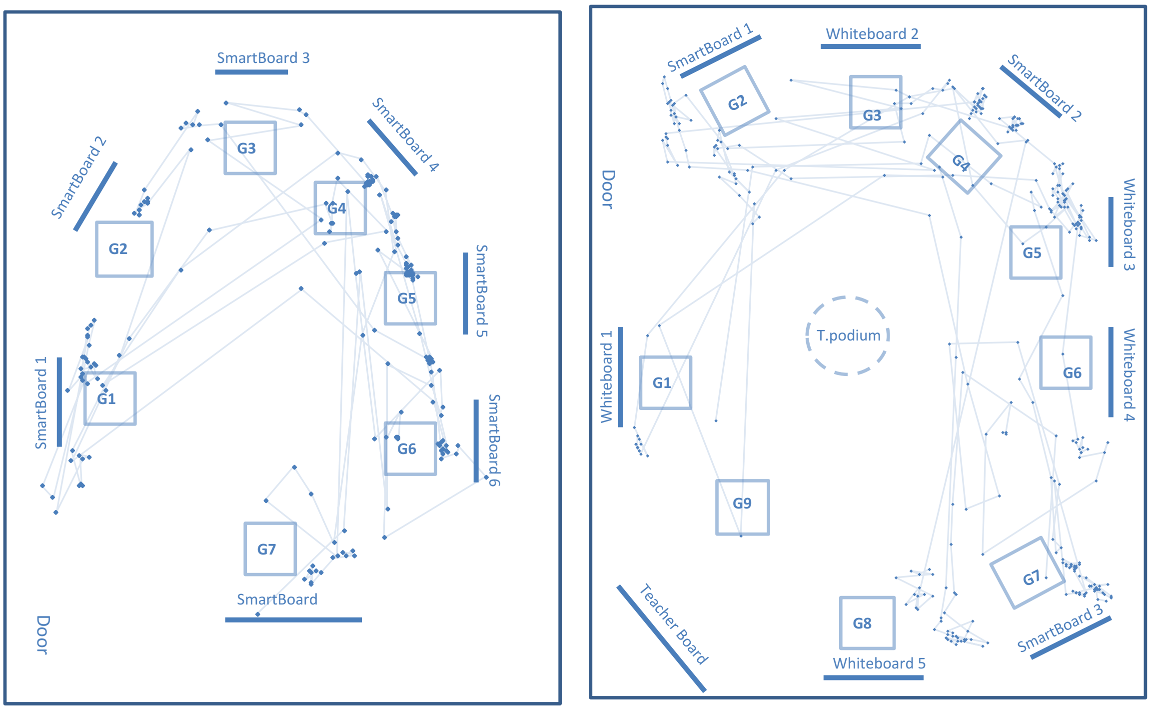

Figure 3a & 3b. Tracking analysis of the teacher's physical location within the classroom during their respective students' group activity: T1 (3a_left-side) & T2 (3b_right-side).

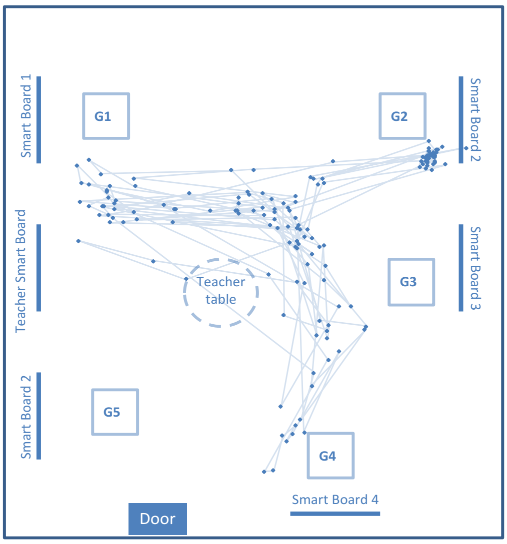

Figure 4. Tracking analysis of the teacher's physical location within the classroom during their respective students' group activity: Teacher T3.

Turning to T3 and his orchestration, it appears different from the other two. In addition, the layout of the room is also very different—i.e., though this is not to scale, the groups are spread further apart which means there is much more space for the teacher to monitor. In fact, it appears that group G5 is behind the teacher and difficult to attend to. Additional information from the video also confirms that the teacher T3 is called over to group G2—i.e., student help seeking—which draws his attention to the interactive whiteboard display. Apart from that instance, the teacher monitors the students' engagement from a more central position, perhaps because of the size of the room and orientation of the wall technology—i.e., it is difficult to see the boards without being directly in front of them. We will discuss the implications of the room design later.

Our third and final question asks how room-design impacts how teachers interact with each group individually. To answer this question, we again look at the percentage of time teachers devoted to one of two types of orchestration—i.e., monitoring and engaging. These results are displayed in Figures 5, 6 and 7 representing teachers T1, T2 and T3, respectively. Again, one thing is clear, T3's pattern is different from the other two.

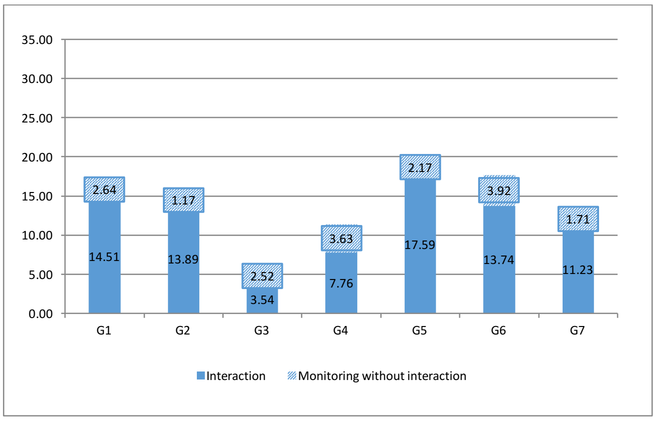

Figure 5. Percentage of time T1 spent with each of the seven groups.

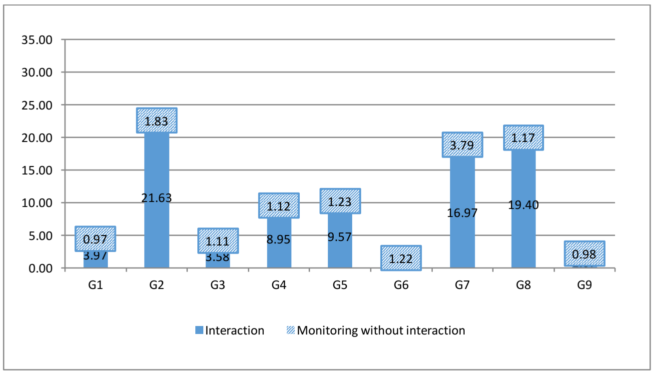

Figure 6. Percentage of time T2 spent with each of the nine groups.

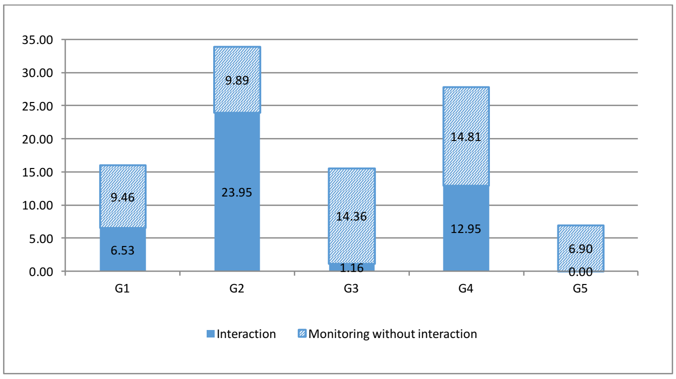

Figure 7. Percentage of time T3 spent with each of the five groups.

While T 3 monitors all groups with an average monitoring of 10.9% per group during their group work activity, it is clear that the percentage of time spent interacting with groups was divided primarily between two of five groups, i.e., 37% between G2 and G4. On the other hand, T1 and T2 showed many similarities in how they orchestrated their respective classes. They both spent greater percentage of their time interacting with the groups, with smaller percentages in monitoring. From the Figures 5–7, it is clear that for each class, teachers do not spend equal percentages of time with all groups. However, what is less clear is whether or not there are differences between how these teachers distribute their time. In other words, are there more or less equal distributions of time among a majority of groups? In order to answer that question we examined the skewness of the distributions of the percentage of time each teacher spent with their respective groups.

Focusing on the two physics teachers T1 and T2, while the mean time spent per group is similar for the observations of T1 and T2, we claim that T1 distributes his interactions more evenly between groups. To see this, we examine the by-group distributions of the two teachers. First, we note differences between mean and median values for T1 (mean fraction = 11.8%, median fraction = 13.7%) and T2 (mean fraction = 9.7%, median fraction = 7.5%) corresponding to a negative skewness for T1 (−0.514) with a positive skewness for T2 (+0.419). This means is that, in the case of T1, fewer groups take more than "their share" of the teacher's time. In contrast, a plurality of groups in T2's class take more than the average, leaving significantly less for the other groups. Examining the regression for the ordered distributions (Figure 8), which are normalized for the different number of groups in the class, supports this claim. T2's slope is steeper than T1's by a significant amount: $\text{Slope}_{T2} - \text{Slope}_{T1} = 0.070 \pm 0.058$ (95% confidence interval).

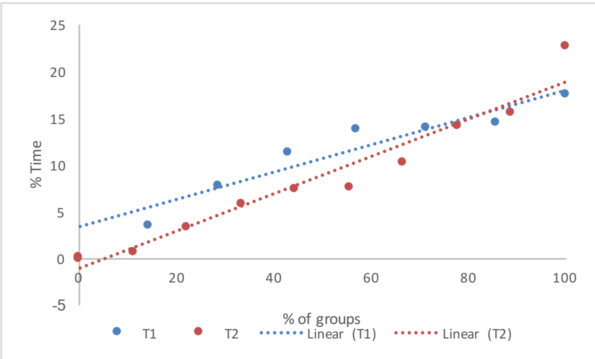

Figure 8. Regression coefficient ordered graph of % class time vs. % of groups for T1 and T2.

Discussion

The aim of this research was to examine three fundamental questions about the design of three active learning classrooms and how these spaces and their technologies impact the teacher's orchestration. We examined how teacher's orchestration of their pedagogies and noted differences. Some of those differences appear to be less about the space itself and perhaps more about the content of the activities. Specifically, we noted that teacher T3's enactment of his pedagogy included more lecture than the others, and his group work was orchestrated with more monitoring and fewer hands-on interactions. A plausible explanation for these results is his subject matter, biology, and the subsequent types of activities. That is to say, the nature of his group activities, for example constructing a concept map, is more likely to require a wait and see attitude on the part of the teacher, compared to problem-solving that is common in physics activities.

In answering our second question we noticed that the designs of some of these active learning rooms seemed to play a more directive role in how the teacher moved through the spaces. What seems to be revealed in this analysis is that there are two aspects to the monitoring the progress of group work. Some, such as Wang et al. (2011), describe this monitoring of progression as quantitative and qualitative—do the students seem to be making progress (quantitative) and what is the content of this progress (qualitative)?. We describe this monitoring of progress also into two types: monitoring for engagement (quantitative—how many students are engaged) and monitoring the task itself (qualitative—what is being produced). Our results show that some teachers are using the digital wall technologies (interactive boards) as *ambient orchestrational awareness* tools—when the room is an appropriate size and the angle of the boards allow the teacher to see their content. There is a simple elegance to this augmentation tool in that it provides teachers with requisite feedback without adding the cognitive load that is associated with dashboards, and the complexity involved in fully connected classrooms. There is nonetheless a caveat that once again there is a possibility that content may also direct the teacher's need for awareness of what is going on these boards.

Last but not least, our results for the third research question are perhaps the most controversial. They showed that the architecture and technologies may be interacting to constrain the teacher's interactions with groups. While there should never an expectation that a teacher could reach all groups equally, what is disturbing is that at least one, if not two, of these room designs might be making it exceptionally difficult for a teacher to support a majority of groups. The exception, of course, is classroom A, in which we note that the design may in fact be helping to create an awareness of the majority of groups so much so the teacher was able to interact and spend significant time with over two thirds of his class. This is a design that we should examine further. Taken together our research findings suggest a rethinking of the current *design language* to better reflect the interdependence of space and technologies in these new classrooms.

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