

The Effects of Physical Design on Users' Behavior and Perception in University Classrooms: A Pilot Study

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Abstract

Users' behavior and perception were evaluated in two university classrooms—one had a rigid layout with fixed furniture, and the other had a flexible layout with movable and adjustable furniture. One instructor taught the same course to the same group of students for about seven weeks in each classroom. In each classroom, users' behaviors related to academic and non-academic activities were recorded during class sessions, and a questionnaire survey on users' perception of classroom experience was conducted. Data show improvements for users' behavior and perception in the classroom with flexible layout and movable and adjustable furniture. Limitations of the study and strategies to overcome these limitations are discussed.

Keywords: University Classrooms; Classroom Behavior and Perception; Classroom Layout; Movable and Adjustable Furniture

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A. Introduction

Designing classrooms for effective learning is difficult. We know very little about efficient learning spaces that are also effective. Most evidence we have on effective learning environment depends on a traditional view of teaching as a one-way process controlled and conducted in one-type-fits-all spaces by an instructor. The changing needs of learning environments in the 21st century make a large portion of this research evidence irrelevant. As opposed to the traditional students-in-rows classroom model, what we may need today is a flexible setting to facilitate more peer-to-peer as well as self-directed learning. This is particularly true in higher learning environments.

This study of the effects of classroom design on behavioral and perceptual/experiential outcomes at a research university is an attempt to contribute to the current discourse on the appropriate nature of learning environments of the 21st century. Classrooms at a research university seem particularly apt for the study because the need for physical changes of the learning environment is more evident here.

Rigorous research focusing on the effects of university classroom design on learning is also rare as reported in many recent reviews (e.g., Clark, 2002; Fisher, 2001; Gump, 1987; Schneider, 2002).

Particularly notable is the fact that the published literature on the topic reports more the effects of the ambient aspects of the physical environment, such as color, heating, lighting, air quality and acoustics, and less the effects of the layout and furniture arrangement of university classrooms.

Studies in other educational settings show that there are reasons to believe that the university classroom layout and furniture may affect users' behavior and perception. In a study on children's behavior and sitting positions in relation to traditional classroom furniture and ergonomically designed furniture,

Knight and Noyes (1999) find that children show a significant improvement in on-task behavior and a marked change in sitting positions following the introduction of the newly designed furniture.

The research, which specifically compares rows and tables (Galton et al, 1999; Hastings, 1995; Wheldall et al, 1981; Wheldall & Lam, 1987), suggests that less attentive and less successful students are particularly affected by the desk arrangement, with their on-task behavior increasing significantly when seated in rows instead of at tables. These authors point out that the vital mediating element between the physical environment and improved classroom climate may be the reduction in negative interactions between teacher and student, since the student in the rows arrangement is able to concentrate and so provokes fewer admonishments. In contrast, it is also reported that children ask more questions when seated in horseshoe arrangements than they do when seated in rows (Marx et al, 2000), and that group size often seems to be determined by the furniture and its arrangement rather than by educational or pedagogical considerations (McNamara and Waugh, 1993).

The purpose of this study, then, was to extend this line of investigation to university classrooms. It asked if changes in the layout and furniture of university classrooms would affect students' and instructors' classroom behaviors and experience.

A. Research Methods

B. Study Settings

The study was conducted in two classrooms—one traditional and the other innovative. The traditional classroom had a fixed-front. In the front was the instructional area with a lecture table and a blackboard. The heavy metal tables of the classroom were laid out in straight rows of threes and twos with aisles in-between. This classroom did not have any special furniture or accessories to facilitate teamwork or group discussion (**Figures 1 – 3**).

In contrast, the innovative classroom did not have a fixed-front. The height-adjustable movable tables and very light-weight chairs of the classroom could easily be reconfigured, grouped, or ganged for team projects and collaboration. The classroom also had several marker boards for quick sketches.

Additionally, comfortable movable lounge chairs with tablet arms and one café table with stools were also provided to facilitate collaborative learning experience (**Figures 4 – 6**).

For study purposes, several other physical design features of the two classrooms were kept comparable. Both classrooms were located in the same building, opposite to one another on a secondary corridor. Each had one access door. Each had approximately the same size and shape. The classrooms had no natural light. Each classroom had similar access to power and data. It should be noted here that the colors of surface painting in the innovative classroom were warmer. In addition, a large photograph of nature with sky, water, and trees was hung in the innovative classroom. It is possible that these extra features had some positive effects on users' experience in the innovative classroom. However, the research design did not allow the researcher to isolate these effects.



Figure 1: A view of the traditional classroom from the entrance door.



Figure 2: A view of the traditional classroom from the instructor's position.



Figure 3: A view of the traditional classroom from the back of the classroom looking toward the



Figure 4: A view of the innovative classroom looking at the position of the instructor in the



Figure 5: A view of the innovative classroom looking toward the entrance door.



Figure 6: A view of the innovative classroom looking at the large group meeting area.

B. Study Plan

The study was conducted for a semester (16 weeks approximately). A 2-week training/preparatory phase was followed by two data collection phases that continued for about 14 weeks. During the preparatory phase (4 class sessions), the instructor taught students in a classroom with no experimental controls, and no research data were collected. During this phase, students were allowed to get used to the course and the instructor, and the field observer was trained to collect research data. At the end of this phase, the class moved to the traditional classroom for the first phase of data collection.

During the first 8 weeks of the data collection phase (16 class sessions), the instructor taught the course in the traditional classroom. During the following 6 weeks (12 class sessions), she taught in the innovative classroom. Initially, it was planned that data would be collected for 7 weeks in each classroom. The plan had to be modified because the innovative classroom was not ready for instructional purposes in time.

B. Course and Participants

The course was an introduction to human factors. The instructor, who had taught this course before, had volunteered for the study. Students self-selected the course. All students were eligible to participate in the study. In total, 22 fulltime undergraduate students enrolled for the course. Out of 22 students, 14 were females and 8 were males.

B. Research Instruments and Data Collection Processes

For the study, the data on students' and instructor's behaviors were collected using a behavior observation protocol, and the data on students' perception of classroom experience were collected using questionnaires. The data collection processes commenced after IRB had approved the project.

C. Behavior Observation

Students' behaviors. The behavior observation protocol included both on- and off-task students' behaviors. Within each category, behaviors were defined following Rosenfield, Lambert and Black (1985). According to these authors, on-task behaviors included actions directed toward solving an academic problem and verbal or physical actions supporting an academic activity in the class. This study included the following on-task behaviors:

- Hand-raising: Student raising hand to make a contribution to an ongoing academic discussion.
- Listening: Student paying attention to the subject being taught or discussed as supported by her physical orientation or gestures (e.g., leaning forward, shaking head approvingly, etc.).

- Discussion Comment: Any verbal act or response supporting an on-going academic activity made in response to a directed and/or open question or comment by the instructor or a student. The student must follow the proper procedure to respond. For example, she may raise her hand, may respond only after being called on, or may respond when she gets her turn, etc.
- Out-of-order comment: Any verbal act or response made in an attempt to support an on-going discussion without following the proper procedure. For example, the student may respond to a question out of turn, may interrupt someone else who is speaking after having been called on, etc.
- Oral response or speaking: Verbal behavior that are not prohibited but unrelated to an ongoing academic discussion (e.g., bringing up a topic that is next in order or that has already been discussed).
- Interaction with instructor: Any verbal exchange between a student and the instructor supporting an ongoing academic activity. It cannot be a mere response to a question and must have a time span.
- Interaction with classmates: Any verbal exchange between any two or more students supporting an ongoing academic activity. It cannot be a mere response to a question and must have a time span.

The same authors defined off-task behaviors as those that are not directed toward solving an academic problem and verbal or physical actions not supporting an academic activity in the class. This study included the following off-task behaviors:

- Disruptive behavior or conduct: Any verbal or behavior unrelated to an ongoing academic activity that are prohibited and that has the potential to disrupt the ongoing discussion (e.g., insulting, teasing, yelling, fighting, unnecessary movement, whispering, talking to one another on prohibited topics, etc.).

- **Withdrawal:** A behavioral condition that implies disassociation from all ongoing classroom activity (e.g., sleeping, listening to music, etc.).

Instructor's behaviors. Instructor's behaviors were defined on the basis of the amount of control the instructor exercises on learning activities. The protocol included the following teaching behaviors or styles, ranging from most restrictive to least restrictive:

- Lecturing
- Providing instructional stimuli and facilitating discovery
- Creating a forum for open and free student/teacher dialogue
- Fostering interdependence through break-out group activity
- Teaching students to take learning into their own hands

In addition, the instructor's positions were also recorded at regular intervals during a class session. The total movement of the instructor during a session was calculated by adding the distances between the positions in sequence (**Figure 7**). It was assumed that the layout and furniture of a classroom would affect the amount of control an instructor exercised in relation to a learning activity and how much she would move in the classrooms.

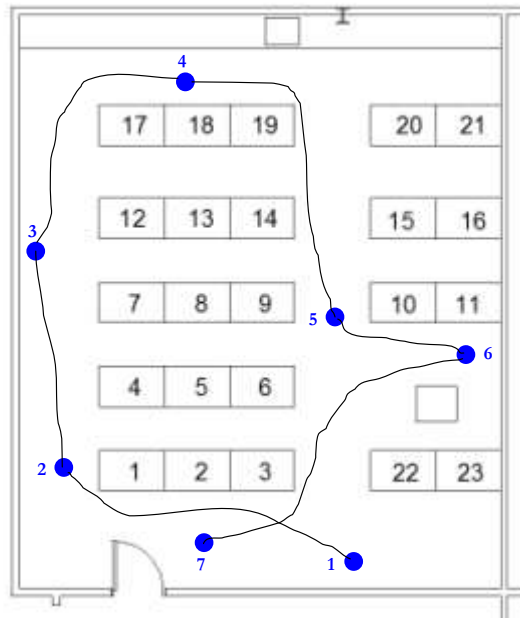


Figure 7: Measuring instructor’s movement during a class session.

Observation Methods. The field observer had about 90 minutes of observation time during each class session excluding the first and last 10 minutes of a session. She made her observations in rounds to facilitate data collection. The total time for a round of observation was 10 to 12 minutes, with about 7 to 8 rounds in every class session. In total, 163 rounds of observation were completed during the data collection phases. Out of 16 sessions in the traditional classroom, 3 were excluded from the study because of unusual in-class activities. During the other 13 sessions in the traditional classroom, 96 rounds of observation were completed. During 12 sessions in the innovative classroom, 67 rounds of observation were completed. Levene’s test for equality of variances showed the data collected in the two classrooms were statistically similar despite the differences in the numbers of observation in these classrooms (**Table 1**).

C. Questionnaire Survey

The questionnaire on student classroom experience included the following modules:

- The ‘Background Information’ module included questions on age, gender, race, and preferred learning styles.
- The ‘Classroom Experience’ module included questions on overall satisfaction with the classroom, satisfaction with individual aspects of the classroom, satisfaction with classroom support, and on the differences between the traditional and innovative classrooms.
- The ‘Classroom Flexibility’ module included questions on the importance of and the need for flexibility, biggest limitations to flexibility, and things that were moved around most.

The questionnaire was administered right before the end of the data collection phase in each classroom.

Out of 22 students in the class, 21 completed the survey in the traditional classroom and 19 completed the survey in the innovative classroom.

A. Data Analysis and Results

First, the differences between student and instructor behaviors in the traditional and innovative classrooms were studied using ANOVA. For additional explanations, regression models were also used. Following this, the differences between students’ experience of the learning environment in the traditional and innovative classrooms were studied also using ANOVA.

B. Changes in Students’ Classroom Behaviors

Statistically significant increases (at the level of 0.05 or less) were observed in students’ interaction with the instructor, students’ interaction with students, and withdrawal in the innovative classroom. Increases were also observed in listening and out-of-order comments in the innovative classroom, but these increases were not statistically significant. In contrast, a statistically significant decrease in oral response was observed in the innovative classroom. Decreases were also observed in hand-raising, discussion

comments, oral response, and disruptive behavior in the innovative classroom, but these decreases were not statistically significant (**Table 1**).

In light of previous studies, the observed increase in interactions in the innovative classroom is not surprising. In an American college in the 1970s, Sommer and Olsen (1980) found that in a classroom with soft furnishings and friendly and attractive design student participation rates in discussions and in asking questions during classes were ‘two or three times as high’ as in comparable classes taught in traditional rooms.

However, the fact that withdrawal and interactions had increased simultaneously in the innovative classroom was surprising, because it is hard for someone to be withdrawal when s/he is engaged in an interaction. In this regard, it can be noted here that listening and out-of-order comments had also increased in the innovative classroom suggesting that the positive statistical effects of these two behaviors on withdrawal might have been stronger than the negative statistical effects of interaction on the same. In order to verify the statement, a regression model was used with withdrawal as the dependent variable, and students’ interaction with instructor and with students, listening, and out-of-order comments as predictor variables. Taken together, these variables explained about 14% of variability of withdrawal. When both types of interaction were taken out of the equation, listening and out-of-order comments explained about 10% of variability of withdrawal. In other words, interactions had less effect on withdrawal than listening and out-of-order comments. However, when the effects of each of the four variables were considered separately, only listening had a significant effect on withdrawal ($p = 0.02$) (**Table 2**).

	Levene's Test for Equality of Variances		Mean		F	Sig.
	F	Sig.	Traditional	Innovative		
Students' Behaviors						
Hand-raising	1.43	0.23	0.58	0.39	1.58	0.21
Listening	8.44	0.00	11.25	11.55	0.09	0.76
Discussion Comment	0.20	0.66	0.65	0.54	0.07	0.79
Interaction with Instructor	47.31	0.00	0.30	1.51	18.21	0.00
Interaction with Classmates	9.00	0.00	1.98	4.24	7.94	0.01

	Levene's Test for Equality of Variances		Mean			
Out-of-order Comment	12.17	0.00	0.05	0.16	3.34	0.07
Oral response	19.17	0.00	0.70	0.03	5.90	0.02
Disruptive Behavior	4.48	0.04	0.85	0.57	1.95	0.16
Withdrawal	7.94	0.01	2.22	3.12	4.98	0.03
Instructor's Behaviors						
Length of Movement per observation (in feet)	4.88	0.03	19.96	17.81	0.27	0.61
Length of movement per session (in feet)	0.01	0.92	145.90	106.86	1.13	0.30

Table 1: Students' and instructor's behaviors in the traditional and innovative classrooms.

Model	Predictors	R	R Square	F	Sig.
1	Interaction with Instructor, Interaction with Classmates, Listening, Out-of-order Comments	0.37	0.14	2.50	0.05
	Interaction with Instructor				.29
	Interaction with Classmates				.24
	Listening				.13
	Out-of-order Comments				.67
2	Listening, Out-of-order Comments	0.31	0.10	3.44	0.04
	Listening				.02
	Out-of-order Comments				.75

Table 2: The regression model uses interaction with instructor, interaction with classmates, listening, and out-of-order comments as predictor variables to explain withdrawal in the innovative classroom.

B. Changes in Instructor's Classroom Behaviors

Instructor's movement decreased in the innovative classroom, but the change was not statistically significant (**Table 1**). This finding may not be surprising in light of previous studies on the topic.

Ahrentzen & Evans (1984) found that more open classrooms did have some direct effect on how teachers teach, but Rivlin and Rothenberg (1976) found that this was not dramatic: Despite being encouraged by the policies of the school and despite having more flexible and less traditional classroom layouts, many of the teachers they studied stayed in one place, essentially 'taught from the front' and did not move the

furniture. Horne-Martin (2002) found that styles of teaching and room organization were linked, although it was not clear which was cause and which was effect.

Regarding teaching styles, the instructor did less lecturing, and provided less instructional stimuli in the innovative classroom. While ‘creating a forum for open and free student-teacher dialogue’ was used as a teaching method 9 times per 100 times in the traditional classroom, this method was not used at all in the innovative classroom. However, ‘fostering interdependence through break-out groups’ occurred three times more in the innovative classroom (33 times per 100 times in the innovative classroom as opposed to 11 times per 100 times in the traditional classroom). In other words, the instructor gave students far more learning independence in the innovative classroom (**Table 3**).

Teaching Styles	Occurrences of teaching styles (as % of all occurrences in each classroom)	
	Traditional	Innovative
Lecturing	56.99	53.73
Providing instructional stimuli and facilitating discovery	16.13	10.45
Creating a forum for open and free student/teacher dialogue	8.60	0
Fostering interdependence through break-out group activity	10.75	32.84
Teaching students to take learning into their own hands	5.38	0
None of the above	2.15	2.99
Total	100.00	100.00

Table 3: Teaching styles used by the instructor in the traditional and innovative classrooms.

B. Changes in Students’ Perception of Classroom Experience

ANOVA was applied to compare students’ perception of classroom experience in the traditional classroom with that in the innovative classroom. The findings are reported in **Table 4**.

Students reported statistically significant improvements in overall satisfaction, comfort, attractiveness, and suitability with the innovative classroom. Students also reported statistically significant improvements in their satisfaction with seating, lighting, color, whiteboard spaces, break-out spaces, flexibility and reconfigurability, and ability to see the instructor/students and displayed materials in the

innovative classroom. Additionally, students reported improved satisfaction with desk space, but the improvement was not statistically significant. When asked to compare with other traditional classrooms, students reported significantly higher satisfaction with the innovative classroom. Students also reported that they used the innovative classroom more and they moved things around more in the innovative classroom, but these differences were not statistically significant.

		Mean		F	Sig.
		Traditional	Innovative		
Overall satisfaction	Measured on a scale 0 to 10	3.62	8.42	89.57	0.00
Overall comfort	Measured on a scale 0 to 10	4.19	7.74	30.38	0.00
Overall attractiveness	Measured on a scale 0 to 10	2.81	7.68	76.76	0.00
Overall suitability	Measured on a scale 0 to 10	4.76	7.95	40.59	0.00
Satisfied with desk space	Measured on a scale 1 to 6	3.95	4.11	0.33	0.57
Satisfied with seating comfort	Measured on a scale 1 to 6	2.67	3.68	11.98	0.00
Satisfied with lighting	Measured on a scale 1 to 6	2.81	3.68	8.70	0.01
Satisfied with color/aesthetics	Measured on a scale 1 to 6	2.14	3.74	22.79	0.00
Satisfied with whiteboard space	Measured on a scale 1 to 6	2.48	3.79	13.51	0.00
Satisfied with breakout spaces	Measured on a scale 1 to 6	2.67	4.79	61.39	0.00
Satisfied with flexibility	Measured on a scale 1 to 6	2.19	4.74	117.47	0.00
Satisfied with abilities to see instructors, students, and/or displayed materials	Measured on a scale 1 to 6	3.38	4.21	9.28	0.00
Comparison to other traditional classrooms	Measured on a scale 0 to 3	1.90	2.84	23.23	0.00
how often use the classroom	Measured on a scale 0 to 4	1.14	1.26	0.10	0.75
how often move things around	Measured on a scale 0 to 4	1.52	2.11	2.33	0.14

Table 4: Students' perception of classroom experience in the traditional and innovative classrooms.

B. A Summary of the Findings

When compared with the traditional classroom, the following important behavioral changes were observed in the innovative classroom: (1) statistically significant increase in students' interactions with instructor and with other students; (2) statistically significant decrease in oral response; and (3) more

learning freedom for students. In addition, students' perception of the classroom experience improved significantly in the innovative classroom along most design dimensions included in the questionnaire.

A. Advantages, Limitations, and Future Directions of the Study

In this semester-long pilot study, a small group of students was moved from a traditional classroom to an innovative classroom to study the effects of physical design on behavioral and perceptual changes. One instructor taught the same course to the students for about seven weeks in each classroom. Consequently, any likely effects of the differences among two or more instructors on students were eliminated. Additionally, the small sample size of the study allowed one field observer to collect the necessary field data, thus reducing mistakes arising from multiple interpretations of the same field phenomenon by many field observers.

Among the negative aspects of the study design was the fact that the students changed their classrooms in the middle of a semester. This, on the one hand, disrupted the flow of the course impacting behavioral outcomes. On the other hand, as students moved from one classroom to the other, they probably carried some behavioral norms of the previous setting to the new classroom. These behavioral norms might have existed as 'halo effects' for the first one or two weeks of a study phase. Since the study phases were short, it was not possible to take these first weeks of each phase out of the study to eliminate any halo effects.

Since the study was not conducted simultaneously in the two classrooms, it can also be argued that the observed improvement in interaction in the innovative classroom could have been an effect of time. In other words, during the first phase of the study in the traditional classroom students did not know each other and the instructor very well, so they interacted less. As they got to know each other better in the innovative classroom during the second phase of the study, they interacted more.

Additionally, due to a small sample size it was not possible to study the effects of students' motivation levels and learning styles on their behavioral outcomes. It is possible that the physical design of a classroom would have very little impact on the learning behavior of a highly motivated student. Likewise, a student who learns by doing may assume a more active role in various educational activities in any classroom when compared with the one who learns by seeing or hearing.

In order to eliminate these observed limitations, any future research on the topic needs to be conducted over a longer period using a larger sample. For example, students may be taught in the two classrooms simultaneously for a semester. One instructor may be able to teach the course if the class time in the two classrooms is staggered. Several field observers may be required to collect field data from a larger sample. They will need to be trained together, and inter-rater reliability will have to be tested before they set off to conduct field observations. A more significant limitation of a research design involving simultaneous teaching in two classrooms will be the fact that students will be different in these classrooms. In such a research design, two control groups will be necessary. These groups will switch classrooms in the middle of the semester raising additional concerns.

Finally, issues related to this pilot study that may need further considerations are:

- The effects of university classroom design on overall usability of space, group activity, and individual and team learning outcomes.
- The effects of university classroom design on the effectiveness of various teaching and/or learning strategies (formal vs. informal, passive vs. active, individual vs. collective, intentional vs. unexpected, etc.).
- The link between user engagement and the success of environmental change in university classrooms. Previous studies have shown that the ownership of innovation, in contrast to the externally imposed solution, appears to tap directly into motivational aspects which are key factors in maximizing the impact of change.

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