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Tiered Classrooms at St. Olaf College: Faculty and Student Perceptions of Three Different Designs

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In designing St. Olaf College's Regents Hall of Natural and Mathematical Sciences, we attempted to create learning spaces to accommodate classes of 50-100 students and a variety of teaching pedagogies. In this study, we compared three different 72-seat classrooms furnished with half-round tables for four, straight tables, or a serpentine shaped table with crests that seat four students. We found that faculty preferred the learning environment of the half-round tables for all pedagogies. Students preferred the half-round tables for group work or a combination of group work and lecture, but preferred the straight tables for lecture classes.

Introduction

Over the last several decades, educators have expended considerable effort in reforming the pedagogical practices in higher education. Advances in understanding of neuroscience and learning (Donovan, Bransford, & Pellegrino, 1999) have led to the development of a variety of pedagogical approaches designed to promote the active construction of knowledge. The Project Kaleidoscope Pedagogic Collection is a good resource for information and references for several of these pedagogies (Project Kaleidoscope, 2008). While the initial focus of studies of such pedagogies aimed to assess the efficacy of the strategies in promoting student learning, educators also came to recognize the important role that physical facilities play in the success of active learning pedagogies. With the classroom design in our new Regents Hall of Natural and Mathematical Sciences building, we realized that we can contribute to the ongoing conversation about the space-learning synergy.

St. Olaf College's Regents Hall of Natural and Mathematical Sciences

By way of background, Regents Hall of Natural and Mathematical Sciences consists of a 195,000 gross square foot new building for the natural sciences (biology, chemistry, physics, and psychology), 18,000 gross square feet of renovated space for the mathematical sciences (mathematics, statistics, and computer science), and an 8,000 gross square foot link between these two buildings.

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The natural sciences and link portions of Regents Hall opened in Fall 2008; the renovated mathematical sciences building opened in Fall 2009. More details on the building design can be found elsewhere (Van Wylen & Walczak, 2011; Muir & Van Wylen, 2009).

As we began designing the classrooms, we recognized two significant constraints:

- All departments teach large (50-100 students) sections of introductory courses and staffing levels were not likely to change in the foreseeable future.
- Faculty span a pedagogical spectrum from traditional lecturers to active learning aficionados, with most faculty implementing a mixture of classroom activities.

As a consequence of these constraints, we needed large classrooms with sufficient capacity for our introductory courses and designs that were flexible enough to accommodate lectures and active learning activities easily. In the end, we agreed on creating seven tiered classrooms with movable chairs and different types of tables. Although not of importance in this study, Regents Hall also has 11 flat-floored classrooms, 8 seminar rooms, 4 computational rooms, 26 teaching labs, and 13,000 square feet of student-faculty research space.

The seven tiered classrooms were designed to accommodate 108 (1), 72 (3), or 56 (3) students. Depending on seating capacity, the rooms have two to five levels. Although data were collected regarding all seven tiered classrooms, here we focused on the results for three classrooms. These three rooms were selected because they seat the same number of students (72) but have different types of tables, allowing direct comparison. The general design is illustrated in Figure 1. The room dimensions are identical and all rooms have two windows at the back corners. The classrooms include three different types of tables. Room 210 is furnished with movable half-round tables; room 310 has straight, fixed tables; room 410 has fixed tables with a serpentine shape. Although some of the

other tiered classrooms use the same kind of tables, other features of those classrooms (e.g., low light levels, varying ceiling heights) confounded the results.

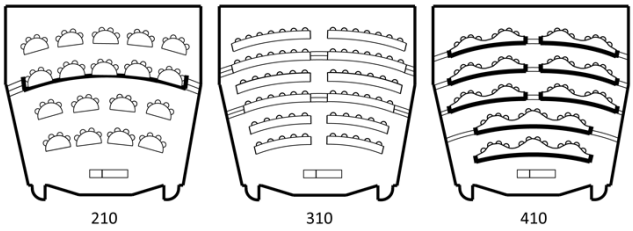

Figure 1. Layout of each of the 72-seat classrooms. Room 210 features movable half-round tables; Room 310 has fixed straight tables; Room 410 has fixed serpentine shaped tables.

During the design of the building, we sought to create learning spaces that facilitated active learning pedagogies while at the same time making spaces that worked well for a more traditional (lecture) format. The classrooms with the half-round and serpentine tables were designed with group work in mind. The half-round tables seat four students, facilitating group work at those tables. The straight table rooms work well for lectures, but can also be used for group learning side-by-side in pairs or by having two students in the front row of a tier turn around and work with a pair seated in the second row. The serpentine tables were designed to accommodate groups of four students around each curve. We envisioned this room as a compromise between the forward-focus environment of a lecture hall and a group-focused format of round tables.

Each classroom also contains two LCD projectors directed toward two pull-down screens, a dedicated computer, a document camera, laptop connector, telescoping white boards, blackboard, and writable walls (IdeaPaint).

Our goals for this study were to (a) determine whether the three classrooms worked well as flexible spaces for different pedagogical strategies, (b) identify the design elements that enhanced the teaching and learning experience of faculty and students, and (c) evaluate the effectiveness of the technology resources in the classroom.

Relevant Studies of Classroom Efficacy

The majority of the published studies of classroom efficacy in higher education focus on the SCALE-UP (Student Centered Active Learning Environment with Upside-down Pedagogies) style classrooms first developed at North Carolina State University (Beichner, 2006; Beichner et al., 2007; Gaffney, Richards, Kustusch, Din, & Beichner, 2008). These classrooms feature 7-foot wide round tables that seat 9 students. There is no "front" of the room and instructors use technology to varying degrees in different implementations.

Brooks (2012) compared two sections of an introductory biology course at the University of Minnesota in which the only variable was the type of classroom. The instructor taught one section in an "Active Learning Classroom" (ALC, a SCALE-UP type classroom) and the other in a traditional classroom with tables arranged in rows. The instructor, time of day, class materials, assignments, schedules and exams were identical for the two sections and the instructor worked to keep the course delivery the same in each classroom. The instructor spent more time at the podium lecturing to students in the traditional classroom and more time in class discussion and consulting with students in the ALC section. The level of interaction between the instructor and students was much higher in the ALC than in the traditional classroom.

Van Horne *et al.* (212) reported the utilization of Transform, Interact, Learn, Engage (TILE, another SCALE-UP type classroom) classrooms at the University of Iowa. One of the research questions in their study involved student perceptions of the learning environment and activities. Students reported that the TILE classroom facilitated student-student interaction and collaboration. They also noted the importance of matching the course pedagogy to the classroom facilities. To that end, faculty who wish to teach in a TILE classroom must receive extensive training in a 3-day workshop. Through this training, faculty learn how to integrate the pedagogy with the physical features of the room. Many faculty attribute the lack of implementation of active learning pedagogies among college faculty to the scarcity of such experiences in their own training. Consequently, having a support structure to help faculty adapt their teaching to these innovative spaces is an important component for success.

Although we opted not to pursue the SCALE-UP design for the reasons already stated, we anticipated that high levels of student-student and student-faculty interaction were possible in our classrooms. We sought to create classrooms that allowed for both forward- and group-focused activities.

A few studies of other types of classroom design have been published. Tom, Voss, & Scheetz (2008) reported that faculty who taught in their new studio classroom for 30-40 students found that the space supported pedagogical changes in their teaching. Student response to the studio classroom was also positive, leading to increased engagement.

Henshaw, Edwards, & Bagley (2011) investigated a classroom for up to 48 students with fixed tablet arm chairs that swiveled 360 degrees. Researchers designed the classroom intending to facilitate face-to-face interaction

between students, instructor movement throughout the classroom, and transition between instructional modes. Of particular interest to us, they found that this classroom design allowed very quick transitioning between instructional modes. We expected that our movable chairs and different table designs would also lead to fairly rapid transitioning between forward- and group-focused activities.

Finally, Veltri, Banning, & Davies (2006) investigated student perceptions about classroom features. Among the elements that students considered negative impacts on their learning were insufficient personal space, furniture that prevented student-student interaction, distracting noise, low lighting, excessively high temperatures, and the absence of ambiance in the room. Many of the features that students cited as having positive impacts on their learning were opposite of those described as negative characteristics (e.g., adequate lighting). They liked spaces that facilitated group work, student-student interaction, good sight lines, and had ambiance. When the researchers asked the participating students to sketch their ideal classroom they consistently ensured good sight lines from all classroom locations and furniture that facilitated interaction between people.

Methodology

Survey and data collection

This study included three independent surveys. In the Fall 2011 semester, we randomly selected students currently enrolled in classes that met in one of the tiered classrooms to participate in an online survey. As shown in Table 1, the random sample represented about 25% of the enrolled students. The response rates for the invited students varied between 43-57%; the overall response rate was 47%. The Fall Survey included seventeen common statements for all classrooms plus an additional 3-5 statements tailored to specific classrooms. Students responded on a five-point Likert scale with *strongly agree, agree, neutral, disagree,* and *strongly disagree* responses. Finally, students could respond to the prompt: "Describe how the classroom design and furniture helped or hindered working with other students in class."

In the Spring 2012 semester we invited all senior biology, chemistry and psychology majors (247 individuals) to complete an online survey. Students majoring in these departments were likely to have taken classes in several of the tiered classrooms during their tenure in college. As part of this Senior Survey, students reported their major(s). Table 1 includes the respondents' majors. Some students reported multiple majors. The overall response rate was 51% with all three majors well represented.

Table 1. Response rates and counts for the three surveys

Fall Student Survey	**Room**	**half-round 210**	**straight 310**	**serpentine 410**
	Enrolled	427	533	585
	Selected	99	137	152
	% Sampled	23%	26%	26%
	Respondents	56	59	69
	Response Rate	57%	43%	45%
Spring Senior Survey	**Major**	**Biology**	**Chemistry**	**Psychology**
	Respondents	61	48	27
	Response Rate	50%	65%	41%
Spring Faculty Survey	**Room**	**half-round 210**	**straight 310**	**serpentine 410**
	Respondents	20	23	16
	Response Rate	77%	85%	52%

Table 1. Response rates and counts for the three surveys

Seniors evaluated each of the classrooms as an overall learning environment on a five-point scale (*Excellent – Very Good – Good – Fair – Poor*). An additional choice, *I have not had a class in this room,* was included. In addition, seniors were invited to respond to two open-ended statements:

- For your rooms ranked good, very good or excellent, what features made it a good learning environment?
- For your rooms ranked poor or fair, what features made it a poor learning environment?

Finally, we invited faculty who taught in any of the large classrooms to complete an online survey in the Spring 2012 semester. Fifty-nine of the 84 invited faculty completed the survey, corresponding to an overall response rate of 70%. Table 1 also includes the number of responding faculty and response rates for each of the three classrooms that are the focus of this report.

Since some faculty may have taught classes in more than one classroom, we constructed the faculty survey using skip logic making it possible for faculty to respond only for classrooms in which they had taught. The Faculty Survey included seventeen statements with a five-point Likert scale (*strongly agree, agree, neutral, disagree,* and *strongly disagree*). The statements were similar to those proposed to the students in the Fall Survey. We also asked faculty four additional questions beyond the 17 Likert scale statements for each classroom:

- Approximately what percentage of time is spent in forward-focus activity in your courses in Room xxx?

  81-100% 61-80% 41-60% 21-40% 0-20%

- How often do you have students use the writable walls in this classroom?

Often	Frequently	Occasionally	Never
100-67%	67%-33%	<33%	Never

- Describe how the classroom design and furniture helped or hindered teaching and learning in this class. *(Open-ended)*
- What else would you like to tell us about your experiences teaching in this classroom?

Analysis methods

We analyzed the Likert scale items within each survey (Fall Student, Spring Senior, Spring Faculty) using ANOVA analysis followed by Tukey Honest Significant Difference (Tukey HSD) analysis, if warranted. For each statement we calculated the overall mean and median for all three classrooms and for each classroom individually. In cases where the initial ANOVA analysis indicated a statistically significant difference ($p \leq 0.05$) we analyzed the responses using Tukey HSD analysis. This test calculated p-values for t-test comparisons with correction for multiple tests. In this way, it is possible to determine for which room responses were statistically significantly different ($p \leq 0.05$). We performed all statistical analysis using the R statistical programming language.

We also compared student and faculty responses to statements for each classroom. We compared these independent groups using both normal theory and non-parametric tests in a corroborative fashion to examine the possibilities of significant differences in group means between the faculty and student assessments of the Likert-based classroom characteristics. The influential effects of outlier observations in the datasets suggested that use of the non-parametric comparison method was a more effective statistical methodology for these data. Thus, reported p-values for all comparisons were based on the Wilcoxon Rank Sum test, instead of the usual grouped t-tests.

Open-Ended Responses

We analyzed the open-ended questions by coding responses into categories. We reported results for items that more than three participants mentioned.

Results and Discussion

Quantitative Results

Table 2 contains the summary data gathered in the three surveys. In addition to the statements presented to the respondents, Table 2 also includes the mean response on the five-point Likert scale (5 = Strongly Agree, 1 = Strongly Disagree). These mean responses for both faculty and students are presented for each of the three 72-seat classrooms: half-round tables (room 210), straight fixed tables (room 310), and serpentine tables (room 410). The last two columns report the findings of the statistical tests to ascertain any differences in the faculty or student responses to the statements as pertaining to the three different classrooms. Finally, in cases where there is a statistically significant difference between the student and faculty responses on an item for a certain classroom, the faculty mean is marked with an asterisk. Any indication or statement of statistically significance corresponds to $p \leq 0.05$.

Classroom Design

The first nine statements in Table 2 relate to the classroom design. These statements generally pertain to elements in the classroom (e.g., whiteboards), consequences of design choices (e.g., no center aisle), or affective elements resulting from design elements (e.g., cramped and congested). Generally, both students and faculty agree that they enjoy the classroom ambiance and think the classrooms are well designed. Although students did not respond differently to the ambiance or design statements by classroom, faculty prefer the ambiance of the classroom with half-round tables over that of the serpentine table classroom. Faculty think that the rooms with straight tables and half-round tables are better designed than the room with serpentine tables. Faculty are more likely than students to agree with both of these statements regarding the room with half-round tables, but students are more likely than faculty to agree that the room with serpentine tables is well designed.

Faculty and students alike disagree with the third statement about whether the classroom is cramped and congested. Generally, faculty think that the room with serpentine tables is more congested than the room with half-round tables. Students, on the other hand, found no difference in the congestion of these two rooms, but found the room with the straight tables less cramped than either of the other two.

The fourth statement which asks only about the room with serpentine tables, focuses on the lack of a center aisle in the first two rows of the serpentine tables, as shown in Figure 1. Consequently, faculty circulating among the students during group work requires walking in the space between the first and second rows of tables where students often leave their backpacks. Room 210 with the half-round tables, on the other hand, has four stand-alone tables across the front of the room, allowing easier movement through that part of the classroom. There is no statistically significant difference between faculty and student

	Statement	Average Faculty Response			Average Student Response			Summary Statements	
		half-round 210	straight 310	serpentine 410	half-round 210	straight 310	serpentine 410	Faculty	Students
Classroom Design	I enjoy the ambiance of this classroom.	4.6*	4.1	3.4	3.9	3.8	4.0	Faculty think the ambiance of Room 210 is better than that of Room 410.	No statistically significant differences.
	I think this classroom is well designed.	4.6*	4.2	3.3*	4.0	4.3	4.1	Faculty think Room 410 is less well designed than either Room 210 or 310.	No statistically significant differences.
	This classroom feels cramped and congested.	1.8	2.0	2.7	2.7	1.9	2.4	Faculty think Room 410 is more cramped and congested than Room 210.	Students think that Room 310 is less cramped and congested than either Rooms 210 or 410.
	I like that there is no center aisle for the first two rows.			2.4			3.0	Only asked of faculty who taught in Room 410	Only asked of students about Room 410
	The write-on walls are a benefit to the overall learning environment of this classroom.	4.0	3.8	4.2	4.1	4.1	4.3	No statistically significant difference.	No statistically significant differences.
	The design of this classroom inhibits me from expressing my opinion.				2.0	2.1	2.3		No statistically significant differences.
	When I take an exam in this classroom, I have enough personal space.				4.2	4.2	3.7		Students feel that they have more space for exam taking in Room 310 than in Rooms 210 or 410.
	It is important to me to have both whiteboard and chalkboard options in this classroom.	1.9	2.2	2.2				No statistically significant difference.	
	The layout of this classroom facilitates active learning pedagogies.	4.5	3.7	3.5				Faculty think Room 210 works better for active learning pedagogies than Rooms 310 or 410.	
Classroom Mechanics	When engaged in a forward-focus activity (e.g., lecture), the table/chair layout of this classroom effectively allows students to gather the presented information.	4.7*	4.4	3.8	4.1	4.4	4.0	Faculty think Room 210 is better than Room 410 for gathering information in forward-focus activities.	Students think Room 310 is better for forward-focus activities than Room 410.
	When engaged in a group-focus activity (e.g., a group problem solving exercise), the table/chair layout of this classroom effectively promotes group interaction.	4.7*	3.6	3.6	4.4	3.2	3.4	Faculty think Room 210 is better for group-focus work than either Rooms 310 or 410.	Students think Room 210 is better for group-focus activity than either Rooms 310 or 410.
	Going back and forth between forward-focus activity and group-focus activity is readily accomplished with the table/chair layout of this classroom.	4.7*	3.6	3.8	4.2	3.3	3.5	Faculty think Room 210 facilitates switching between group and forward focus activities better than either Room 310 or 410.	Students think Room 210 is better for switching between activities either Rooms 310 or 410.
	Sitting at a table location that does not naturally face forward does not impede my ability to learn course material.				3.4		3.4		No statistically significant differences.
	With two tables on each level, it is easy for students at the front table to turn their chairs around to talk with students behind them when doing group work.					3.8			Only asked of students about Room 310

[**Table 2.** Continues on next page.]

	Statement	Average Faculty Response			Average Student Response			Summary Statements	
		half-round 210	straight 310	serpentine 410	half-round 210	straight 310	serpentine 410	Faculty	Students
Classroom Technology	Sight lines to the front of the room are fine in this classroom.	4.0	4.1	3.9	3.8	4.2	4.2	No statistically significant difference.	Students prefer the sight lines in Room 410 over those in Room 210.
	The arrangement of projection screens and boards works well in this classroom	4.3	4.0	4.2	4.3	4.3	4.4	No statistically significant difference.	No statistically significant differences.
	The classroom technology (e.g. projection, computers, document cameras) effectively allows the transfer of information.	4.3	4.4	4.4	4.3	4.3	4.6	No statistically significant difference.	Students prefer the technology in Room 410 over that in Rooms 210 or 310.
Teaching and Learning Environment	Overall, this classroom is conducive to teaching and learning.	4.7*	4.2	4.0	4.2	4.3	4.1	Faculty think Room 210 is more conducive to teaching and learning than Room 410.	No statistically significant differences.
	I like the teaching and learning environment created by the _____.	4.7*	4.0	3.6	3.8	3.8	3.6	Faculty like the teaching and learning environment in Room 210 better than Room 410.	No statistically significant differences.
	The physical aspects of this classroom (as opposed to the curricular aspects of the course) help me be a more effective teacher/help me stay focused during class.	4.2*	3.8	3.4	3.6	3.7	3.7	No statistically significant difference.	No statistically significant differences.
	I prefer the learning environment created by the _____ tables to a more traditional classroom (e.g., fixed chairs with tablet arms).	4.8*	4.2	3.7	3.9	4.1	3.6	Faculty prefer the learning environment in Room 210 over that of Room 410.	Students have preference for Room 310 over Room 410.
	Evaluate each room as an overall learning environment.				3.3	4.2	3.4		Seniors consider Room 310 to be a better learning environment than either Room 210 or 410.
	Regardless of the specific class activity, I like coming to this classroom for class.				3.8	3.8	3.7		No statistically significant differences.
	By the end of class, I am tired of being in this space and anxious to leave.				2.5	2.4	2.3		No statistically significant differences.

Table 2. Summary of Responses from Faculty and Student Surveys

responses to this statement. A percentage breakdown of the responses to this statement can be found in Table 3. In general, student responses were symmetric about the "neutral" response, while faculty responses tend toward the disagree end of the scale.

The lack of a center aisle in the room with the serpentine tables is likely the reason that faculty thought the room with serpentine tables is more cramped and congested than the room with the half-round tables but students found no difference between these two rooms. Pedagogical practices influence the extent to which student backpacks contributed to the congestion in the room. If the instructor circulates through the rows during most class periods, students learn to place their backpacks in other locations.

When the instructor only occasionally moves through the rows students are more likely to leave their backpacks in locations that impeded movement through the classroom rows.

As mentioned, all the classrooms have walls painted with whiteboard paint allowing students to work "at the walls." We find no differences in the student and faculty opinions regarding this statement. For both groups between ⅔ and ¾ of the respondents agree that the writable walls benefit the learning environment. In our Faculty Survey we ask faculty

Percentage of Responses					
Survey	**Strongly Agree**	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**
Students	3%	27%	45%	22%	3%
Faculty	7%	14%	29%	14%	36%

Table 3. Fall Survey and Faculty Survey responses to statement *"I like that there is no center aisle for the first two rows."*

to specify the extent to which they have students use the writable walls during class. The results, shown in Table 4, indicate that most faculty use the writable walls "occasionally" or "never." Nevertheless, faculty and students agree that the writable walls benefit the learning environment (Table 2).

In the open-ended comments a few faculty comment on the difficulties of having a large number of students working at the wall at the same time. However, one faculty member pointed out that "Write-on walls are essential for accountability in groups."

Students also report that the writable walls are a fun place to work with other students. One student commented that "The write-on walls helped to collaborate with other students because everyone is able to see your work and can critique to help everyone solve the problem." Overall, both students and faculty had positive responses to the writable walls, despite the walls' low utilization.

Room	*How often do you have students use the writable walls in this classroom?*			
	Often	**Frequently**	**Occasionally**	**Never**
	67-100% of class meetings	33-67% of class meetings	<33% of class meetings	0% of class meetings
half-round 210	10.0%	15.0%	45.0%	30.0%
straight 310	0.0%	9.1%	45.5%	45.5%
serpentine 410	0.0%	20.0%	40.0%	40.0%

Table 4. Faculty Survey: Perceptions of Writable Wall Utilization.

Students generally disagree with the statement about expressing opinions and there is no statistically significant difference between classrooms. The statement about having enough personal space during exams, also asked only of students, shows that most students agree with this statement. However, students felt that they have more space with the straight tables than with either the half-round tables or the serpentine tables. This is consistent with the student responses to the open ended questions to explain what makes a space good or poor. Frequently, students cited that there is not enough personal space at the ends of the rounded tables.

We posed the last two Classroom Design statements to faculty only. The boards at the front of the room include three vertically telescoping whiteboards with a chalkboard mounted on the wall behind the whiteboards. Faculty disagree that the availability of both types of boards is important. Classroom design supports active learning pedagogy in all three rooms, however, faculty think that the room with half-round tables are better for active learning pedagogies than either the rooms with straight or serpentine tables.

Classroom Mechanics

The next set of statements refers to ideas about the mechanics of teaching and learning in the classroom. In contrast to the classroom design statements, this section involves ways in which students engage with the instructor and/or classmates. As mentioned, we intended to use the classrooms for both group-focused and forward-focused work interchangeably. Both the students and faculty agree that the rooms work well for both of these kinds of activities, as well as for switching between forward- and group-focused activities.

In comparing the three different classrooms, we find that:

- Both students and faculty think the half-round tables are better for group-focused work than either the straight or serpentine tables.

- Students and faculty both think that switching between group- and forward-focused work is most readily accomplished with the half-round tables.
- Students prefer the straight tables for forward-focused activities over the half-round or serpentine tables.
- Faculty report no difference between the half-round and straight tables, although they preferred the half-round tables over the serpentine tables.

All faculty agree with the statements about forward-focus, group-focus, and switching between activities for the half-round tables. While the majority of students also agree with these statements, there is a statistically significant difference between students and faculty. Students are less likely to agree with these statements regarding the half-round table room.

For the half-round and serpentine tables, students report a "neutral" response to whether sitting at a non-forward facing seat impedes learning. For the straight tables, students agree that they can easily turn around chairs to form a group with students seated in the second row of a tier.

Classroom Technology

The next three statements relate to the use of technology in the classroom. Since the technology installations were identical in the three classrooms, we did not expect differences between the responses. There are, however, some statistically significant differences in the responses. Students and faculty both agree there are good sight lines to the front of the room, although students prefer the sight lines in the serpentine table room to those in the half-round table room. Consistently, the open-ended comments from students in regards to the half-round table room include many mentions of having trouble seeing the front of the classroom from certain areas of the room; such comments are infrequent for the serpentine table room. Given that the serpentine table room is the only one of the three classrooms where each row of tables was on a separate tier, this finding makes sense.

As illustrated in Figure 1, the half-round table room (210) has four student groups across the front of the room, while only three such groups span the front of the serpentine table room (410). Consequently, the students sitting at the far edges in 210 are further from the center of the room, causing less direct sight lines. Students in the straight table room (310) only comment on difficulties seeing the front of the room from the second row on each tier due to taller individuals in the first row, not because of room design.

Student and faculty alike agree that the arrangement of projection screens and boards work well. Similarly, the technology (projectors, etc.) also appear to work well in these three rooms. Curiously, students prefer the technology in serpentine table room over that in either the half-round or straight table rooms. The exact same technology setup is installed in all three rooms.

We expect the ways in which the faculty utilized the classroom technology to influence the student's experiences. Each classroom has two projection screens: one located in the center of the room and one angled toward the left side of the room as seen from the front. If the angled screen is used, students seated on the right side of the classroom would have more difficulty seeing it than students seated in other room locations.

Teaching and Learning Environment

The final section of Table 2 relates to the classrooms as teaching and learning environments. The statements in this section are largely affective in nature and sought opinions or attitudes about the classrooms as teaching and learning spaces. For the most part, the majority of students and faculty agree with these statements. Faculty favor the learning environment of half-round tables over that of the serpentine tables as evidenced by the responses to the statements about the classroom being conducive to learning, the classroom learning environment, and preferring this classroom over a more traditional classroom.

Students indicate a preference for the straight tables over the serpentine tables when responding to whether they prefer the classroom in the study to a more traditional classroom and as an overall learning environment. On the other hand, student responses show no statistically significant differences between the three classrooms for statements about the classroom being conducive to learning and the classroom learning environment. There are no statistically significant differences between the classrooms in the faculty or student responses to the statement about the physical aspects of the classroom helping with effective teaching (for faculty) or with staying focused during class (for students).

The first four "Teaching and Learning Environment" statements in Table 2 result in statistically significant differences between faculty and student responses to the half-round table room. In all cases faculty agree with the statements to a greater extent than students.

We posed the last three statements to students only. When evaluating each room as an overall learning environment, seniors prefer the straight table room over the half-round or serpentine table rooms. The Fall Survey includes statements about whether students like coming to the classroom for class and whether they feel tired and anxious at the end of class. In both cases there are no statistically significant differences in the responses for each classroom.

The last two statements in this study are similar to statements included in a previous study about our laboratory spaces (Van Wylen & Walczak, 2011). In that study, when we asked students whether they liked coming to *lab* in this building, 77% of students agreed or strongly agreed. In comparison, about 67% of students in this study report liking to come to *class* in this building. Similarly, the majority of students in the previous study (73%) were not anxious to leave *lab* after 3-4 hours, and in this study ~90% do *not* feel tired and anxious after a 55 or 85 minute class. Thus, our results in this study on the *classrooms* are consistent with student sentiments about the labs in the building.

Open-ended Responses

Faculty

Predictably, faculty provide conflicting opinions regarding some of the features of each room. For instance, faculty report that the serpentine tables were "less effective for small group discussion" and "really, really good for discussion." Similar conflicting opinions about other features include the difficulty of students moving to and from the writable walls in the room with straight tables and the suitability of the straight tables for group work.

In spite of these differences of opinion, some features of the rooms hinder the teaching and learning environment. The serpentine and half-round tables are awkward for testing as students are located close together and may face each other. The half-round and serpentine tables, while preferred for group work, do not work as well for forward-facing activities.

Other features help teaching and learning in these rooms. The combination of whiteboard and projection screens works well for most faculty, although in some cases faculty express concern about difficulty seeing the side screens from some classroom seats. The open design of the rooms with half-round or straight tables allow faculty to move easily among the students.

Students

Fall survey students responded to the open-ended statement: *Describe how the classroom design and furniture helped or hindered working with other students in class.* The most frequent comments for each room are summarized in Table 5. Students appreciate the way that the half-round tables allow groups to form easily. Sometimes when students are asked to work in groups for a portion of a class period there is awkwardness around deciding with whom to work, especially if the instructor does not direct the group formation. Since the half-round tables are designed for four students, groups formed naturally at the table, thereby removing this social barrier. Students also comment that the serpentine table design facilitates group formation. Students also feel that there are sufficient options for forming groups at the straight tables.

Describe how the classroom design and furniture helped or hindered working with other students in class.		
half-round tables (210)	**straight tables (310)**	**serpentine tables (410)**
Tables facilitate student-student interaction (11)	Primarily lecture occurs in my class (7)	There is insufficient personal space (10)
Whiteboard walls as a learning tool (6)	Sight lines from the second row of each tier are poor (7)	Table design is good for large groups (8)
There is insufficient personal space (6)	There are satisfactory ways to do group work (7)	Room is good for both group work and lecture (4)
Sight lines are poor from some locations to the front of the room (4)	This room is not as good for group work (3)	There is sufficient personal space (3)
Tables are too close together (4)	There is sufficient personal space (3)	
	Group work is confined to students around you (3)	

Table 5. Fall Survey: Most frequent (n≥3) student comments about the three classrooms.

Students expressed dissatisfaction with the sight lines to the front of the room for both the half-round and straight table rooms. In the straight table room the comments focus on problems seeing from the second row on each tier. One student said "I am average height (5'6") but often am stuck behind taller people and cannot easily see the board."

Finally, students comment about the amount of personal space in all three classrooms. Students who mention personal space at the half-round tables thought there is not enough, especially at locations at the table edges. At the straight tables, on the other hand, the few students who mention personal space thought it is sufficient. Curiously, with the serpentine tables, students said *both* that there is insufficient (n=10) and sufficient (n=3) personal space. The serpentine table shape can explain this apparent discrepancy. Students seated at the widest part of the table think the space is sufficient while those at the narrow sections of the table feel cramped for space.

Similarly, seniors report that a learning environment was excellent, very good or good if it had large work surfaces and comfortable chairs (n=34), is used in ways that match

the classroom layout (n=23), has good sight lines (n=22), is bright and featured natural light (n=20), and uses the tables to provide group structure (n=12). Features that warrant a fair or poor ranking include insufficient space at tables (n=36), the serpentine table shape (n=9), poor lighting (n=9), difficulty seeing the front of the room (n=8), and having a classroom configuration that is a poor match to the class activities (n=7). Our students sought the same kinds of features as reported by others (Veltri, Banning, & Davies, 2006).

The classrooms are designed to accommodate a variety of different pedagogies and thus far we have paid little attention to aligning classroom assignments with teaching strategies. Consequently, it is not surprising that students recognize when the classroom design and the pedagogy are mismatched. The only data we gathered to date regarding actual utilization was faculty self-reported percentages of time spent in forward-focused activities, as shown in Table 6. Since this is self-reported data from faculty, it is difficult to draw firm conclusions. Faculty indicate that the classes in the straight and serpentine table rooms may have more forward-focus activity based on the percentage of faculty choosing the 81-100% response. In the future, we intend to explore the actual uses of different types of pedagogies more closely.

We are interested in the amount of time your students spend in forward focused activity (e.g., lecture) vs. group or individual work. In general, approximately what percentage of class time is spent in forward-focus activity in your courses in RNSxxx?

	Percentage of Time in Forward-focused Activity				
Room	**81-100%**	**61-80%**	**41-60%**	**21-40%**	**0-20%**
half-round 210	10.0%	55.0%	20.0%	10.0%	5.0%
straight 310	22.7%	31.8%	27.3%	4.5%	13.6%
serpentine 410	26.7%	46.7%	20.0%	6.7%	0.0%

Table 6. Faculty Survey: Self-reports on time spent in forward-focused activity.

Conclusions

We had three goals for this study. First, we wanted to determine whether the three classroom layouts were effective teaching and learning spaces for a range of pedagogical approaches. Faculty thought the room with the half-round tables was the best all-around classroom because it was flexible and allowed easy transitions between forward- and group-focused activities. Students preferred this room for group work, but considered the room with the straight tables the best configuration for lectures. Seniors regarded the straight table room as the best overall learning environment.

Second, we sought to identify design elements that enhanced teaching and learning for faculty and students. Students responded positively to all three classroom designs. They appreciated the tables that suggest ready-made groups and encouraged student-student interaction. Faculty had a clear preference for the room with the half-round tables over the other rooms regarding classroom design, classroom mechanics, and teaching and learning environment.

Both faculty and students saw the writable walls as a benefit to the learning environment. However, since most faculty reported using the walls "occasionally" or "never," we suspected that this benefit may be underutilized in practice.

Finally, we wanted to evaluate the effectiveness of the technology resources in the classroom. Faculty responded to statements about the room sight lines and technology in the same way for each room. Students noted that the sight lines in the room with half-round tables were not as good as in the room with serpentine tables and preferred the technology in the serpentine table room over that in either the half-round or straight table rooms. Since the technology installations were identical in all three rooms, we speculate that the students' perceptions of difference are related to the ways in which the technology was *used* in the different classrooms. While examining the classroom technology efficacy was a goal of this study, the identical technology installations and the type of data collected limits the conclusions we can draw.

Overall, we were pleased that our classroom designs for these three classrooms in Regents Hall were so well received by students and faculty. The systematic analysis of the data provided some ideas for others in the design stage of a project to consider as they develop their plans. In addition, some issues arose that might be implemented in our own spaces, such as making an effort to match pedagogy and classroom, shifting movable tables to increase personal space as possible, and paying more attention to sight lines for students in certain room locations.

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