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POE: Understanding Innovative Learning Places and Their Impact on Student Academic Engagement—Index 6–8 'Alpha' Survey Developments

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Abstract

New evidence builds upon the Student Engagement Index™ and Teacher Engagement Index™ research (Scott-Webber, Konyndyk, & French, 2019; Scott-Webber, Konyndyk, French, & French, 2018; Scott-Webber, Konyndyk, French, Lembke, & Kinney, 2017) determining post-occupancy answers to, "*Can we demonstrate that the design of the built environment for grades 6–8 impacts student academic engagement levels post-occupancy?*" The early studies used respondents from grades 9–12. This one is from users in grades 6–8 ('alpha' pilot). All studies were conducted in the USA as convenience samples. Engagement performance is a high predictor of student success across multiple domains and learning/work experiences. Specifically, "Research that shows that engagement, the time and energy students devote to educationally purposeful activities, is the best single predictor of their learning and personal development" (Anonymous, NSSE, 2010, p. 2), and thus our research focus. From both the students and educators perspectives, design of the built space impacts engagement performance ($p < .0001$).

Keywords: academic engagement, architecture, learning place design, post-occupancy evaluation, survey development

1. Introduction

1.1 Does Design Make a Difference in Learning and Teaching?

Why survey students and educators to see if design makes a difference in their everyday learning or teaching situations? Because, evidence indicates engagement performance is a high predictor of success across multiple domains and learning/work experiences. Specifically, "Research shows that engagement, the time and energy students devote to educationally purposeful activities, is the best single predictor of their learning and personal development" (Anonymous, NSSE, 2010, p. 2), and thus our research focus. Furthermore, and perhaps just as importantly, most of our human experiences are inside this built 'box' called school; the USA average is 6.5 hrs per day for approximately 180 days = 1,170 hrs per year; added up = 15,210 hours. Therefore, it stands to reason that where we spend our time and how these places are designed to support individual needs is critical to understand.

This current work builds on a career effort and the questions used are framed from multiple researchers in several domains in a holistic approach titled the Users Environmental Interaction Framework.v2© (UEIF.v2) (Scott-Webber, 1999). This study builds upon that work in trying to understanding how the deign of the built environment impacts student academic engagement levels (Scott-Webber, Konyndyk, French, & French, 2018; Scott-Webber, Konyndyk, French, Lembke, & Kinney, 2017; Scott-Webber, 2004; Scott-Webber, Marini, & Abraham, Spring, 2000). This report differs as it studies a new age cohort - students in grades 6 to 8. The research question for this study continues to be the same as for the higher grades of 9 to 12. It is, "*Can we demonstrate that the design of the built environment for grades 6-8 impacts student academic engagement levels post-occupancy?*" The research design is explained next.

This research team utilized a Human-Centered Research Design (HCRD) protocol to study this question post-occupancy. The focus for human-centered research understands how the design of the built environment impacts human behavior, importantly how users behave and if that behavior was anticipated in the development of the design solution. Multiple methods are often used to answer research questions, but fall into two areas, qualitative and quantitative. To ensure a rich set of data is generated, the HcRD (see figure 1) protocol always uses a mixed-method (Johnson, Onwuegbuzie, & Turner, 2007) research design (inclusive of both quantitative and qualitative) for comparative purposes, and thus limits research bias. The HcRD method uses the following:

1) Quantitative techniques = literature review, "questionnaires and surveys" (Hanington, 2010, p. 22), and

2) Qualitative techniques = "observing and talking to people…these methods are typically ethnographic in nature, and may include participant observation, artifact analysis, photo and diary studies, contextual inquiry, cultural probes, and other methods designed to sample human experience" (Hanington, 2010, p. 23).

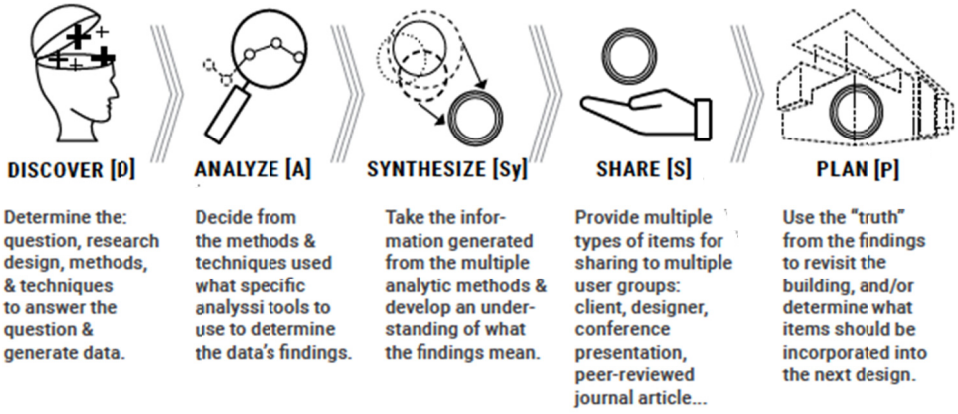

Figure 1. A human-centered research design protocol (HcRD)

The research question and the research design are in harmony as the HcRD is human-centered and supports inquiry relating to how the built environment impacts human behavior. Our research question asks the same in the context of the educational setting for grade levels 6 to 8 and used post-occupancy.

1.2 Exploring the Importance of Studying the Problem from a Post-Occupancy Perspective

As we research new design concepts for education, and in order to mitigate the effect of experiencing something new, we survey post-occupancy at a minimum of at least three months after occupation in a new building. Although many definitions of Post-Occupancy Evaluation (POE) have been proposed, a useful, classic definition is that "…POE can be defined as 'the process of evaluating buildings in a systematic and rigorous manner after they have been built and occupied for some time' (Preiser, Harvey, & Edward, 1988," in, Anonymous, 2008). Our research over multiple years has indicated that from both the students' and the educators' perspectives the design of the school makes a significant difference relative to academic engagement performance. However, their responses differ slightly. Engagement is a critical piece of this research. This work has the opportunity to understand: (1) the level of academic engagement as perceived by both students and by educators about their students, (2) whether students at grades 6–8, a new cohort level can discern this impact, (3) if design is supporting the educational efforts, and then (4) how this knowledge may be used to impact designs for the next learning spaces. This study followed a rigorous scientific research protocol and provided the following:

- Research-grounded questionnaire proven to be both reliable and valid, pre-tested at ~~a~~ different eductional levels across multiple years
- Perceptions received from both user groups, students and educators, about academic engagement levels
- Awareness of the building's (macro or overall/rest of the built environment) building's design, as well as the individual learning spaces' (micro or classrooms) design and how they contribute to levels of engagement
- Comparison to instructional strategies and how these built spaces support these endeavors.

Overall, this 6–8 'alpha' pilot (3 schools, students *n = 2,007*; teachers *n = 210*) continues to extend the knowledge that the design and use of the built space at both the micro (classroom/learning place), and macro (overall/rest of built learning spaces) areas impacts student academic engagement levels. This team continues to work to build reliable and valid instruments for which to study this important question.

1.3 Relevant Scholarship

The Student Engagement Index™ (SEI) questionnaire is focused on the student's perspective. This current work builds on a career effort and the questions used are framed from multiple researchers in several domains in a holistic approach titled the Users Environmental Interaction Framework.v2© (UEIF.v2) (Scott-Webber, 1999). A review of the framework is next. The graphic in Figure 2 represents the complexity of interaction/engagement understandings with multiple facets including these specific segments: (1) layers of the design of the built spaces—the micro level, or classroom, and macro level, or overall, (2) two Dimensions of Value and Environment, (3) two Responses of Internal and Behavioral, and (4) Proxemic Zones at the micro level. This framework has built on the research of many others, particularly classical Environment Behavior Theorists, in an effort to more fully examine space and its relationship to its users (Hall, 1966; Sommer, 1959; Maslow, 1943; Bloom, Krathwohol, & Harrow, 1956; Elliot & Covington, 2001; Scott-Webber, 2000 & 2004; Scott-Webber, Abraham, & Marini, 2000) (see Figure 2).

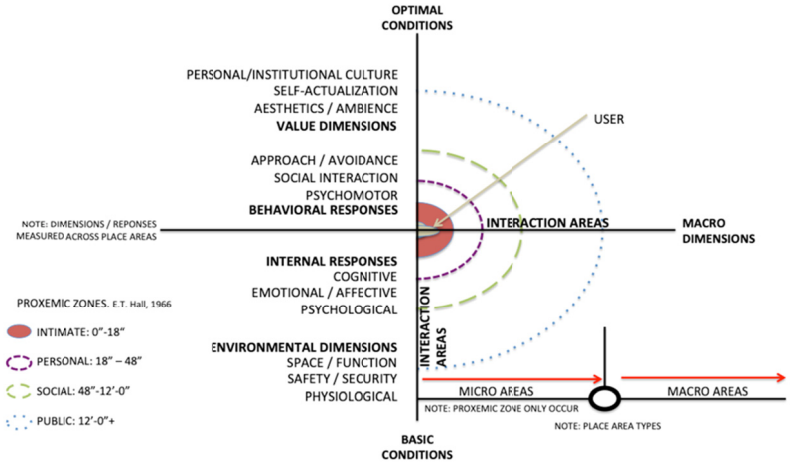

Figure 2. Users environmental interaction framework.v2© (UEIF.v2)

The current study built upon early work done in higher education (Scott-Webber, 2014; Scott-Webber, Strickland, & Kapitula, 2013; Scott-Webber, Marini, & Abraham, Spring, 2000), and the relatively new research for grades 9–12 survey instruments. This newest research effort studies grades 6 through 8. The surveys are designed to ask a series of questions related to the UEIF.v2 relative to two spatial areas (1) the overall (or macro environment) (2) the classroom (a micro environment), or learning spacebuilt environment of the school. It also asks how well one can move about, navigate from instructional strategy to instructional strategy; the opportunity of choice and control over where and how students may wish to learn and with whom; whether indoor environmental qualities are touched upon; accessiblity to 'tools' within their learning spaces; ability to see, hear, be comfortable and be connected to others; and motivational factors. It then focuses on the situational culture [the situation of each school, and its organization's culture] of the school and their perceived understanding of the values placesd on different types of learning experiences. Finally, it ends with a set of demographic questions.

The Teacher Engagement Index™ (TEI) questionaire follows the SEI with two specific foci. First, it asks the educator to rate his/her student's engagement levels using the same questions the students' receive. This perspective is critical and the teacher responses are compared to the student responses. Second, it asks the educator how the design of the built space is supporting his/her needs, again at the macro and micro levels. It digs in deeper in the educators perspective to unpack the instructional strategies and how the design of the spaces support them.

This research was attempting to 'prove' that the design of space makes a difference in how individuals engage with each other, with their teachers, and with the academic content. This work tried to understand and measure

what was impacting interactions or engagements. We believed it was important to not just answer the research question, but try and provide a tool, or index and measurable awareness levels to use as gauges of engagement and environmental fit. This document reports on a survey of three middle schools, grades 6–8, and is the first time we have attempted to survey students in this age group, as an 'alpha' test, and expected to learn some things to do differently the next time around. Our earlier surveys were of high schools, grades 9–12. Surveying middle school students raised several questions:

1) Would middle school students understand a survey of the type we need to do?
2) How much language would need to change to ensure these cohorts would comprehend our questions from high school?
3) Would middle school students be willing to respond to a survey?
4) How much would the survey need to be simplified and/or shortened for them?
5) Would we get results similar to the high school surveys, and how would results differ?
6) How might middle school teachers answer differently than high school teachers?

We are pleased that overall, students responded well to the survey, and the results were similar to those of the high schools' surveys. To address our concern stated in #2, we asked a former assistant superintendent and some of her educators to review the 9–12 text and help ensure the vocabulary and meaning would fit with this age cohort. Some slight changes were made to the original surveys (three pilots for high school) as a result of their reviews. While we encountered a couple issues along the way, there was nothing that would call the validity of the survey into question. As one would expect, there were some differences between the middle school and the high school survey responses.

2. Method

A short definition for each step in this Human-Centered Research Design protocol (refer back to Figure 1) is shared:

- Discover [D]: Develop a research question/hypothesis and understand what will be the best research design, methods and techniques to find answers, and use them to gather data. It's best to use three techniques to ensure bias is reduced. Once gathered the researcher(s) puts this information into appropriate format(s) for analysis. Whether using quantitative methods or qualitative methods, all data will be worked to produce some numerical findings. Once this latter stage is done, these become research 'instruments' or tools. (NOTE: a human subject's protocol has been reviewed by a third party prior to beginning work with a client; all consent forms approved and received).
- Analysis [A]: Take the data from the research techniques and use appropriate methods to break down the information. By using multiple discovery techniques to avoid bias ensures the comparisons generates consistent and reliable findings. Use statistical methods when appropriate. Pilot test and test again to vet the data for reliability and validity.
- Synthesis [Sy]: Recognize the analysis phase of this work only generates facts. What these facts 'are saying,' how each is connected to the next is revealed by generating meaning and understanding relative to the original question. This segment takes time and expertise to clarify and built a 'truthful' and unbiased consensus from the data.
- Share [S]: Be prepared to share information to multiple audiences and for multiple purposes—clients, designers, conferences, and research manuscripts.
- Plan [P]: Know all data reveal a truth—not always the ones we're looking for or expecting. Be prepared to plan for next steps (ex, go back and address an issue found in a design and/or adjust the design solution for the next time it is used).

The sample information and response rates are shared next.

2.1 Sample and Response Rates and Analysis of Missing Data

There were three schools used as convenience samples with purposeful user groups (students and teachers), each school designed by a particular architectural firm, with 1,381 total responses to the student survey. Student response to the survey was very good, with over 60% of the students in each school responding to the survey. Response rates from the teachers were much lower at schools A and B; the reason is unknown (see Table 1). The small number of teachers responding made it difficult to draw statistically valid inferences about how the

teachers viewed the different schools. To ensure anonymity, school names are coded, and all data represented here are from the 6-8 study.

Table 1. Response rates by school

School	No. Students	Respondents	%	No. Teachers	Respondents	%
A	848	545	64.3	120	31	25.8
B	479	403	84.1	45	20	44.4
C	680	433	63.7	45	29	64.4

We had a good mix of students by grade level, which proved to be an important factor in the student data (see Figure 3).

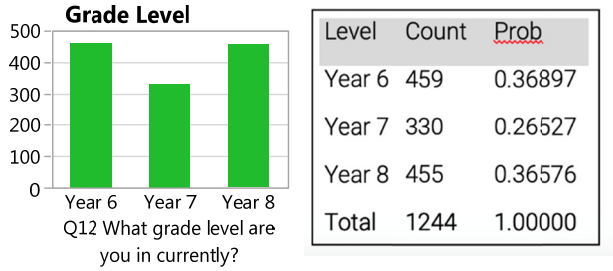

Figure 3. Grade level indicators/students

Similarly, we had a good mix of teachers by grade level; focus on grades 6-8. Of course, many teachers teach more than one grade; see self-identified other grade levels taught (see Figure 4).

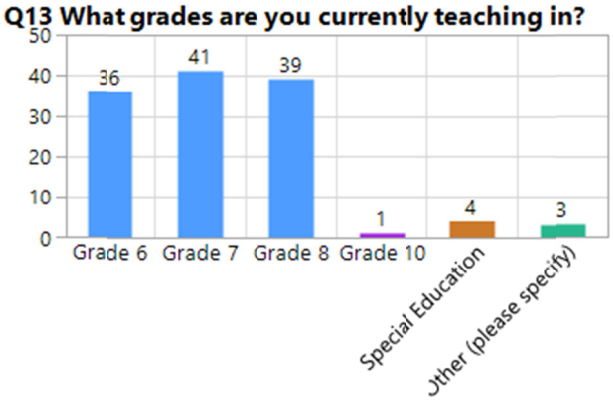

Figure 4. Grade level indicators / teachers

Of the "Other" group, there was one answer each of "Office", "Grade 5", and "Counseling". Overall, there was little problem with non-response to questions on the survey. Among the students, 68% answered every question, and another 12% skipped only one question (but not the same question). However, we did see a little "survey fatigue" in the student survey, as the number of skipped questions rose toward the end of the survey (see Figure 5).

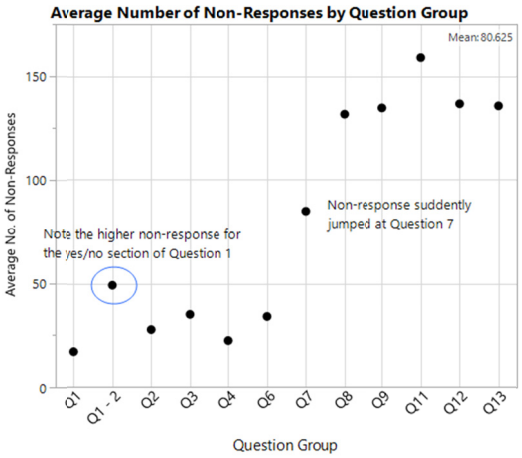

Figure 5. Survey response rate—survey fatigue/students

Eighty teachers in all took the survey, although one person answered only the demographic questions at the end. Looking at the question items with numeric answers (1–4 and 6–9), 70 of the 80 teachers answered every numeric-rating item, and 4 teachers skipped only one item (see figure 6). Non-Response of individual numeric questions was not a problem on this survey; for each question group with numeric answers the response rate was 95% or better on those questions. Five teachers quit after question 9, so there was a bit of "survey fatigue", as shown in the graph below. The greatest non-response was for the second part of question 10, whether the design supported the teaching method the teacher used (see Figure 6).

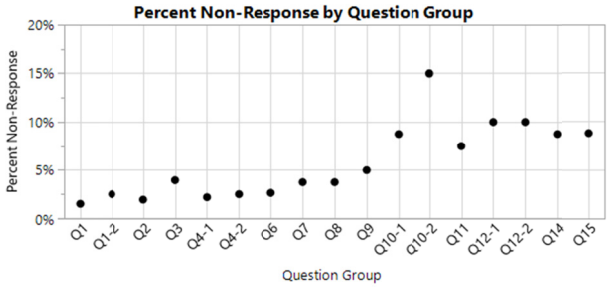

Figure 6. Survey response rate—survey fatigue/teachers

3. Results

3.1 Reliability & Validity

The objective behind measuring reliability of a survey is to assess whether people give similar answers to similar questions on the survey. Consistent with the earlier surveys, we used Cronbach's Alpha to assess reliability. Alpha is a number between 0 and 1, with a value of 1 indicating that questions are answered in exactly the same way. We have very good reliability numbers overall for both the teacher and the student surveys. On the teacher survey, only question 4 (classroom and building ratings) had Alpha below .80, and the classroom and building rating values were both greater than .70. On the student survey, all the values of Alpha were also greater than .70, with only question 1 (importance of various items) being less than .80. Thus, we conclude that both the teacher and the student surveys are reliable.

The idea of validity in a survey is to ask whether the study measures what the researcher desired to measure. Another method to determine whether the survey is providing the results intended is through convergent (items are strongly correlated as expected) and divergent (weak or negative correlation) validity. We have good evidence of validity in both the student and the teacher surveys. A strong indicator is the fact that the findings of these surveys are similar to, but not identical with, the surveys done of high school students and teachers. One difference is that the response by grade level is of greater importance in this survey than in the high school surveys, an intuitively pleasing result, given the younger ages of the students. Teachers also seem to sense the

building as having a greater impact on them than at the high school level.

Convergent and divergent validity in the student survey may be seen in the correlations of the composite variables; questions 2–9, about how things actually work and are well correlated with each other, while the more theoretical question 1 (Importance of…) has lower correlations with all the other variables. Thus, we see high and low correlations where one would expect them to be.

A similar pattern occurs in the teacher survey. Question 1 has relatively low correlations with the other variables, and questions 2, 3, 4, 6, 8, and 9 have good correlations with each other. Some individual questions of particular interest, along with a comparison of students and teachers are offered next.

3.2 Statistics and Data Analysis

Classroom ratings overall were fairly similar (see Figure 7). Not surprisingly, teachers saw the items in question 1 as being more important than did the students. Question 1 had the greatest divergence of opinion between teachers and students. The environmental quality questions generated complaints about the temperature, which seems to be universal but the students rated the noise level as being just as bad (see Figure 8). In general, the students were slightly more critical than the teachers. For both students and teachers, only 26% rated the temperature "Excellent" or "Very good". The overall average rating by students was 2.78, and 2.74 for teachers on our 5-point scale. The average student rating for Noise Level was 2.74 (see Figure 9). Differences by school were minor. The most divergent variables are "belonging to the school's community" and "collaboration," yet "mentoring" shows less divergence. These three more than the other six variables are related to inter-active sociability, i.e., inter-personal relationships and engagements, rather than individual experiences and outcomes (testing, critical thinking, creativity, etc.).

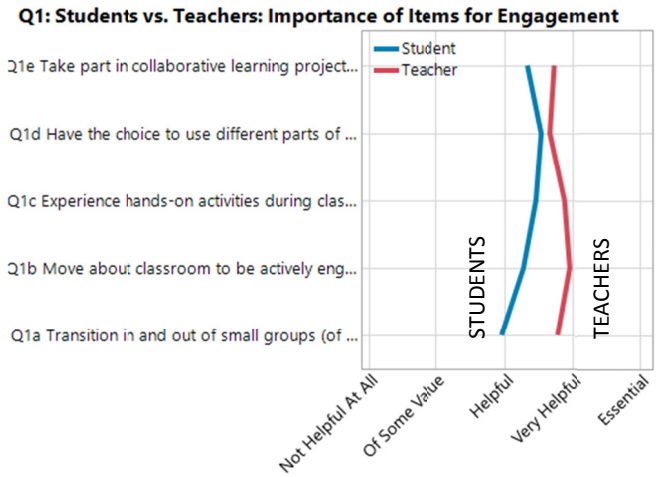

Figure 7. Importance of items for engagement/students vs. teachers

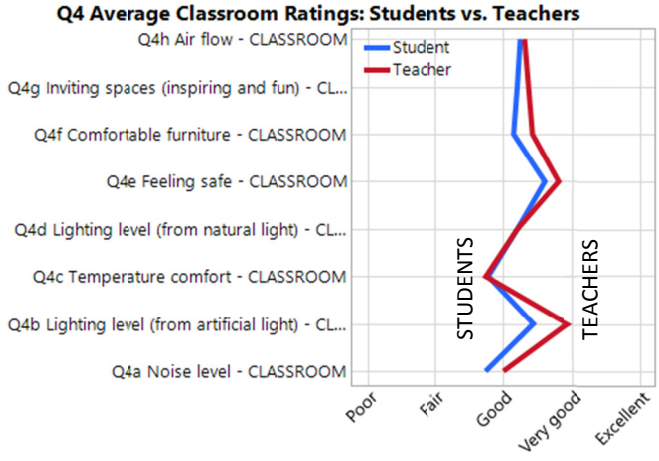

Figure 8. Environmental quality ratings from both student and teachers

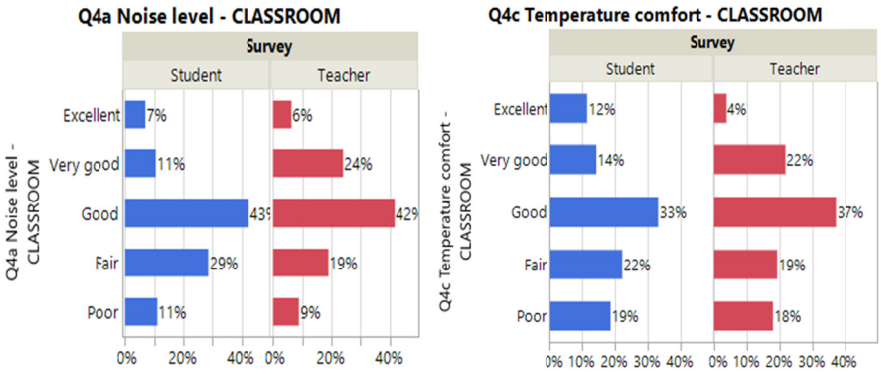

Figure 9. Perceptions of noise and temperature comfort levels

On question 6, the values of the school, teachers were sometimes more positive than the students (see Figure 10).

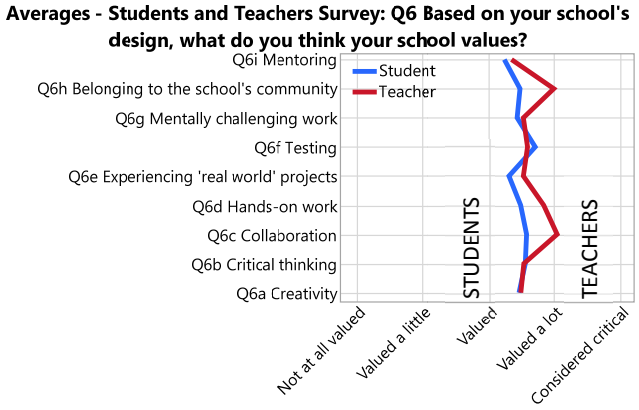

Figure 10. Perceptions of what the school values

3.3 The Role of Demographic Factors

Some demographic information was collected on the surveys. For the students we asked about their gender and their grade level, and we asked the teachers what grades they taught, their gender, and what academic degrees they held. We knew which school they were at without asking. Unlike the "Omega's" (Scott-Webber, Konyndyk, French, Lembke, & Kinney, 2017; Scott-Webber, Konyndyk, French, & French, 2018), survey for the high school level, the schools in this survey did not become a factor in most of the questions. For students, the grade level produced some interesting differences, perhaps a reflection of the changes a child experiences in middle school. In the regressions described below, demographic factors were checked for relevance, but typically only the student grade level mattered.

3.4 Principal Component Analysis & Composite Variables

Before constructing the composite variables, described below, Cronbach's Alpha was computed for each question group, and a principal components analysis was performed in order to verify that the mean of each question group would be a reasonable proxy for the group.

For each numeric question group, the mean of the group was used as the composite variable to represent the whole group. If more than one question in the group was skipped, then the composite variable for that group was set to a missing value. The composite variables were used in the regression analyses and in the cluster analysis.

The composite variable for question 7 (At the end of a school day, how often do you feel that you…) was used as

the engagement index for both teachers and students. The overall average values for both the teacher engagement index (TEI) and the student engagement index (SEI) were similar to the corresponding values on the "Omega" survey, and like that survey, the student values showed greater variability (see Figure 11). The results of the analysis are next.

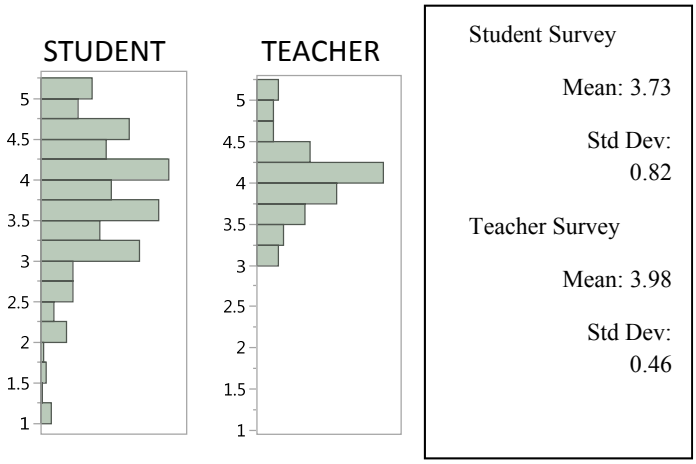

Figure 11. Distributions of the engagement indexes

3.5 Analysis Results

3.5.1 Regression Analysis/Students

In general, the school played little or no role in the regression results in this survey, while gender had some impact, and grade level had even more impact. Consistent with the surveys of high school students, girls tended to have slightly higher engagement than boys, and those who opted for the "prefer not to say" sector having lower engagement. Engagement also tends to drop as the grade level rises.

Results of the regressions in this survey were very similar to those of the "Omega" at the high school level. While there were a couple of statistically significant interactions, they were of little practical importance. The impact of the various questions on student engagement is basically the same across school, gender, and grade level. These are shared next:

- *SEI and Question 1: (The importance of various items for engagement).* Of all the numeric questions (1–4, 6, 8, and 9), question 1 has the weakest relationship with student engagement. Regressing the SEI on just question 1 yields a small $r^2 = .13$. Students who perceive that the items in question 1 are important show only a slight tendency to have a higher level of engagement.
- *SEI and Question 2*: (*How well do the classrooms provide you with the ability to…?).* Regressing the SEI on question 2 by itself gives a very strong $r^2 = .29$ with $p < .0001$. The school is not a factor, but adding in grade level and gender to the regression raises r^2 to .34. Also, there is no interaction of Q2 with either grade level or gender, and we see that students who believe that the classrooms provide the ability to see and hear well and give access to appropriate items are also likely to be more engaged. The values of r^2 here are quite similar to those of the "Omega" survey (see Figure 12).

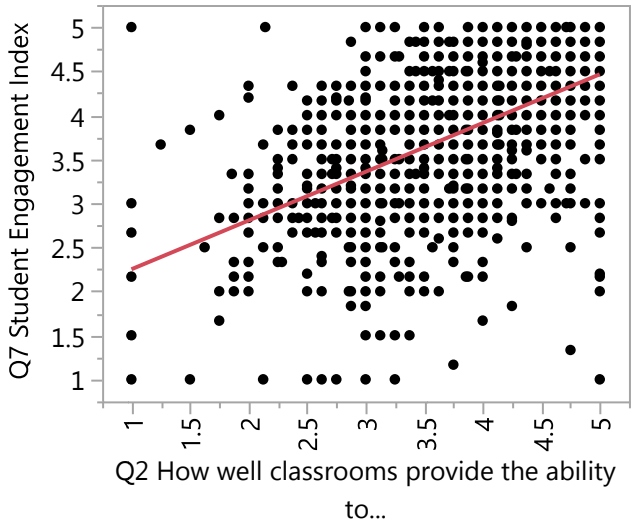

Figure 12. Regression plot of the SEI vs. Q2

- *SEI and Question 3, (How much impact does the design of the classroom have on you…*). For this question, the school figures into the regression, and there is an interaction between question 3 and grade level, though none with school or gender. Thus, using question 3, gender, grade level, school, and the interaction between question 3 and grade level yields $r^2 = .31$, with $p < .0001$. The interaction, while statistically significant, only increases r^2 from .30 to .31, resulting in little practical impact. Using only Q3 to predict the SEI gives $r^2 = .26$, with $p < .0001$, shows a good association by itself (see Figure 13).

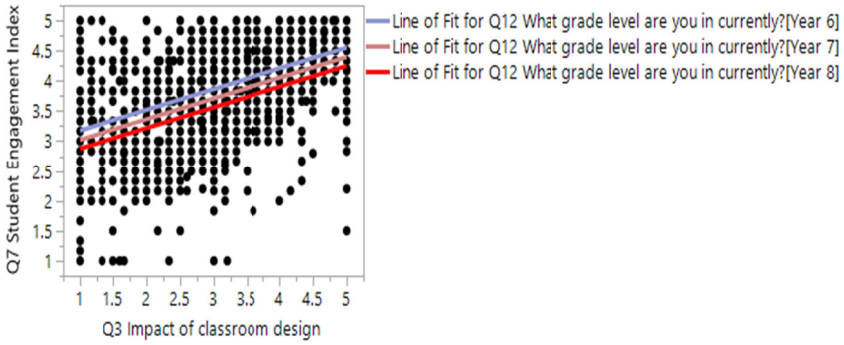

Figure 13. Regression plot of the SEI on Q3 (impact of classroom design)

- *SEI and Question 4: (Please rate the following aspects of the classroom environment*). Students were asked to rate their classrooms on several aspects (noise, temperature, lighting, etc.), though they did not rate the building overall, a change from the grades 9–12 survey. The association between the ratings and engagement was fairly strong, with $r^2 = .29$, very similar to the "Omega" survey. Gender and grade level, though statistically significant, raised the value of r^2 by only .03, indicating that they are minor effects (see Figure 14).

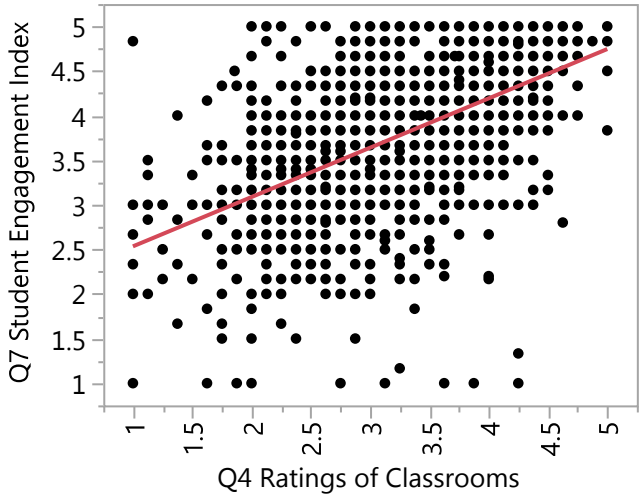

Figure 14. Regression plot: SEI regressed on Q4 (classroom ratings)

- *SEI and Question 6: (What do you think your school values…).* Consistent with the "Omega" survey of grades 9–12, we see a strong relationship between student engagement and whether the student believes that the school values items such as creativity, critical thinking, and mentally challenging work. Regressing the SEI on question 6 alone gives $r^2 = .39$. (The corresponding regression on the "Omega" survey had a similar r^2 of .45). This question and question 8 (impact of the design of the school on access to peers and teachers and on the ability to move in the classroom) had the strongest association with student engagement, of all the questions.

Once again, school is not statistically significant, even at the p = .05 level. Adding grade level and gender into the regression gives only a small improvement in r^2, to .42. We may conclude that the effect of the values of the school is the same across gender, grade level, and school, and the effect of the perceived values on engagement is quite strong (see Figure 15).

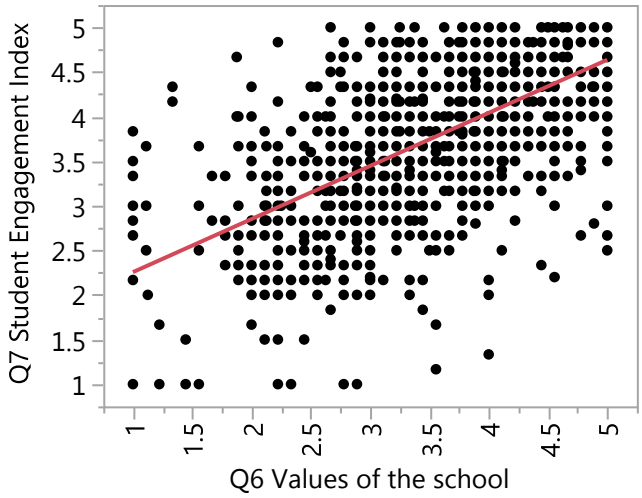

Figure 15. Regression plot: SEI vs. values of the school

- *SEI and Question 8: (How much to you believe the design of the school overall impacts your ability) to….).* Once again, school is not significant, nor is any interaction terms. Grade and gender add only a little to the information provided by question 8, improving r^2 from .42 to .45. We have another very

strong association here; students who believe that the design of the school facilitates access to peers and teacher and provides the ability to move in the classroom tend to have higher engagement. In the "Omega" (9–12) survey, the regression of the SEI on the corresponding question produced a very similar $r^2 = .39$ (see Figure 16).

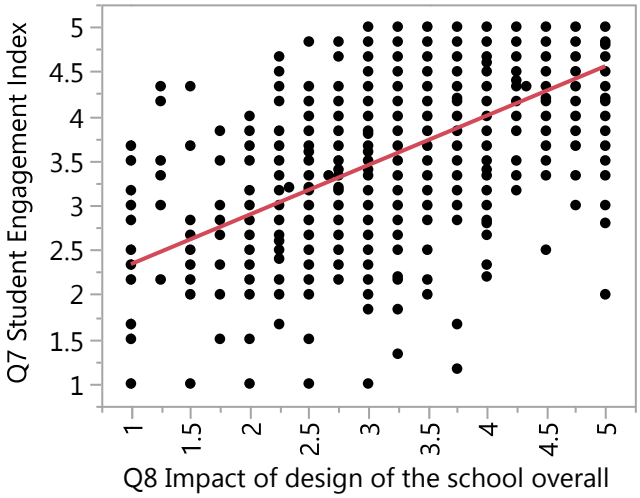

Figure 16. Regression plot: SEI vs. Q8

- *SEI and Question 9: (Level of impact of the design of the building on your…).* We see a strong relationship between Q9 and the SEI, with $r^2 = .30$ with the SEI regressed on question 9 alone. Adding in the grade level improves r^2 to .33. Gender, school, and the interaction of grade level with Q9 are statistically significant, but of little practical importance, as each of them improves r^2 by only .01.

In summary, these regressions show a strong statistically significant relationship between satisfaction with the building and the student engagement index.

3.5.2 Regression Analysis/Teachers

3.5.2.1 The TEI and Demographic Variables

Looking at gender by itself, there were no detectable differences in the values of the Teacher Engagement Index (TEI). The means of the TEI were an all-but-identical 3.98 for women and 4.01 for men. "Prefer not to say" had a lower mean of 3.58, but with only three people in that group, there is no statistical significance. Similarly, a one-way ANOVA for the TEI on level of education yielded no statistically significant difference. Gender and level of education appear to have no impact on the TEI. Differences by school were statistically significant, at the $p = .0012$ level, giving $r^2 = .166$, with school C having the highest mean (4.17) and school A the lowest (3.75) (see Figure 17).

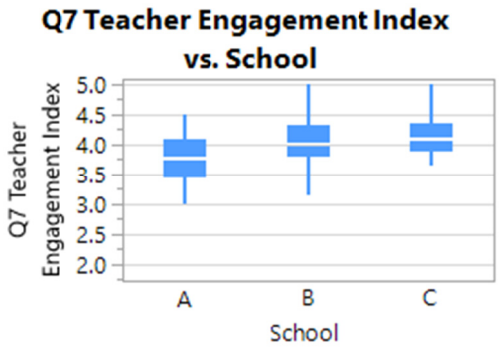

Figure 17. Boxplot of teacher engagement index by school

3.5.2.2 The TEI and the Numeric Questions (1–4 and 6–9)

Perhaps because of the smaller sample size in this survey, the relationships between the numeric questions and the TEI lack statistical significance. As we saw with the "Omega" 9–12 survey, the school is a better predictor of the TEI than are any of the numeric questions. A summary of this information is next:

- Question 1, the second part of question 1 (Design supports), and question 2 do not come close to statistical significance for the TEI, whether with or without the demographic variables
- Question 3 hovers near statistical significance, but only at the p = .05 level. The school is of greater importance to the TEI than is question 3. Regressing the TEI on just question 3 yields a measly r^2 = .055, with p = .0425, while including the school in the model gives r^2 = .22.
- Question 4 Classroom Ratings are statistically significant, with r^2 = .10 and p = .0052. Again, school is more important; adding it to the model raises r^2 to .25. This actually a bit stronger relationship than we saw in the "Omega" survey.

These results are similar to those of the "Omega" from grades 9–12 survey, which also found only weak relationships between teacher engagement and the other numeric questions. Cluster analysis is described next.

3.6 Custer Analysis

3.6.1 Clusters for the Students

For the students, four clusters worked well. As with the previous surveys, Ward's Method was used for the clustering. Average engagement in the clusters varied widely, from a high of 4.70 in cluster 2 to a low of 2.91 in cluster 4. Alas, cluster 2, with the highest average engagement, is the smallest cluster. Except for question 1, part 2, a higher number means "good" and a lower number means "bad" for the questions. Question 1, part 2 asked whether the design helped the items in the first part of Q1 succeed, and the scale of question 1, part 2 was reversed, with 1 = Yes and 2 = No. That explains the strange look in the graph at that question. Thus, the four clusters are quite neatly stratified, with cluster 2 having the highest means for each question, followed by cluster 1, and then cluster 3, with cluster 4 having the lowest means for each question (see Table 2).

Table 2. Student cluster means

Cluster	Count	Q7 Student Engagement Index	Q1 Importance of various items	Q1 part 2 Is the design helpful? (1 = Yes, 2 = No)	Q2 How well classrooms provide the ability to...	Q3 Impact of classroom design	Q4 Ratings of Classrooms
1	356	4.19	3.57	1.06	4.15	3.50	3.62
2	133	4.70	3.97	1.03	4.51	4.58	4.08
3	499	3.46	3.20	1.14	3.43	2.73	2.91
4	182	2.91	2.66	1.55	2.85	2.16	2.38

Cluster	Q6 Values of the school	Q8 Impact of design of the school overall	Q9 Impact of design of building's physical spaces
1	3.97	4.14	3.70
2	4.57	4.76	4.81
3	3.22	3.17	2.82
4	2.48	2.40	2.10

A corresponding graph of the cluster means is in Figure 18 (see Figure 18).

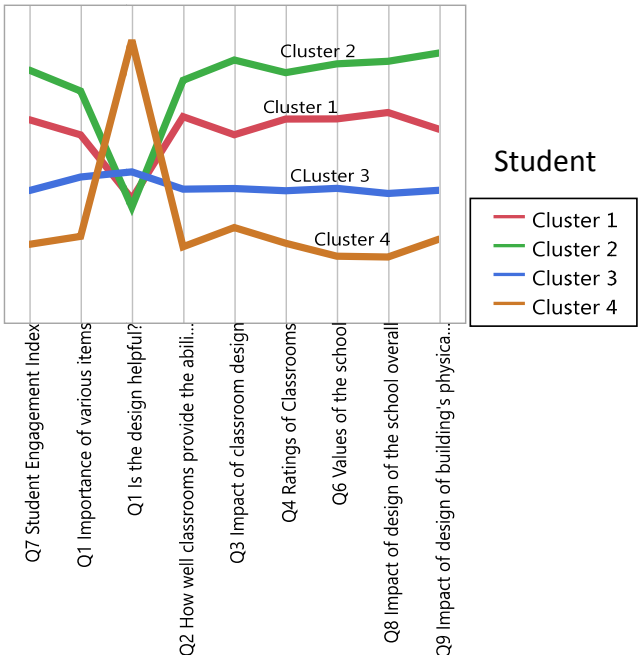

Figure 18. Corresponding cluster graph of interpretation of design support/student

A look at the clusters by school does not show strong differences, a change from the "Omega" 9–12 survey (see Figure 19).

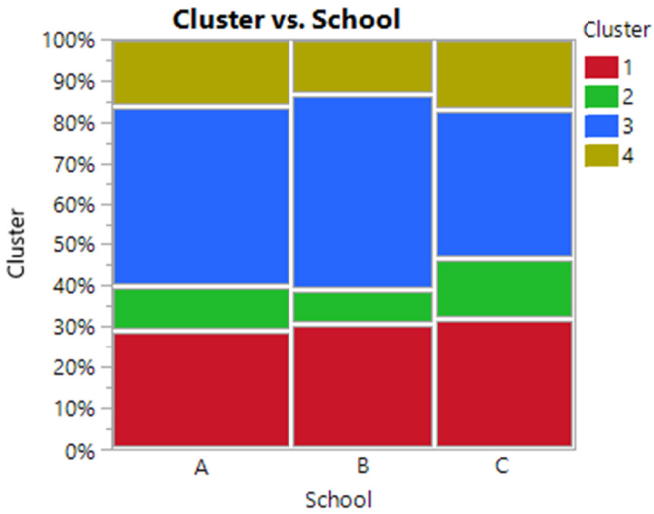

Figure 19. Cluster means by school

Consistent with the regression results, one can see a little higher percentage of females than males in clusters 1 and 2, with a bigger drop-off in "prefer not to say" when viewing cluster by gender (see Figure 20).

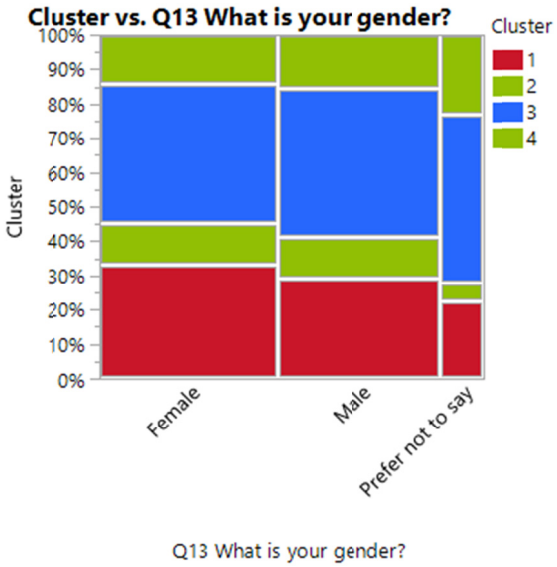

Figure 20. Cluster by gender

The graph of clusters by grade level (Figure 21) is more dramatic, and the indicators are going 'in the wrong direction!' Next, is the clustering for the teachers.

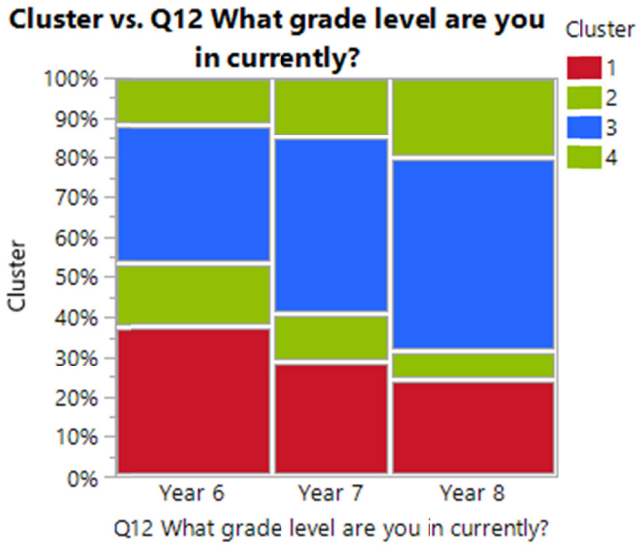

Figure 21. Cluster by grade level

3.6.2 Clusters for the Teachers

The results of the cluster analysis of the teachers are reminiscent of the surveys of high school teachers. Clusters 3 (blue) and 4 (orange) both show high engagement, while the 26 teachers of cluster 4 are very happy with their physical environment, the 9 teachers of cluster 3 are quite unhappy with it. This divergence among highly engaged teachers helps explains why the regressions showed so little connection between the TEI and the various questions (see Figure 22).

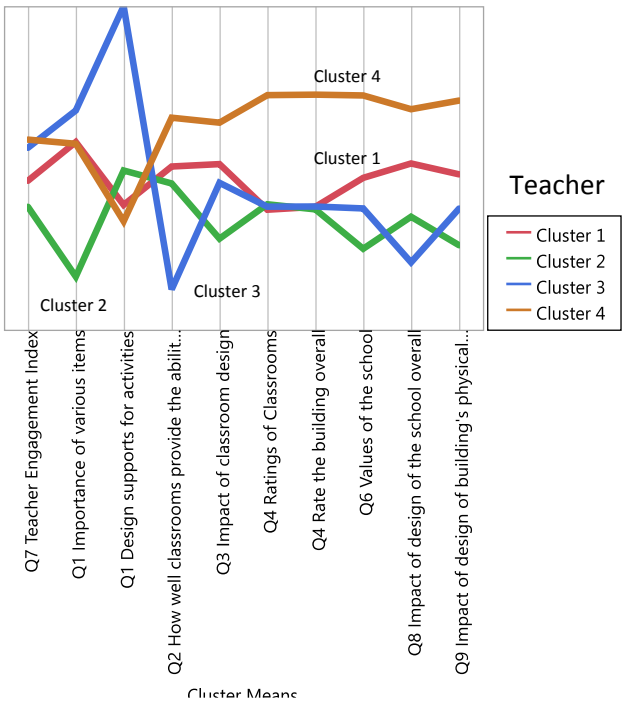

Figure 22. Corresponding cluster graph of interpretation of design support/teachers

Table 3. Cluster analysis

Cluster	Count	Q7 Teacher Engagement Index	Q1 Importance of various items	Q1 Design supports for activities	Q2 How well classrooms provide the ability to…	Q3 Impact of classroom design
1	23	3.908	4.061	1.087	3.555	3.065
2	16	3.758	2.900	1.238	3.392	2.292
3	9	4.097	4.333	1.956	2.374	2.870
4	26	4.144	4.046	1.015	4.024	3.494

Cluster	Q4 Ratings of Classrooms	Q4 Rate the building overall	Q6 Values of the school	Q8 Impact of design of the school overall	Q9 Impact of design of building's physical spaces
1	3.060	3.207	3.588	3.661	3.435
2	3.102	3.188	3.083	3.125	2.696
3	3.083	3.208	3.370	2.667	3.079
4	3.928	4.024	4.175	4.208	4.203

The cluster means are in the Table 3 (refer back to Table 3). As with the student survey, the second part of question 1 (“Design supports?”) had 1 = Yes and 2 = No. Therefore, low values are desirable rather than high values for that question. Note that cluster 4, with the highest TEI, also had the “best” mean for each question other than the first part of question 1. Cluster 3, which also had a high mean TEI, had the “worst” ratings for the “Design Supports” part of Q1, and questions 2 and 8, along with nearly bottom ratings for questions 4 (both parts) and 6. Clusters 1 (red) and 2 (green) had similar average TEI values, but cluster 1 assigned very low importance to the items in question 1, while saying that they were very well supported, and cluster 1 saw much more impact from the building than cluster 2 (questions 3, 8, and 9)

Comparing the teacher cluster by school, results show that School B has the highest percentage of teachers in cluster 4, the “happy” group, with the highest means for TEI, and no teachers in cluster 3, the group that seems quite dissatisfied with their classrooms, despite having a high TEI (see Figure 23). What we found regarding the impact the physical surroundings has on the teachers and students follows.

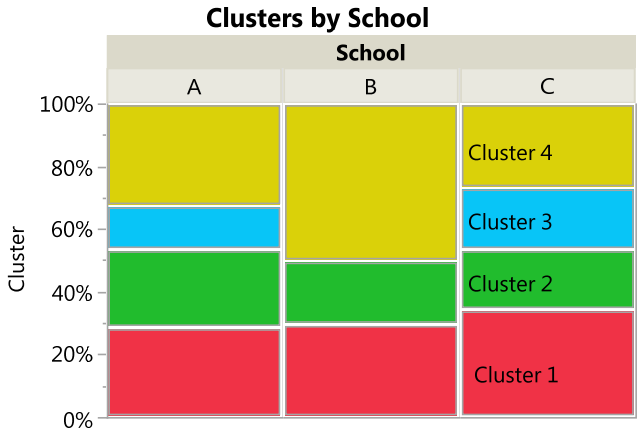

Figure 23. Clusters by School

4. Discussion

4.1 Impact of the Physical Surroundings

4.1.1 Teachers

The table below shows the results of t-tests for H_0: Mean = 3 vs. Mean > 3 for the questions about the impact of the building (see Table 4). Meanings of the numbers:

- Q3: 3 = Moderate impact - 4 and 5 are Makes a noticeable (or big) difference.
- Q8: 3 = Acceptable - 4 and 5 are Easy or Very easy.
- Q9: 3 = Moderate impact - 4 and 5 are Makes a noticeable (or big) difference.

Different question items elicited distinctly different average values of the perceived impact of the built environment. Items significant at the p = .01 level are underlined. The overall view seems to be that the impact of the design of the school on teachers' ability to do things is better than merely "Acceptable" (Q8), but that the impact of the building on teachers (Q9) is greater than the impact on students (Q3). Average values in question 3 are slightly lower than in the "Omega," while answers to Question 9 tended to be a little higher ~~than~~ for the corresponding questions in the "Omega."

Table 4. Impact of built environments/teachers (selected items)

Question Item	N	Mean	T-Test statistic	P <= 3
Q3 How much impact does the design of the CLASSROOM have on your students? It....				
Q3a Motivates them to attend classes	77	2.77	-1.867	.9671
Q3b Enables then to do their best work	77	3.31	2.800	.0032
Q3c Allows classroom participation	76	3.63	5.975	<.0001
Q3d Makes then willing to work hard	77	2.68	-2.665	.9953
Q3e Inspires then to achieve better grades/outcomes	77	2.69	-2.593	.9943
Q3f Provides the ability to create or lead or teach others	77	3.13	1.12	.1331
Q8 How much do you believe the design of the school overall impacts your ability to...				
Q8a Access your peers for collaborating	77	3.60	4.857	<.0001
Q8b Access your students for mentoring and feedback	77	3.66	6.818	<.0001
Q8c Ability to have your students move to engage in classroom activities	77	3.62	5.329	<.0001
Q8d Access appropriate teaching technologies for your use	77	3.74	6.928	<.0001
Q8e Access places to display your students' work	77	3.34	2.675	.0046
Q9 How much impact does the design of the building's physical spaces have on your…				
Q9a Motivation to teach your classes	76	3.22	1.662	.0503
Q9b Perception that teaching is valued	76	3.43	3.650	.0002
Q9c Ability to move around to get your students deeply engaged in their learning	76	3.77	7.217	<.0001
Q9d Willingness to work for higher learning outcomes for your students	76	3.34	2.767	.0036
Q9e Ability to do your best work	76	3.55	4.642	<.0001
Q9f Perception that you can stay connected to the school community	76	3.43	3.369	.0006
Q9g Perception that learning is valued	76	3.66	5.809	<.0001

4.1.2 Students

Students were asked most of the same questions as the teachers about the impact of the built environment. Question 3 asked about the impact of classroom design on the student's attitudes. Question 8 asked about the impact of design on the student's ability to do certain activities, and question 9 asked about the impact of the physical spaces on various things. The table below shows the results of t-tests for means of 3 or higher (see Table 5). For questions 3 and 9, this means at least a moderate impact vs. a little or no impact. For question 8, this means the impact is acceptable or better. Overall, the averages here are a little higher than those on the "Omega" survey. The descriptors by grade level are next.

Table 5. Impact of built environment/students (selected items)

Question Item	N	Mean	T-Test statistic	P <= 3
Q3 How much impact does the design of the CLASSROOM have on you? It....				
Q3a Motivates me to attend classes	1355	2.87	-3.65	.999
Q3b Enables me to do my best work	1342	3.14	4.05	< .0001
Q3c Allows classroom participation	1346	3.35	10.41	< .0001
Q3d Makes me willing to work hard	1344	3.07	1.85	.032
Q3e Inspires me to achieve better grades/outcomes	1348	3.09	2.31	.0106
Q3f Provides the ability to create or lead or teach others	1342	3.13	3.57	.0002
Q8 How much do you believe the design of the school overall impacts your ability to...				
Q8a Access your peers for studying	1252	3.433	14.05	< .0001
Q8b Access your teachers for mentoring and feedback	1250	3.61	20.40	< .0001
Q8c Ability to move to engage in classroom activities	1249	3.65	21.42	< .0001
Q8d Choose either to sit/lounge/stand in order to be active in the classroom	1245	3.39	10.70	< .0001
Q9 How much impact does the design of the building's physical spaces have on your…				
Q9a Motivation to attend my classes	1250	3.03	0.926	.1774
Q9b Perception that learning is valued	1247	3.24	6.90	< .0001
Q9c Ability to move around to become deeply engaged in my learning	1249	3.32	8.95	< .0001
Q9d Willingness to work for higher learning outcomes	1238	3.28	7.75	< .0001

4.1.3 The Impact of Grade Level

The means of the answers to several questions clearly differed by grade level. In fact, the means for all of the composite questions go down as grade level goes up. Thus, as students progress from grades 6–8, they seem to become more negative in their answers to the questions. The students in grade 8…

- See less importance in the activities mentioned in question 1 than younger students.
- Are less likely to believe that the classrooms provide them with the ability to use the basic functions of a classroom (question 2).
- See less impact from the classroom on their motivation and ability to participate (question 3).
- Are less likely to be happy with their classroom overall—noise, lighting, temperature, furniture, etc. (question 4).
- Are less likely to believe that their school values creativity, critical thinking, etc. (question 6).
- Tend to have a lower engagement overall (question 7).
- Are less likely to believe that the design of the school overall facilitates movement and access to others (question 8).
- Tend to see less impact from the building on their overall motivation and ability to move around.
- Are less likely to be in the "better" clusters.

This information is illustrated below (Figure 24). The next figure (see Figure 24) shows the average answers for each individual item in question group 6, which asked about the values of the school. The blue line is grade 6, the red line in the middle is grade 7, and the green line is grade 8. Average values go down as grade level goes up. A section of questions looked at how the physical environment enabled the ability to move about in the classroom and this analysis follows by user group.

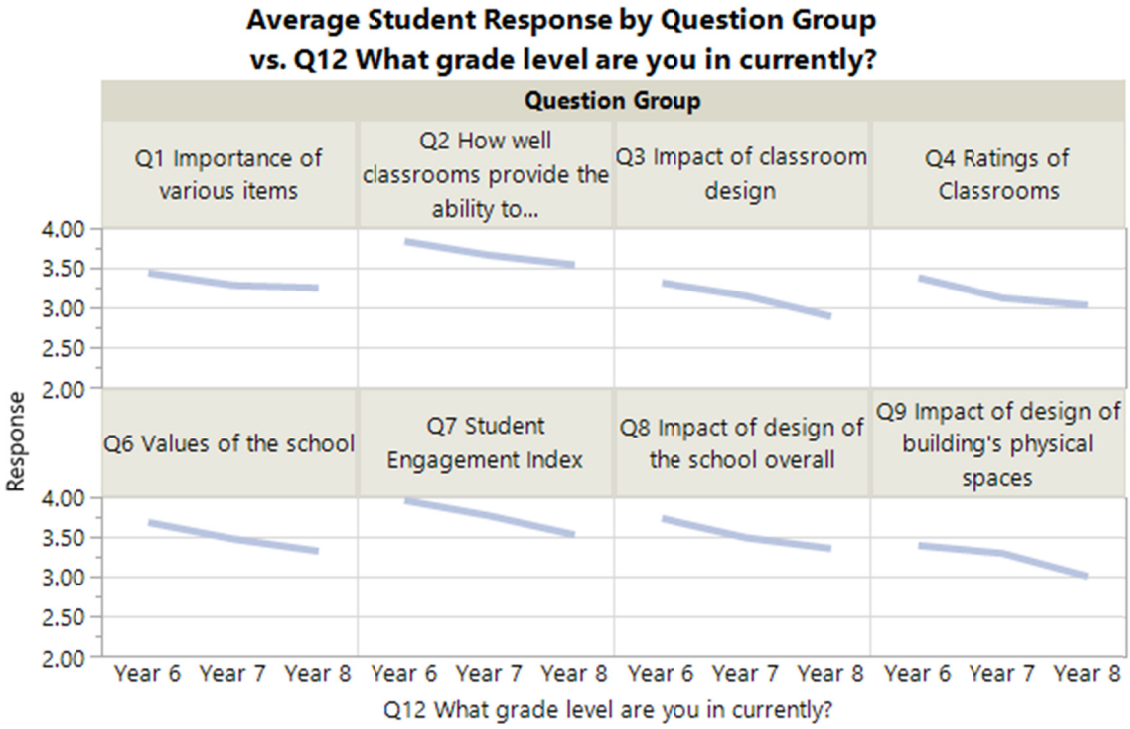

Figure 24. Grade level of student vs. mean values of composite variables

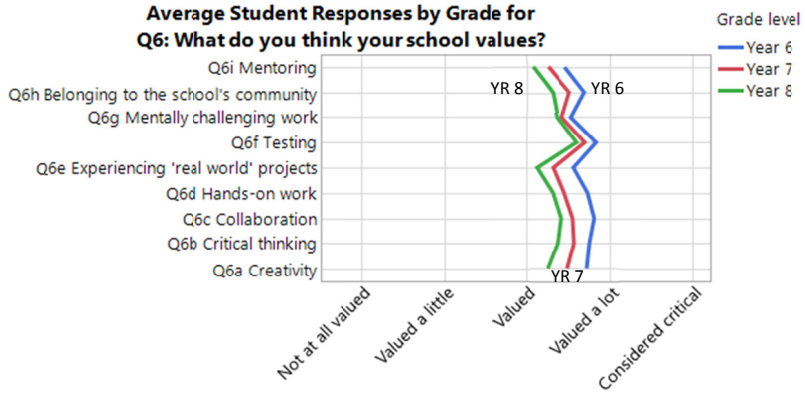

Figure 25. Averages Q6: what the school values/students

4.1.4 “Movement” Questions

4.1.4.1 Students/Movement

Comparing “movement” questions with student engagement somewhat duplicates the regression analyses reported above, but the point is worth repeating for some individual questions. The ability to move goes hand-in-hand with higher student engagement. For students, question 1, about the importance of being able to move, is a bit theoretical, and not surprising that question items about the perceived importance of movement in question 1 are less strongly related to engagement than are the questions items in questions 8 and 9 about actually being able to move, as shown in the table below (see Table 6).

Table 6. Questions related to movement and engagement

Question Item	Correlation with the SEI
Q1b Move about classroom to be actively engaged - Importance of…	0.248
Q1d Have the choice to use different parts of the room to work with others - Importance of…	0.208
Q8c Ability to move to engage in classroom activities	0.573
Q8d Choose either to sit/lounge/stand in order to be active in the classroom	0.496
Q9c Ability to move around to become deeply engaged in my learning	0.507

The overall message is that for these middle school students, the ability to move correlates strongly with student engagement. A look at the "ability to move" question items in question groups 8 and 9, and engagement shows that engagement is higher for students who believe that movement is easier (see Figure 26). (A note about boxplots: the line inside the box indicates the median value, and the box itself contains the middle 50% of the values, giving an idea of the "spread" of the values.)

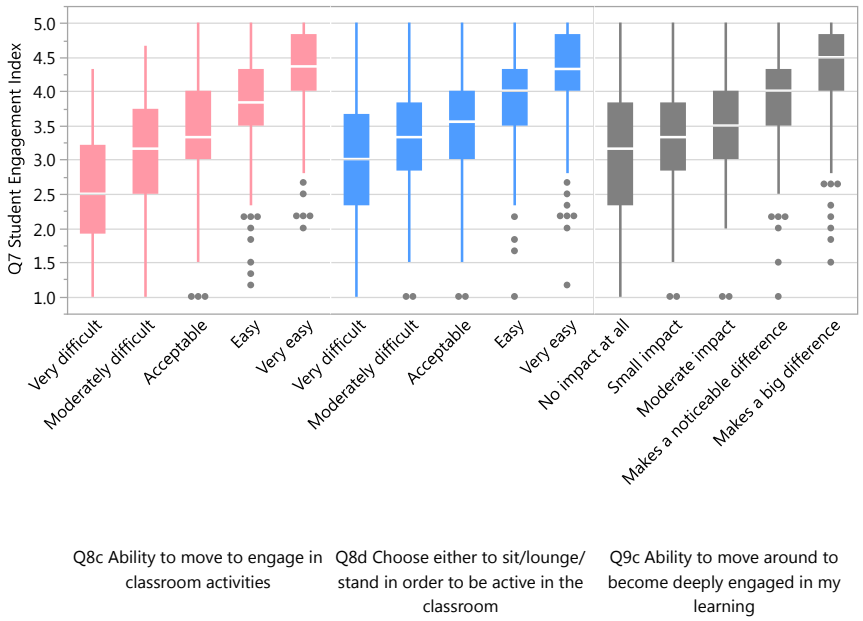

Figure 26. Ability to move corresponding to level of engagement / students

4.1.4.2 Teachers

Teachers were also asked some questions directly relating to movement, specifically:

- Q1a Transition in and out of small groups—Importance of…
- Q1b Move about classroom to be actively engaged—Importance of...
- Q1d Have the choice to use different parts of the room to work with others—Importance of...
- Q2i Move around to keep students engaged (How well do classrooms provide this ability)
- Q2j Have your students move around to keep themselves engaged
- Q8c Impact of the design of the school on: Ability to have your students move to engage in classroom activities
- Q9c Impact of the physical space on: Ability for you to move around to get your students deeply engaged in their learning.

While the student answers to the analogous questions in their survey were positively correlated with the student engagement index, the teachers' answers to their questions showed little relationship to teacher engagement. The questions listed above are all positively correlated with each other, and they fall into two basic groups: the three parts of question 1 are well-correlated, indicating that teachers who viewed one type of movement as important tended to view the other types of movement as important. The second group consists of items 2i, 2j, and 8c,

which have to do with the ability to move, and they are strongly correlated with each other, but not with the items in question group 1. Question item 9c is on its own, though a factor analysis suggests that it could be grouped with the items in question 1. The means of the teachers' answers to the "movement" questions show that they believe that movement is important (question 1), but are perhaps a little less enthusiastic about the actual ability to move (see Table 7).

Table 7. Mean answers to "movement" / teachers

	Mean
Q1a Transition in and out of small groups (of 2 to 4) - Importance of...	3.78
Q1b Move about classroom to be actively engaged - Importance of...	3.96
Q1c Experience hands-on activities during class time - Importance of...	3.88
Q1d Have the choice to use different parts of the room to work with others - Importance of...	3.67
Q2i Move around to keep students engaged	3.49
Q2j Have your students move around to keep themselves engaged	3.41
Q8c Ability to have your students move to engage in classroom activities	3.62
Q9c Ability for you to move around to get your students deeply engaged in their learning	3.76

4.1.5 Teaching Outside the Classroom

According to the teachers, very little teaching is done outside the classroom at school A, while more teaching is done outside the classroom at school B; no teacher at school B reported always staying in the classroom. The students do not completely agree with the teachers, in that they reported much more non-classroom teaching in school A. Still, students in school B seem to report the most teaching outside the classroom, similar to the teachers (see Figure 27).

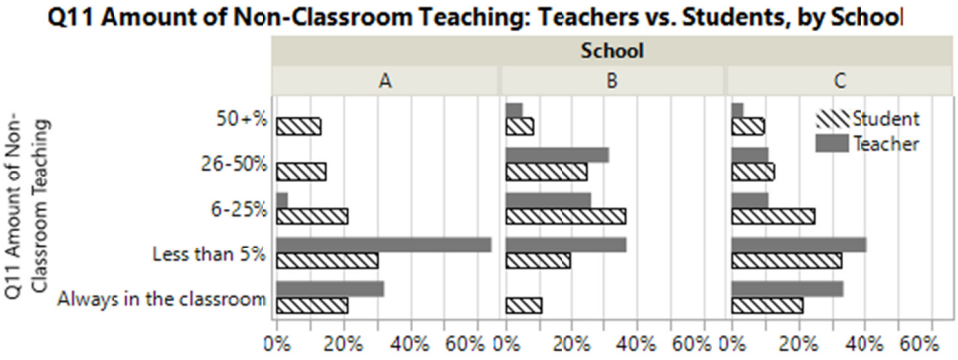

Figure 27. Teaching outside the classroom

Students report little difference in non-classroom teaching by grade level. Interestingly, engagement rises a bit as students get outside of the classroom more (see Figure 28).

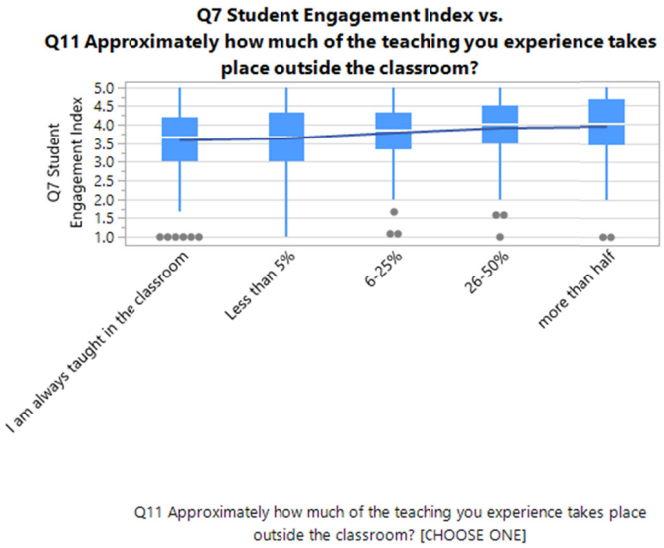

Figure 28. Teaching outside the classroom / students

A one-way ANOVA shows that the differences in means are real ($F = 8.0289$, with $p < .0001$). For students always taught in the classroom, the mean engagement is 3.58, compared to 3.91 for the 6–25% group and 3.94 for the "more than half" group. These results are similar to what we saw in the "Omega" survey. Teaching methods are often a predictor of active engagement by the students. These data are shared from both user perspectives.

4.1.6 Teaching Methods and Strategies Used

4.1.6.1 Student Responses

The students reported only minor differences by school, but as the grade level rises, hands-on learning and team projects seem to decrease, while lecture and discussion increase (see Figure 30). The graph shows the percent of students reporting each method as one of the top two methods used.

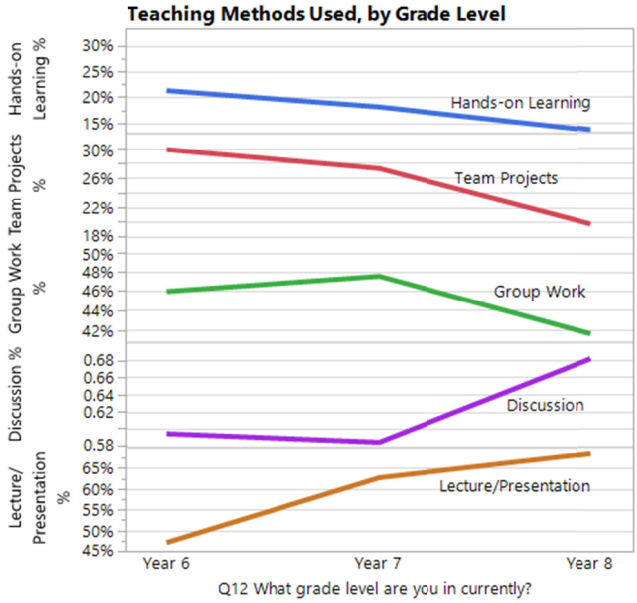

Figure 30. Teaching methods by grade level/students

Another important way to illustrate these perceptions from students is in the figure below (see Figure 31).

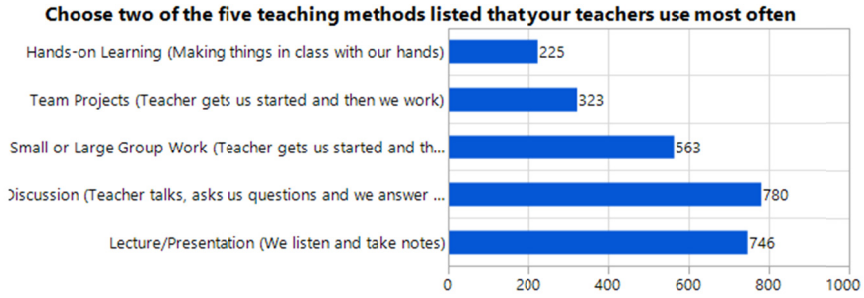

Figure 31. Teaching methods/students

4.1.6.2 Teacher Responses

In question 10, which asked about teaching methods used, differences between schools were not significant, and so only the total grouping is shown here. The teachers put lecture/presentation near the bottom, while the student put it near the top; an obvious and important perception to consider (see Figure 32). One of the most important take-home messages; teaching strategies and practices to ensure a variety of activities take place make a difference to student outcomes. Perhaps this data shows a best practice scenario for consideration.

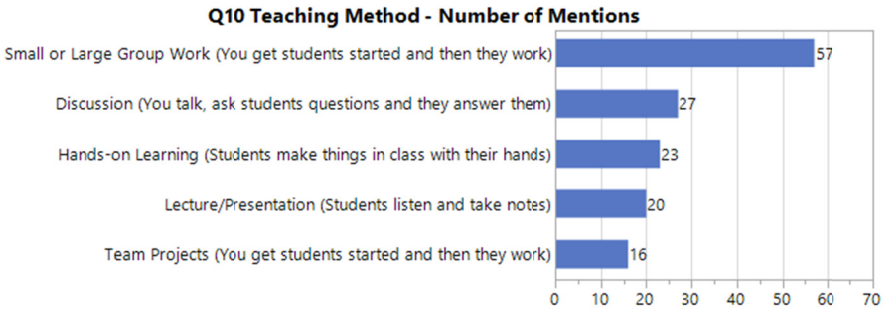

Figure 32. Teaching methods / teachers

There were too few responses to detect differences in the “Design Supports?” answers by teaching method. In Question 12 (Teaching strategies used), differences by school were not significant. This question was not asked of the students (see Figure 33).

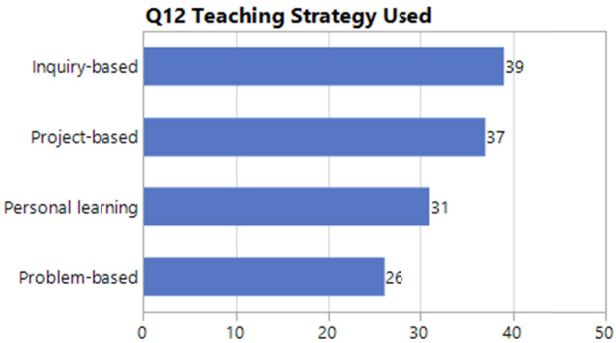

Figure 33. Teaching strategies used/teachers

In the "Design Supports?" portion of question 12, only 7 of the 133 respondents gave an answer of "Not well, 5 of the 37 for "Project-based, and 2 of the 29 answers of "Personal Learning" (see Figure 34).

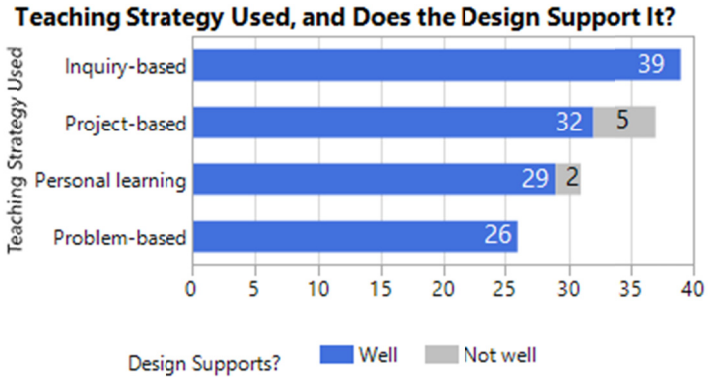

Figure 34. Teaching strategy & does design support it?

5. Limitations

Action research at the post-occupancy level recognizes that there are multiple factors that contribute to user responses, and therefore controlling for variables is challenging. This survey worked to include some control in determining the types of teaching strategies used versus the level of student activity permitted, and how the design of the learning place afforded those activities.

First, while the surveys showed high correlations between satisfaction with the physical surroundings and student engagement, it must be noted that correlation was not the same as causation. Someone might argue, for example, that an overall positive attitude could be behind both being more engaged and being more satisfied with the building and classrooms. Second, one must be very cautious in generalizing from our non-random sample of three schools to all schools in the country.

6. Conclusion

Overall, this survey "worked", although some tweaks would be helpful. Given that this was the first attempt at surveying middle schools, the survey went well. The students showed only a little 'survey fatigue' and they seemed ot understand the questions as they answered like those of the high school students. As was the case for high school students, satisfaction with the physical facilities goes hand-in-hand with engagement for these middle school students, and the correspondence is the same across gender, grade level, and school, with little interaction. Some specific findings are shared in terms of how they connect to the UEIF.v2 are:

- Students and teachers both perceived the design of the built space impacted student academic engagement levels at a high rate of significance (Environmental Dimensions)
- Teaching techniques changed with grade level, and along with these more didactic changes students' attitudes seem to become more negative. Thus, the more teachers embraced active learning strategies, the more their students elicited higher levels of academic engagement (Behavioral Responses)
- Moving to learn was important as it increased engagement levels, and both response groups recognized its importance (Environmental Dimensions)
- Connecting to nature and being outside to learn was viewed as important, but actually moving outside was not done very often. When it was, students responded positively that it increased their levels of engagement (Internal Responses)
- When respondents recognized the values of the school, or its situational culture relative to active engagement, the perception was there were higher levels of student academic engagement, higher learning outcomes, and motivation to attend classes (Value Dimensions)
- As with the high school surveys, we found strong correlations between student academic engagement and satisfaction with the physical environment, however, for teachers, that connection was much weaker (Environmental Dimensions). For teachers, the cultural/situational climate was

more important (Value Dimensions).

Both student and educator perspectives are important to provide a holistic understanding of how the design of a space for learning impacts student outcomes. A high level of statistical significance has been reached across all schools, geographies participating, grade levels, demographics and user groups that YES the design of space makes a difference for student academic engagement levels at $p < .0001$.

The knowledge gained across the level of cohorts we measured, and will continue to measure, impacts the way one should consider developing design solutions from the macro level to the micro level. The UEIF.v2 continues to ensure questions connect to this grounding framework. The 21st century learning goals, and teaching strategies to support them are well articulated, and through post-occupancy analysis we bridged the connection between design and performance.

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Notes

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