EYP/ research

Plan to Evaluate the Imapct of STEM Buildings on College and University Campuses

Volume 1: Dimensions of Assessment

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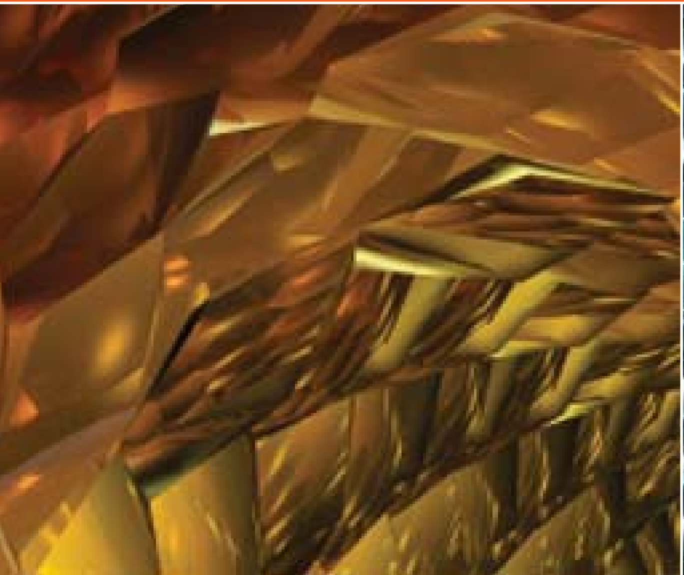

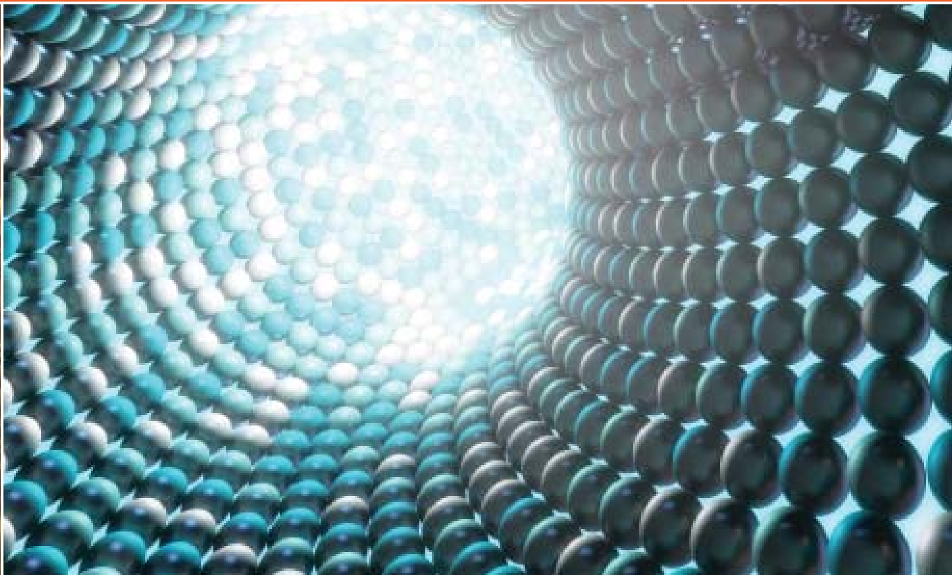

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Background

The mission of EYP is to design buildings that improve the quality of science education. To go beyond anecdotal evidence that it is fulfilling this mission, EYP aims to develop a plan to systematically evaluate its designs. At the same time, the firm intends to provide a general model to assess the impact of science learning environments. Architects expect designed environments to meet specific needs and to have certain behavioral effects. College administrators expect new buildings to achieve particular objectives; they and their donors want to know if they will get a good return on their investment. Therefore, the purpose of this plan is to identify data sources and measures that may be used to assess expected behavioral changes and outcomes of science buildings.

Systematic evidence of design effects may benefit EYP in many ways. It could

- Demonstrate the effectiveness of EYP designs in improving the quality of science education
- Show institutions and their donors that their investments have achieved desired results
- Inform future design decisions
- Enhance EYP's reputation as a leader in academic planning and design

Dimensions of Assessment

To identify the means of assessment, we first must determine the goals or outcomes that we want to measure and the targets or objects of measurement. By targets we mean the people or groups who will be affected by the environment. For science buildings, this may include science and non-science faculty, current and prospective students, staff, administrators, alumni/ae, and campus visitors. Goals may relate to one or more of these targets. For example, the goal of improving the quality of science teaching applies to science faculty; the goal of constructing an energy efficient and healthy environment concerns the entire campus community.

Further complicating the development of appropriate measures, goals may pertain to the building as a whole, to sub-structures or sections within it, or to specific design features. Different outcomes may be anticipated, for example, for laboratories, classrooms, study spaces, and public spaces. Similarly, laboratories may be designed with glass windows and walls to create specific effects.

To organize the tools of assessment, below we identify the major goals of EYP STEM building projects. As we break down these goals into measurable outcomes, we specify pertinent targets, areas, and design features to which each goal applies.

Goals

To accomplish its mission of improving the quality of STEM education, EYP designs science buildings with several goals in mind. These goals derive from EYP's approach to and experience in designing science environments; take into account the physical, psychological, and social needs of those who use the building; and for any specific project, are worked out as designers meet with clients and consider their needs. Some goals are specific to particular projects; for example, at one college, new science laboratories were placed in a central location in relation to six physical and social science departments to encourage interdisciplinary teaching and research. Yet, many objectives are generic; they apply to virtually every project. Thus, EYP and its clients generally want science environments to accomplish the following:

1. Create a safe and accessible environment.
2. Create an environment that is energy efficient, sustainable, and satisfying to its occupants.
3. Make the institution more competitive in attracting students and faculty.
4. Enhance the effectiveness of science teaching.
5. Advance faculty and student research.
6. Create a welcoming place to congregate, study, and learn.
7. Promote interaction among students and faculty.
8. Enhance students' interest in and attitude toward science.

Goals become measurable when they are broken down into statements or questions about concrete, observable outcomes. Below we present pertinent questions for each goal. After outlining guidelines for measurement and analysis, we identify possible data sources and measures to answer these questions.

1. Create a safe and accessible environment.
    a. Is the building in full compliance with ADA standards?
    b. Have improvements been made to reduce damage risk from natural hazards such as earthquakes, hurricanes, and floods?
    c. Do the laboratories conform to the latest safety protocols?
    d. Do users perceive the building and laboratories to be safe places to study and work?

2. Create an environment that is energy efficient, sustainable, and satisfying to its occupants.
   a. Does the building meet OSHA standards?
   b. How energy efficient is the building?
   c. How good is the air quality in the building?
   d. Does the building contain instruments to monitor energy consumption?
   e. Is the building LEED certified?
   f. How do users or occupants rate indoor environmental quality and what effect does this have on their productivity?
   g. Are users aware of sustainable measures employed in the building?

3. Make the institution more competitive in attracting students and faculty.
   a. Has the number of applications for admission increased since the construction of the building?
   b. Has the diversity of applicants increased?
   c. Has the quality of applicants increased?
   d. Do applicants mention the science building as a factor in their decision to apply or enroll?
   e. Is the institution more successful in hiring its top candidates in the sciences?
   f. Has the building increased the likelihood of retaining faculty members?

4. Enhance the effectiveness of science teaching.
   a. Have the new classrooms and laboratories enhanced the quality of the teaching environment??
   b. Have the new classrooms and laboratories enabled instructors to change their teaching methods, introduce new courses, or teach new course topics?
   c. Have the new classrooms and laboratories enabled instructors to use the time devoted to teaching more productively?
   d. Are instructors more likely to become involved in collaborative teaching?
   e. Do instructors use the building to teach about sustainability?
   f. Do students rate science courses more positively?
   g. Have the new facilities enabled departments to add new areas to their curricula?

5. Advance faculty and student research.
   a. Has the number and amount of research grants and the number of published papers in the sciences increased?
   b. Has the number of students doing research in the sciences increased?
   c. Are faculty members able to pursue new lines of research?
   d. Do the new research laboratories enhance scientists' ability to conduct research?
   e. Have the new research laboratories increased scientists' level of productivity?
   f. Are the science faculty more likely to become involved in collaborative research?

6. Create a welcoming place to congregate, study, and learn.
   a. How heavily used is the building? For renovated buildings, has use increased since the renovation?
   b. Why do students choose to come to the science building?
   c. Do users perceive the building and spaces within it as attractive places to meet, study, and work?

7. Promote interaction among students and faculty.
   a. Do faculty members interact more with faculty colleagues?
   b. Are faculty members more likely to meet with students outside their office, classroom or laboratory?
   c. Do the public areas in the science building facilitate interactions among the faculty?
   d. Are students more likely to meet with other students to study and work on joint projects?
   e. Do the public areas in the science building facilitate interactions among students?

8. Enhance students' interest in and attitude toward science.
   a. Has the number of students majoring in science increased?
   b. Have enrollments in science courses increased?
   c. Do students have a more favorable attitude toward science?
   d. Does the visibility of laboratories and scientific instruments pique students' interest in science?

Methodological Principles

In creating the tools of assessment, we were guided by the following principles:

1. Valid assessment requires comparison.
Assessing goals of architectural design essentially means asking the question, "Does this building make a difference?" For example, what difference does it make in students' interest in science if they can see science in action through glass-walled laboratories? We cannot validly answer this question simply by questioning students exposed to new glass-walled laboratories. Rather, we must compare the scientific interest of the latter with that of students who do not have the same experience. In designing measures of assessment, therefore, we will identify appropriate comparisons that will indicate if a designed environment has made a difference. This may involve comparison over time—before and after a building was constructed; comparison of spaces in a new building with functionally equivalent spaces in other buildings on the same campus; comparison of one college or university with another; and so forth.

2. So far as possible, effects should be assessed in more than one way.
The idea behind this principle is that all measures are susceptible to biases and limitations, but by using different methods that do not share the same weaknesses, and by conducting multiple tests, we perform cross-checks on biases and gain confidence in assessed results. For example, suppose the study area in an existing science building is redesigned to encourage greater use. In independent surveys administered before and after the redesign, we could ask students how often they use the space. Alternatively, through direct observation we could count the number of students using the space during specified time periods before and after the redesign. Each measure provides slightly different information and each is subject to different sources of measurement error. The survey might indicate which students report that they are using the study space, how often they report using it, and the purposes for which they use it. However, subjective estimates of frequency and time generally are unreliable and susceptible to bias; for example, students concerned about being perceived as overly studious might underreport their usage. Observational measures are more accurate in assessing amount of use, but are less amenable to assessing who is using the space (e.g., science majors? First-year students?) and for what purpose. Together the two measures yield more complete information, and each validates the other, strengthening the conclusion that the redesign made a difference.

3. So far as possible, assessment should make use of existing institutional records.
This principle is pragmatic but also adds scientific rigor. Existing data can provide evidence that is unobtrusive; may exist for long periods before and after a new building is constructed; and often are easy to gather and analyze. The challenge is to identify relevant records. For example, consider the hypothesis that placing new science laboratories in a central location in relation to all the physical science and social science departments will encourage interdisciplinary connections. One way to test this hypothesis is to count the number of grant applications, grants, presentations at professional meetings, and published papers that involve faculty and/or students from different science departments before and after the construction of the laboratories. We might be able to obtain such data in faculty and student surveys; however, more accurate and more easily accessible data are likely to be available from annual records maintained by administrative offices within the college.

Although we advocate the use of institutional records whenever possible, valid data may be gathered by several other means, including student and faculty surveys, systematic observation, and focus group discussions. A survey would be the best way to assess perceptions of a new building. If we expect classrooms in a new science building to be perceived as comfortable places to teach and learn, to provide superior acoustics and lighting, and to be aesthetically pleasing, we could ask students and faculty to rate these features. We also could ask students and instructors to rate the overall quality of classrooms.

Surveys are less useful in measuring actual behavior, especially if that behavior can be measured accurately by other means. For example, to assess whether the redesign of a space has increased its use, it would be much more reliable to make direct observations, such as counting the number of students in the space at various points in time, than ask students if their use of the space has increased over time.

4. Effects must be interpreted with caution.
Two important caveats must be considered in interpreting results. First, many of the effects that EYP hopes to achieve are difficult to detect. Some effects will be small; others will be hard to measure because relevant data are not available or existing measures are subject to a large amount of error. For example, given the lifelong learning and experiences that students bring with them to college, we cannot expect a science building to alter students' interests in science to a great extent. Similarly, we cannot expect a new science building to substantially increase admission

applications. Besides the building being only one of numerous factors that enter into students' decisions about where to go to college, the number of applications will vary randomly from year to year. Therefore, for many measures, the absence of a discernible difference should not be interpreted as evidence that the building has had no effect.

Second, analysts must consider other factors that might explain an observed change. For example, besides a newly constructed science building, changes in admission standards, significant increases or decreases in tuition, and national trends such as the number of high school graduates who choose to attend college may affect applications. So, analysts must consider what else changed during the period of building construction. They also must consider the impact of chance factors. One reason that observing change from one year to the next may not be meaningful is that measures tend to go up and down over short periods because of random variation.

For many outcomes, we recommend the use of trend data in which measures are taken periodically, for example, each month or year. Because of random variation, these data must be obtained for an extended time period. In general, the smaller the number of observations, the greater the chance for error; the longer the time period, the more likely that the data will reveal stable patterns of change. We recommend a minimum of 10 years prior to the construction of a new building. For the period after construction, one year is inadequate; two years is better but still not very reliable; and the longer the time period, the more reliable an observed change.

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