Educational Methods for Design Courses: Functional Dormitories

Abstract

The purpose of this paper is to describe a student-led international engineering project that is both exciting and educational. The challenge with this project is to reach the proper balance of student-led creativity and learning, collection of data, adequate expert review, and transfer of knowledge to other students. This paper details an international student project that was then documented as a case study. After providing a synopsis of the example case study, a suggested structure for developing such a case study is provided with references to the example. This can help guide a faculty member design such a project in the future. A suggested classroom teaching methodology prescribes a continual check on student knowledge of the problem as they read through the case study to ensure absorption of key concepts, as well as an iterative design process for solving the problem after understanding all aspects of the problem. Case studies such as the one presented below expose students to complex, real world design problems, therefore giving them a chance to apply previously learned information, practice it by integrating their design knowledge into the process, and obtain valuable teamwork skills.

Introduction

Student-led international engineering projects can be both exciting and educational. The challenge with these projects is to reach the proper balance of student-led creativity and learning, collection of data, adequate expert review, and transfer of knowledge to other students\(^1\). First, the collection of data in an international setting can experience logistical barriers due to language issues, inadequate computer infrastructure, and cultural differences regarding workplace and style. Additionally, international travel is expensive, and much of the funds go directly toward getting the students to the project location and their maintenance costs. Therefore, collection of sufficient data is essential during the trip. Second, because the students are understandably novices in design, an expert review process is critical for both the success of the project and the reputation of the organization. And finally, given the costs involved in international travel, it is critical for the knowledge gained by the student teams to be relayed to other students so that they can gain the design experience without having to travel themselves.

We found that documenting such an international design project in the form of a case study is particularly useful. In design courses, students are required to create a deliverable from a problem statement with certain constraints and needs. So why not make the problem statement from this design project as in depth as possible, citing a need occurring in the real world? Case studies bring a higher requirement for problem understanding than most textbooks give. Design in the real world requires testing initial site conditions, listening to the end user, and noting the flaws in past projects. Immersion in such an intricate predicament can only be done by careful consideration of each aspect, understanding from prior knowledge, and critical debate to find a solution that meets the needs. This process also provides the students who underwent the
international design experience an ability to sort through the data collected at a leisurely pace in the comfort of living at the home institution.

Like any other teaching method, case studies must have some orderly structure that is presented logically yet keeps the reader engrossed. A teaching methodology for case studies must ensure that students are both retaining the essential points and utilizing what they learned to satisfy the client’s need. The overall design of the case study must also give the student a chance to utilize prior gained knowledge and give a realistic expectation of bringing a design from problem to solution in the real business world.

In this paper, we discuss an international project that was conducted at the Indian Institute of Technology (IIT) Madras, India, to compare the design of two dormitories, new and old, based on thermal comfort and social use of spaces. Two U.S. students worked with three IIT Madras students to conduct this study and were guided by a faculty member in India and two faculty members from the U.S. Their project experience was captured using a multi-media case study format. The case presents the design issues involved in building two types of student hostels, older sprawling low-rise and newly created high-rise hostels. The main problem is that the IIT campus is located in a national forest and only a limited amount of land can be used to build new hostels. But the student population is expected to increase by more than 25% in the residential campus and the challenge is to create living areas that use land efficiently but retain the characteristics of the much preferred low-rise hostels. The students designed a case study to capture this complex environment and challenge students in architecture design classes to solve the problem, taking into account factors of engineering and comfort. The next section discusses the functional dormitory architecture project. The method of structuring the case study and teaching it to a classroom of design students is then discussed. Finally, its expected impact on students as well as an analysis of the international project is presented.
During Summer 2009, the authors had an opportunity to spend two months in India applying theories of thermal comfort, use of passive building techniques, functional design, user feedback, and heat stress to examine two kinds of hostels in India.

By law, IIT Madras is only allowed to develop on 24% of its land area because it is located inside a national forest with strict preservation regulations. As student enrollment increases in the future due to India’s demand for well-educated engineers, the administration needs solutions to build efficiently on the limited land that is left available. While building high-rises instead of low-rise hostels is an obvious solution, student occupants widely prefer the design of low-rise buildings because they are relatively more comfortable and seem to encourage a socially active community. When building for future growth, designers need to take this into account and try to bring elements of older low-rise hostels into a spatially conservative format like the high-rise hostels. Figures 1 and 2 show examples of the two hostel types.

To objectively judge the differences between the two hostel types, thermal comfort measurements were taken. This makes it easier to judge the thermal comfort, pinpoint strengths and weaknesses of existing design features, and leave this information to the designer for appropriate design techniques of future structures. This was done using continuous 24-hour...
readings and room-by-room spot measurements of both hostel types. Anemometers, globe and surface thermometers, and light meters were used to evaluate hostel rooms. The readings are an effective gauge to determine how much of a difference passive building techniques such as fenestration layout, vertical overhangs, and shading, make. Figure 3 shows how much of an influence contrasting passive techniques have on airflow through hostel rooms under different fenestration utilization. The open-air design of the older low-rise Krishna hostel is more effective than the newer high-rise Pamba hostel.

Not only were thermal comfort measurements taken by the use of instruments, survey data from over 100 IIT Madras student occupants was taken to document the perception of thermal comfort and social conditions in the hostels. Feedback on thermal comfort was much less statistically significant than feedback on social conditions (Figure 4). While older low-rise hostels yielded a better breeze indoors, they were also mirrored outside, thereby increasing the temperature conditions more than high-rise hostels. Figure 4 shows the two bar graphs from the polling data. The first is the most statistically significant; where students tend to prefer the high-rise hostels as they perceive that they are less hot during the daytime. The second clearly shows that older hostels have an advantage in social conditions because of the open-air, courtyard format. The challenge was to convert this complex design problem into a case study format so that other students who do not have the ability to travel to India can relate to the problem and solve it appropriately.
Structure of the Case Study for Design Courses

Case studies have been used to teach engineering theory courses and have received favorable responses from the students\(^3\). When used for design courses, case studies must be structured in a way that is different from those that may be used for the introductory courses. When used for foundational instruction courses, case studies define certain situations, provide a few alternatives, and request the students to discuss how the problem can be solved. The student can use this information to work the problem at hand from the information presented in the case study itself. The analysis typically tends not to be an in-depth analysis of the problem.

Design courses require the students to assess a broader situation and come up with multiple alternative solutions to the problem. Information from a multitude of prior courses is necessary. The student needs to relate this past instruction with the situation presented. Therefore, instead of merely describing a situation and assigning a problem, case studies for design courses need to be built in a stepwise fashion and must keep compounding the information in multiple steps. The end of the case study leaves a student with a comprehensive problem to solve creatively with all of the skills attained in previous courses. Based on these principles, a multimedia case study was developed for the Functional Dormitory Design project and is available at the website [www.liteecases.com](http://www.liteecases.com).

Design of Multi-Media Case Study for the Functional Dormitory Design Project

A general outline of the multimedia case study is as follows. The case study provides the body of the problem. It starts by introducing the background of the individual problem and does not refer to specifics of the problem itself. It may lead into the predicament involved to give the student an initial idea of what will be asked of him/her in the end. The introductory section leads into preliminary thought about important topics.

Let us use the example of the case study on functional design with respect to dormitories on a college campus. An overview of what the student expects to learn and accomplish is described in Figure 5. Thermal comfort, use of passive building techniques, functional design, and heat stress are topics that the student should either already know or should do some research on to achieve some familiarity. The goals set for the case study are to understand these topics, to understand the need of a client such as the university, and to create conceptual

![Case Study Menu](http://www.liteecases.com)
designs. After the student knows what to expect from the case study, a text or pictorial description of the college campus itself is set. The university’s dilemma of land use restraints in an ever growing school is also explained. Students are then asked to think about their own hometown and how the climate may differ at the campus in a tropical setting. Further discussion of subjective thermal comfort rating and thermal comfort factors are introduced. This section leads the student into what to expect from the case study.

The body of the case is a descriptive and analytical progression through the problem so that the students can form an understanding of the client’s problem and grasp the tools to implement a solution.

The Functional Dormitory Design case study first defines functional design and singles out what aspects of it receive more focus. This case study focuses on thermal comfort and social aspects of design, while visual comfort, acoustics, and air quality are not reported on. In the next pages of the case, spatial, social, and environmental considerations are described for the older, sprawling hostels. This provides an overview so that student can easily compare them with newer high-rise hostels.

The problem in the body of the case is then described more thoroughly by readdressing the land use problem and outlining the options of action: building more older-style sprawling dormitories and therefore ignoring the land use problem, renovating older dormitories to add more rooms, or building more high-rise hostels to meet land use restraints. This section gives information about the planned enrollment expansion data, campus trends on social life and building use, as well as renovation ideas and constraints. An overview of the high-rise hostels, similar to the one describing the older hostels, is given to help the student realize the differences and establish pros and cons of the two designs.

The problem as it exists has now been described fully with a clear idea of the need statement for the client. Knowing the differences between the two hostel types is the key, but when creating a design solution, the student has limited understanding as to which aspects to pick from in his/her own design than subjective whims of what aspects were more attractive in each hostel type. In creating a solution, the design needs the guiding compass provided by comparative analysis of the two hostel types.

The analysis covers a multitude of topics that effect social and thermal comfort. These include heat stress and buildup, air movement, lighting, and lifestyle. Students are given measured data from both hostels of heat flow through walls, psychometric charts, temperature and humidity logs, air velocity logs, and student occupancy levels, all throughout a 24-hr period. Students are also given surveyed data from hostel occupants of their perceptions of thermal conditions to relate to the measured data, as well as the occupants’ perception of social life and additional comments about hostel life. This data helps the student to analyze particular things that make
one hostel advantageous to another, and helps them suggest ideas for solving individual design problems.

A case study’s long problem statement ends with reiterating the dilemma, suggesting students to develop pros and cons of different design strategies, and then finally implementing their findings in one final design. This is exhibited in Functional Dormitory Design by asking students to reflect on what they learned about the present dormitories, and what they can do to bring elements of the low-rise hostels into more efficient land use. Their assignments presented throughout the case study are once again shown in a list after the case study’s conclusion.

Multimedia case studies can also be equipped with sections outside the main body of material itself for reference. At the end of the section, tools such as a list of keywords can aid the student in defining all terms that may not be familiar. This is equipped with a function where student can mouse over these words in the case itself and the definition will appear just as it does in the appendix’s list of keywords (Figure 6).

The appendix may also contain a reference section that reads like a textbook describing all technical information in the case. Psychometric charts, for example, may be well understood by a student with a course background in thermal comfort, but not for students who have no prior experience with them. Such a section of reference widens the potential audience of a case study to those who are not knowledgeable in every detail. This section helps the fluidity of the case study itself so that each figure does not have to be described in the text, which would considerably lengthen it. Another option is to refer to texts that the student can research himself if education on specific aspects is necessary.

**Teaching Methodology**

This case study can be used to trigger student’s individual understanding of this problem and discussion using groups. Case studies are known for promoting understanding of past material and new problems, and also for creating a good classroom atmosphere that helps to generate and sustain participation. Design courses generate more discussion with case studies because of the nature of the class itself. The group discussion is ongoing and iterative because the design process lasts so long.

The first step in choosing and implementing a case study in the classroom is to determine the average amount of knowledge that students have in order to understand the problem at hand and how much background is needed to be given on the subjects themselves before introducing a comprehensive case problem. This is important so that when students do read through a case, the terminology is not discouraging. It is permissible to have material not familiar to students in the

![Figure 6: Keyword Definition Highlighting](image-url)
case study, as long as it is not excessive. Based on this judgment of the individual class, teachers must decide whether to introduce reference material first or to let them begin the case right away.

After students gain expertise in the knowledge required to comprehend the case problems, the time comes when starting the case is no burden to their ability to move through it fluidly. While problems and given information is presented, students must pause to check for understanding. This is done by asking thought questions spaced throughout the case and after an item that needs grasping is presented. For example, in the Functional Dormitory Design case, when looking at graphs from surveys regarding occupants’ perception of temperature in hostels, it would be beneficial for the student to think about which hostels students prefer and if the difference is significant. The student can also compare these subjective answers to readings from instrumentation to see if the occupants’ perceptions matched with reality. Another question could be asked regarding lighting values in high-rises, such as why the light intensity readings taken in hostel rooms vary so much. Students can glance at the data and refer back to hostel descriptions presented earlier in the case and form a statement. The goal of these thought questions are to give the understanding of the situation as if they were walking through the site themselves.

Outside of a creating a design, the main deliverables for students using case studies come in the form of group assignments, along with continuous debate surrounding them. Discussions can be related to the different methods in solving a problem or arguments regarding different aspects of the case. Groups of students can analyze high-rise hostels and their functional design regarding spatial, social, and environmental considerations, just as the older hostels were broken down. Groups can also argue the correct method for solving design issues in a case, such as whether to keep building the sprawling low rise hostels, renovate them to accommodate greater numbers, or build more high-rise hostels that are more effective than the ones previously built. This creates what is known as a “structured controversy,” causing students to see issues from both perspectives and come to a compromise on the best solutions.\(^5\)

In normal instructive classes, the end assignment might stop with these discussions and analyses alone. Design courses extend these tasks because of the creative design that must be made after reviewing the problem. Design courses can vary the level of detail required in the end product, whether requiring just a conceptual design or a more detailed design of the student. Class discussion during the design period adds further to the debate. Students are now not only limited to critiquing the thinking of other students about the interpretation of the case, they can now critique creative solutions. With the example of functional design of dormitories, Student A can discuss Student B’s solution the effectiveness of a structure that is aimed at keeping a central social courtyard space while still minimizing footprint. They can critique each other’s solutions of minimizing heat stress during the warmest periods of the day and maximizing natural lighting based on the shading devices and hostel room configurations that a particular student tried to implement. What used to be an answer to a thought question for understanding can now be used as a resource for critique and for keeping the best interest of the client.
No matter the level of design and expectations of the final deliverable, from preliminary design to a three-dimensional model, there is always room to ask students why certain designs were implemented based on the given information in the case and the current conditions of the hostels that needed improvement. A final presentation can be a final defense of the methods chosen to solve the problems presented in the case.

**Expected Impact of Using this Case Study in Design Courses**

The case study teaching model brings about an enhanced effect for students in design courses. The most important result of any design course is the ability to use knowledge from prior coursework and to create a successful design based on those concepts. A student becomes a better designer by dealing with the many necessities and conflicts that a well documented case study presents.

The use of multimedia in case studies also enhances the initial information to start the design process. Graphical representation helps to show existing conditions in previously built structures, while pictures and plans document these existing structures, and videos are utilized to give occupant feedback and further visual documentation.

Case studies give an additional result of exposing students to an iterative design process. This process starts by fully understanding and analyzing situations. Students then must constantly check back on this understanding to make sure that the solutions implemented are actually alleviating problems. Case studies encourage input, interaction, and criticism among classmates. This is important because for some students, this might be their first teamwork experience in their collegiate career. It enhances the abilities of students to work with others who have different work execution approaches. This is especially true for longer case studies.⁶

**Working on an International Student-Led Project**

Working in a foreign setting can produce unique problems, especially compared to more familiar settings. This is due to logistical and language barriers, travel expenses, and necessary expert review.

Logistical and language barriers on a project in India may vary with other locations. For example, language was not much of a problem because the majority of Indians in higher education are well versed in English. Computer infrastructure is another problem, as the infrastructure of hardware and internet were not up to par with what many Americans expect at home. This requires additional planning for uploading documents for file sharing among peers, which can take many more hours than originally expected. Work schedules and settings can also vary from place to place. In India, there is a tendency to start the day later than in America, pushing mealtimes back by and hour or two. This caused an expectation to work a little later in the evening. Additionally, work schedules can become very dependant of those working around
you. For instance, the PhD students had other obligations until two in the afternoon on most days, so the rest of the team had to wait to begin group work until that time.

Because of these circumstances, the amount of work a team can expect to get done relies on one’s ability to realistically plan how much work can be done in a single day, and that productivity may be much lower than that experienced individually at home.

International travel can be very cost prohibitive, with little funds directly being used on the work itself. The majority of funds go into compensating team members for airfare, lodging, and food expenses. An organizer of an international project such as this should also recognize the benefit to all parties involved to make sure that the work of others is compensated. For instance, three students in India were available to work with us, along with access to the university facilities. It must be made sure that either the rights to the end product be shared or that some other token of appreciation be given to hosting parties. Creating a benefit for others increases the likelihood of being invited with open arms to institutions every year.

It is also very important for students working on international projects to be under constant review from the experts around them. During the project at IIT Madras, faculty from the hosting and visiting universities were present at different times during the project’s duration. Weekly updates would be given to the professors to make sure that there was no cost overrun among each of the project members and that the work done was adequate and in keeping with the project schedule. This schedule was predetermined and provided guidelines for milestones, such as having a rough case study draft done, or having all media such as pictures and videos produced. The faculty would also answer technical questions regarding the material presented as well as provide a critique of the case study itself.

The students working on this case study found it to be a great learning experience. While broadening one’s perspective of the world and seeing an entirely different culture, the project was beneficial as a chance to work in a team and to gain technical knowledge. When working in a team, members must be aware of each other’s needs for everyone to produce well. Working with people of a much different background than me and being able to work successfully with
them is very valuable. It is also not entirely necessary to have extensive prerequisite knowledge in the topic one plans to study and document. If a student does not know the project topic beforehand, it is permissible to study the subject and rely on others in the field of expertise for understanding. This was often the case during the functional dormitory design project when applied to topics such as thermal comfort, heat stress, functional design, and passive building techniques. Being able to study these topics in India and apply them to a case study was very beneficial from a personal learning perspective while not being detrimental to the technical presentation.

**Conclusion**

Case studies are an effective teaching tool for design courses because of the versatility of use they bring. Not only do they provide a problem which students must solve as a design project, but they also encompass the theoretical knowledge that students have gathered throughout their collegiate career, and encourage students to create a logical construction of the client’s complex needs and use this understanding on design projects. This results in an enhanced exposure to design and teamwork that students can bring with them into the working world. Development of such case studies also brings closure to international student-led engineering design projects and makes it possible for these students to share their rich experiences with others.

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