AC 2007-1651: MULTI-STORY STEEL STRUCTURES: MAKING SURE STUDENTS UNDERSTAND THE DESIGN PROCESS

John Phillips, Oklahoma State University

"Multi-Story Steel Structures: Making Sure Students Understand the Design Process"

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Abstract

In the spring semester of the fourth year of the architectural engineering curriculum, students take the intermediate steel design course. During this course, the students apply the knowledge they have gained in the beginning design course, and are expected to go through the process of designing and documenting a steel structure. This process includes an entire steel building design, from building code research through preliminary and final design of a steel structure to production of construction documents for the project.

Historically this course has centered around a steel building design project in which student teams where responsible for the design and documentation of the steel structure. Based on that course model, problems became apparent in subsequent structural design courses and in the comprehensive design studio. These problems included the fact that a large percentage of the students were not aware of the structural design process necessary to complete a building design. A recent change has been made in the course to help alleviate this problem. Each student is now responsible for the design and documentation of the entire structural steel building. They are also each expected to complete all phases of the design and documentation process.

We must be able to assess whether this new course format is providing the students with a more favorable understanding of the design process, and whether it is preparing them for the subsequent design courses in the curriculum. To help facilitate this assessment, at the end of the semester, each student is given a questionnaire to help assess their knowledge as it pertains to the design process and the intended outcomes of this course. This paper will look at the questionnaire presented to the students from both course formats, and will discuss the results of the questionnaire and how they may be used to improve the success of the intermediate steel design course.

Introduction

There are several issues that must be considered when an instructor decides to assign a team project in a structural design course, particularly one that encompasses the total design process for a building structure. There are pros and cons of assigning a team project, and these must be weighed along with the potential benefits for the students in the course. In addition, the student needs to understand the design process in the course so that future structural design courses which employ the same basic processes and techniques will not suffer from lack of student knowledge that should have been learned in the first design course. As noted by Thomas J. Shuell, "*It is helpful to remember that what the student does is actually more important in determining what is learned than what the teacher does*" [1], thus the format used for many years was changed so that each student would be exposed to all phases of the structural design process.

Historically, the intermediate steel design course at Oklahoma State University's School of Architecture has been centered on a team project which dealt with the entire design of the steel building structure. Through assessing the results of this course, and subsequent courses in which the knowledge obtained in this course is built upon, it became clear that the team project was not successful in teaching the students what they needed to know at this point of the curriculum.

The intermediate steel design course consists of the methods and techniques employed to provide a nearly complete structural design experience for a structural steel multi-story building. This is

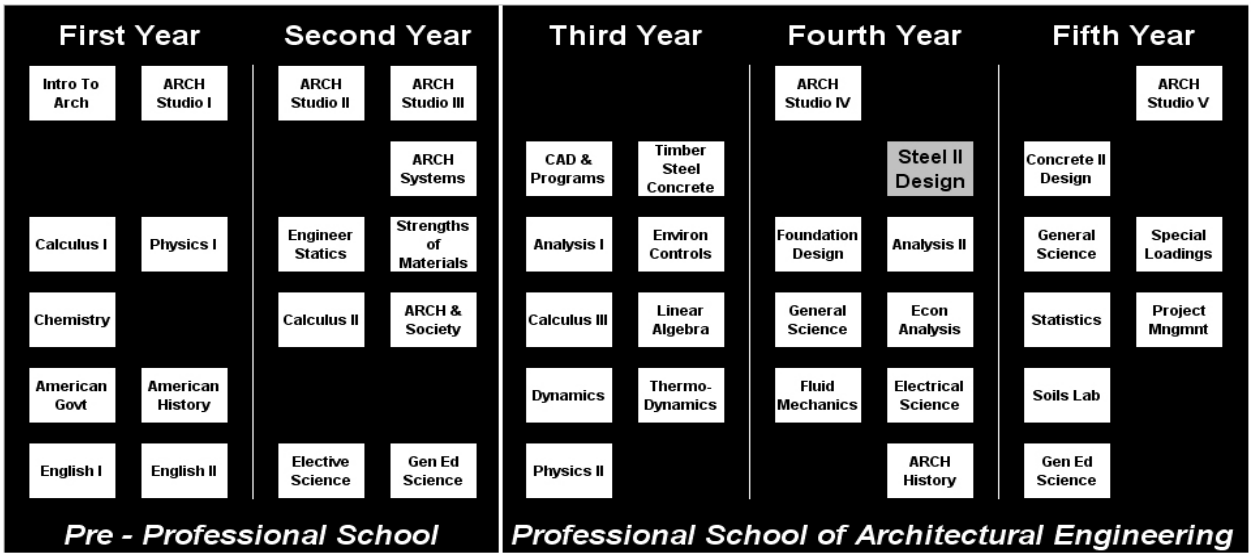


Fig 1: Oklahoma State University - Architectural Engineering majors Curriculum Chart

the first structural design course that looks at the entire design process for a structure, and it is crucial to the student's success in this field of study that they understand and have been exposed to all aspects of the design process. The beginning steel design course pre-requisite for this class taught the students the basics of steel design, including beam and column design along with basic connection design. The intermediate steel design course focuses on a multi-story steel structure consisting of composite steel floor framing and steel joist roof framing that is laterally braced

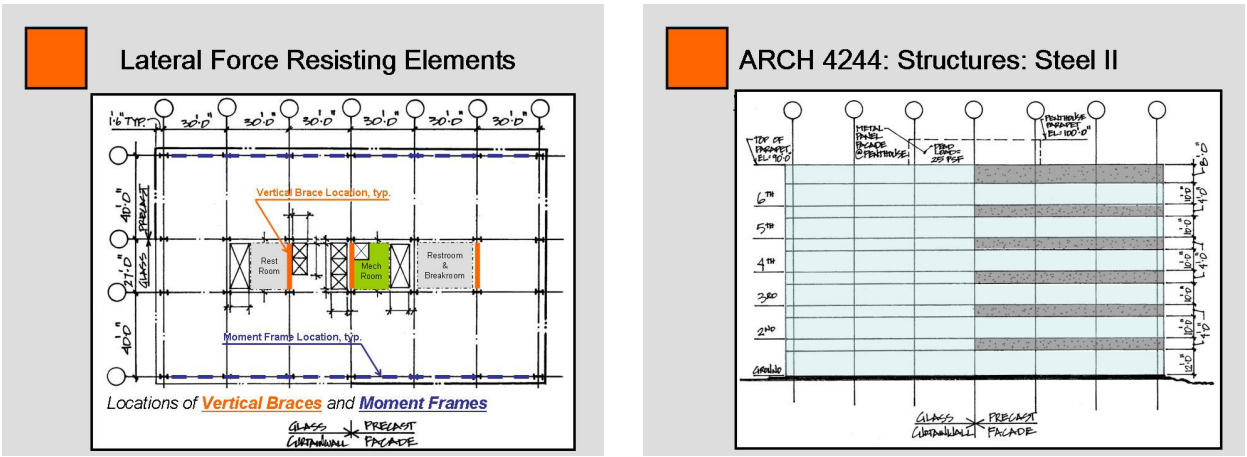


Fig 2: Project information given to students for design of multi-story steel structure

with moment frames in one direction and vertical bracing in the opposite direction. In the course we explore loadings on the building, including dead, live, snow with drift conditions, wind and seismic loads. The snow, wind and seismic loads are determined using the ASCE 7-05 code 'Minimum Design Loads for Buildings and Other Structures'. This is the student's first exposure to this code that will be highly used throughout their careers. Preliminary design calculations are performed to determine structural sizes that are modeled in a frame analysis program used in this course. The frame analysis program used is the RISA-3D analysis/design program, and a model

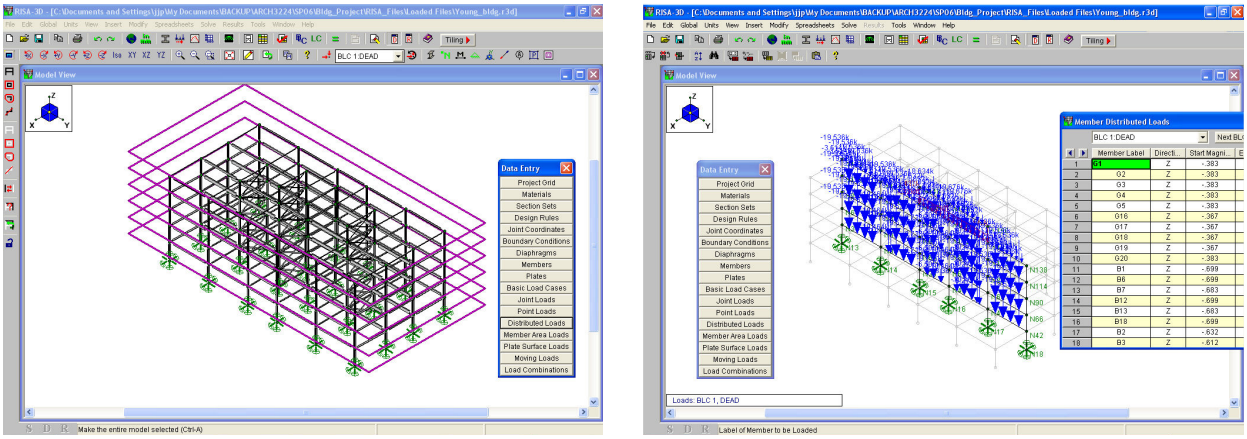


Fig 3: Students utilize the RISA-3D Program during the Analysis Phase of the Project [2]

for the entire building structure is input for analysis. Though the students have used this program in a previous course, its use in that course was limited, and did not include a three dimensional structural modeling. Utilizing this program enables the students to realize the complex nature of modeling structures, and how simple errors during the modeling process can lead to false results. Loadings are modeled in the program along with the preliminary member sizes that have been determined. The model is loaded with each of the load cases (dead, live, snow, wind and seismic) and load combinations including live load patterning is input to achieve the code required load combinations. Results are checked for both strength and serviceability requirements, including seismic requirements for building drift. These results are evaluated and individual structural

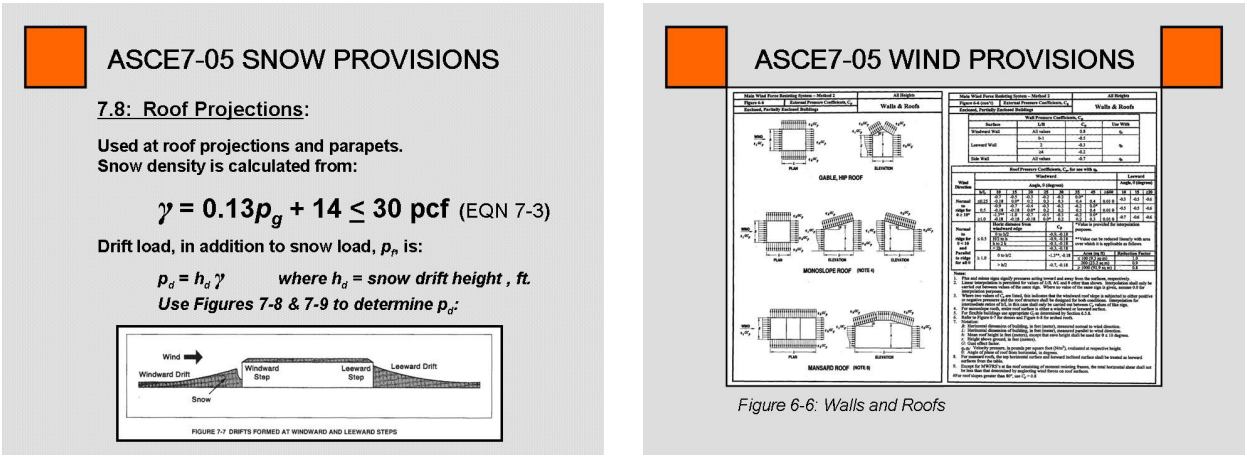


Fig 4: Slides from seminars on structural design code issues affecting multi-story steel design [3]

members are resized until the entire building frame meets both AISC and IBC code requirements using economical sizes, resulting in the final design sizes for the structural steel framing. The

final process in the course is to produce construction documents for the building structure. These include general structural notes, plans, schedules and details. The details include typical details along with specific connection details for both simple and moment frame connections. Though condensed to classroom content, this course enables the students to experience the complete design process for a multi-story steel structure.

Since each student is expected to design and document an entire multi-story steel structure, some concessions had to be made in setting up the individual project course format. Historically, the student teams were given parameters by which to arrive at an architectural design for their building. This would be accomplished by working on code issues, and coming to a team

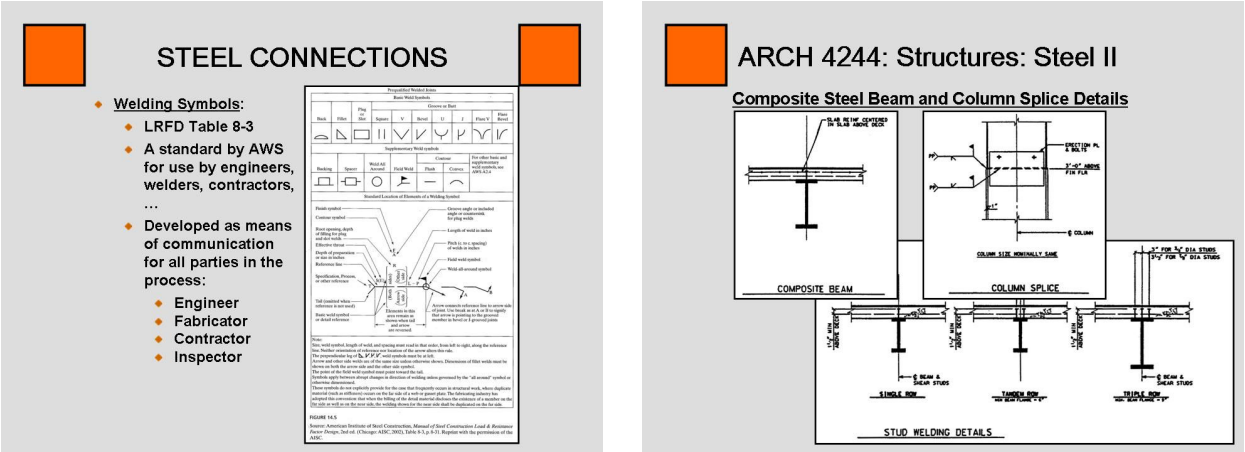


Fig 5: Slides from seminars on structural connections and detailing for multi-story steel design [4]

decision on plan dimensions, floor to floor heights, and number of stories in each team's building. Additionally, the teams would research the exterior skin of the building and arrive at the materials to be used for the facade. This process was established to help the team bond more with their project through ownership of design, and to allow the students to become more familiar with code requirements dealing with occupancies and egress. For the individual project course format, the design requirements were standardized in plan size and number of stories for the building structure. This came about due to both time constraints on the student's behalf, and due to the logistics of evaluating each student's project throughout the semester on the course evaluator's behalf. Though these changes tend to skip an important step in the process, the decision to standardize the requirements for the project was arrived at through the realization that in subsequent design courses the students will work on team projects, and will be expected to arrive at an architectural design for their buildings prior to starting the structural design process. With this being the first course in which the students were exposed to the process of structural building design, the decision was made to focus on the process of structural design so that each students could be presented the requirements for each phase of the project in greater depth.

Through teaching this course for the past six years, a continuing trend has appeared pertaining to breaking the class into teams of three or four students to work on the project. The requirements for the team project stipulated that each team member be involved in *all* phases of the design process, and each member was required to contribute a significant portion of work to the overall design. Although this method of teaching looked good on paper, it never quite materialized as well in the course. Inevitably, there were one or two students on the team who took control of the

project and performed the majority of the work during the semester. This lead to ill wills between the students in that those doing the work understood they were performing the majority of the work in the course and thus carrying the load of those students who were not, while those

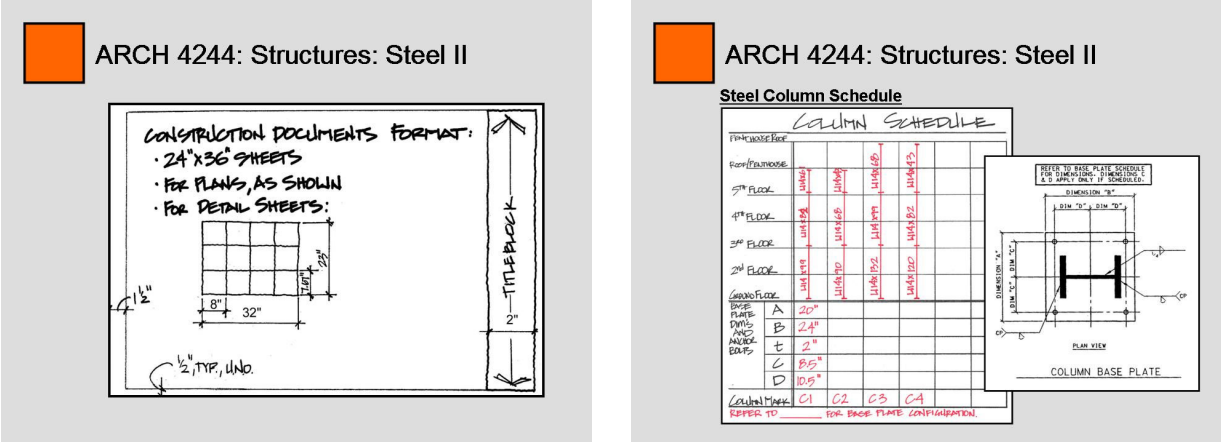


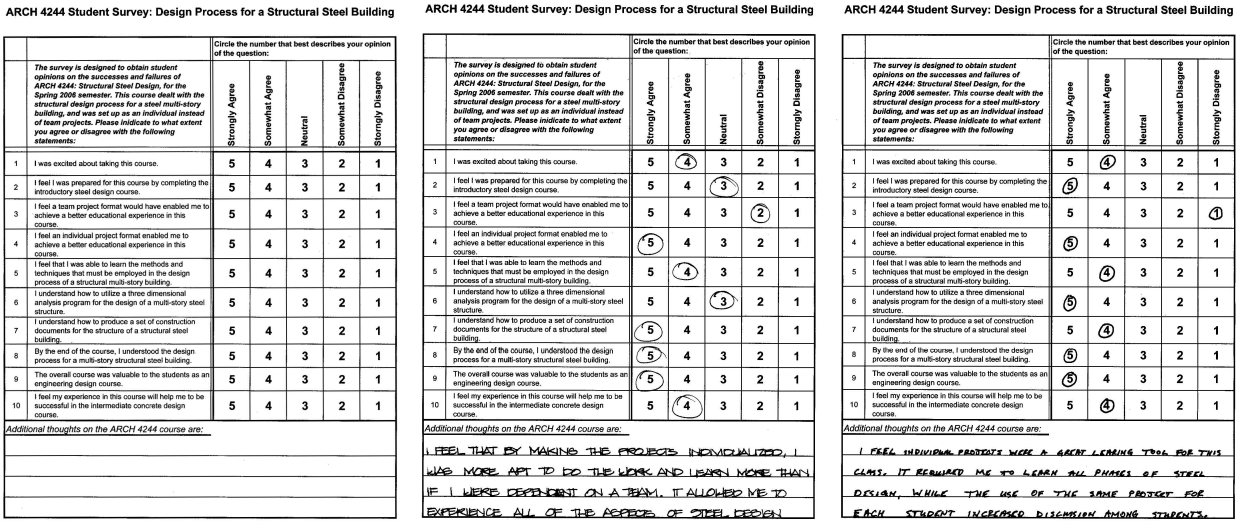
Fig 6: Slides from seminars on documenting the multi-story steel building design

who were not fully participating often felt that they had been left out of the process. Additionally, the potential problems of the team projects did not end with the completion of this initial course on building structure design. Following the intermediate steel design course, the students curriculum include an intermediate design course in concrete as well as the comprehensive studio design course, both of which are designed to build upon the techniques and methods that were presented in the intermediate steel course. With the team projects, the students inevitably do not participate in all phases of the course, and thus had not properly been exposed to the full design process for building structures. A significant percentage of the class was not properly prepared for the class requirements in the intermediate concrete design or comprehensive studio design courses where they are expected to complete entire building structural design individually.

A school's curriculum must be organized in such a way so that the content of a course will build upon and continue the education presented in earlier courses. When students do not properly learn the process of building structure design in an initial structural design course, it causes detrimental effects in subsequent design courses. Through experiencing this effect over several years, it was determined that by restructuring the steel design course into a format that includes individual design projects to the students, the students would have a better opportunity to experience the complete design process for a building structure. It was intended that this format would enable the subsequent design courses to extend the knowledge of the student by not having to cover similar material involving the process of building structures design.

Assessment

With any change involving the format of a course, we as educators must be able to assess the change to help in the determination of its success or failure in the classroom. There are several methods that could be used in the evaluation of the changes made in this course. Student grades can be used as an assessment measure to determine the success of the students pertaining to the revisions in the course. A second measure of the success of the course is to involve the students in evaluating the course and how they perceived the process. This paper uses the results of a



ARCH 4244 Student Survey: Design Process for a Structural Steel Building

		Circle the number that best describes your opinion of the question:				
	The survey is designed to obtain student opinions on the successes and failures of ARCH 4244: Structural Steel Design, for the Spring 2006 semester. This course dealt with the structural design process for a steel multi-story building, and was set up as an individual instead of team projects. Please inidicate to what extent you agree or disagree with the following statements:	Strongly Agree	Somewhat Agree	Neutral	Somewhat Disagree	Stongly Disagree
1	I was excited about taking this course.	5	4	3	2	1
2	I feel I was prepared for this course by completing the introductory steel design course.	5	4	3	2	1
3	I feel a team project format would have enabled me to achieve a better educational experience in this course.	5	4	3	2	1
4	I feel an individual project format enabled me to achieve a better educational experience in this course.	5	4	3	2	1
5	I feel that I was able to learn the methods and techniques that must be employed in the design process of a structural multi-story building.	5	4	3	2	1
6	I understand how to utilize a three dimensional analysis program for the design of a multi-story steel structure.	5	4	3	2	1
7	I understand how to produce a set of construction documents for the structure of a structural steel building.	5	4	3	2	1
8	By the end of the course, I understood the design process for a multi-story structural steel building.	5	4	3	2	1
9	The overall course was valuable to the students as an engineering design course.	5	4	3	2	1
10	I feel my experience in this course will help me to be successful in the intermediate concrete design course.	5	4	3	2	1

Additional thoughts on the ARCH 4244 course are:

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1	I was excited about taking this course.	5	(4)	3	2	1
2	I feel I was prepared for this course by completing the introductory steel design course.	5	4	(3)	2	1
3	I feel a team project format would have enabled me to achieve a better educational experience in this course.	5	4	3	(2)	1
4	I feel an individual project format enabled me to achieve a better educational experience in this course.	(5)	4	3	2	1
5	I feel that I was able to learn the methods and techniques that must be employed in the design process of a structural multi-story building.	5	(4)	3	2	1
6	I understand how to utilize a three dimensional analysis program for the design of a multi-story steel structure.	5	4	(3)	2	1
7	I understand how to produce a set of construction documents for the structure of a structural steel building.	(5)	4	3	2	1
8	By the end of the course, I understood the design process for a multi-story structural steel building.	(5)	4	3	2	1
9	The overall course was valuable to the students as an engineering design course.	(5)	4	3	2	1
10	I feel my experience in this course will help me to be successful in the intermediate concrete design course.	5	(4)	3	2	1

Additional thoughts on the ARCH 4244 course are:

I FEEL THAT BY MAKING THE PROJECTS INDIVIDUALIZED, I WAS MORE APT TO DO THE WORK AND LEARN MORE THAN IF I WERE DEPENDENT ON A TEAM. IT ALLOWED ME TO EXPERIENCE ALL OF THE ASPECTS OF STEEL DESIGN

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1	I was excited about taking this course.	5	(4)	3	2	1
2	I feel I was prepared for this course by completing the introductory steel design course.	(5)	4	3	2	1
3	I feel a team project format would have enabled me to achieve a better educational experience in this course.	5	4	3	2	(1)
4	I feel an individual project format enabled me to achieve a better educational experience in this course.	(5)	4	3	2	1
5	I feel that I was able to learn the methods and techniques that must be employed in the design process of a structural multi-story building.	5	(4)	3	2	1
6	I understand how to utilize a three dimensional analysis program for the design of a multi-story steel structure.	(5)	4	3	2	1
7	I understand how to produce a set of construction documents for the structure of a structural steel building.	5	(4)	3	2	1
8	By the end of the course, I understood the design process for a multi-story structural steel building.	(5)	4	3	2	1
9	The overall course was valuable to the students as an engineering design course.	(5)	4	3	2	1
10	I feel my experience in this course will help me to be successful in the intermediate concrete design course.	5	(4)	3	2	1

Additional thoughts on the ARCH 4244 course are:

I FEEL INDIVIDUAL PROJECTS WERE A GREAT LEARNING TOOL FOR THIS CLASS. IT REQUIRED ME TO LEARN ALL PHASES OF STEEL DESIGN, WHILE THE USE OF THE SAME PROJECT FOR EACH STUDENT INCREASED DISCUSSION AMONG STUDENTS.

Fig 7: Student survey given at end of year for assessing revisions to course format

student questionnaire given at the end of the semester as an assessment tool for the course. The students are asked questions on the individual project format of the course, how they perceive the education they received during the course, and how they feel they will perform in subsequent courses involving structural design. The students were asked to evaluate ten statements on the degree to which the agreed or disagreed with the statements. The questions dealt with the format of the course and with how the students perceived the education they received during the semester, and how they felt they would perform in subsequent structural design courses. In the initial year of the course format revisions, this student survey was the measure used in assessing the course. The results of the student survey can be seen in *Fig. 8*. Based on the student surveys,

ARCH 4244 Student Survey Results for Spring 2006

Question	*Student survey questions presented to students taking the course*	Assessment Value
1	I was excited about taking this course.	**4.86**
2	I feel I was prepared for this course by completing the introductory steel design course.	**4.43**
3	I feel a team project format would have enabled me to achieve a better educational experience in this course.	**1.71**
4	I feel an individual project format enabled me to achieve a better educational experience in this course.	**4.71**
5	I feel that I was able to learn the methods and techniques that must be employed in the design process of a structural multi-story building.	**4.29**
6	I understand how to utilize a three dimensional analysis program for the design of a multi-story steel structure.	**4.29**
7	I understand how to produce a set of construction documents for the structure of a structural steel building.	**4.14**
8	By the end of the course, I understood the design process for a multi-story structural steel building.	**4.71**
9	The overall course was valuable to the students as an engineering design course.	**4.86**
10	I feel my experience in this course will help me to be successful in the intermediate concrete design course.	**4.14**

Fig 8: Results from the student survey used in assessing the Intermediate Steel Design Course

where values range from 1 to 5 with 5 representing that the student strongly agrees with the statement given on the survey, the results for the course survey show that the students feel they

are receiving a better education than they would if the course was formatted with a team design project. If we say that a measure of success is based on a value of 4.0 and above for the survey, then *Fig. 8* shows the reformatting of the course has been successful from the students standpoint. With the spring 2006 semester being the first time that this format has been instituted into the intermediate steel structural design course, the results are just initial and will need to be compiled over the next several years to truly evaluate the success of the revised course. Though we can use the student survey as an assessment tool for the course, it becomes necessary to use other measures to assess the course success. One measure will be the student comprehension of the design process in the subsequent intermediate concrete course as well as the comprehensive design studio, both of which expect students to use the knowledge and techniques learned in the intermediate steel course. The students in these courses can be assessed through their quality of work in those courses pertaining to the structural design process.

Conclusion

Team projects provide students with an important experience that they will most likely encounter throughout their career in this profession. However, to be successful in the structural design process, the students must first understand all phases of the process, and how those phases are incorporated into design so that they lead to a complete structural building design. Once the process is learned, the aspects of working on team projects will enhance the student's education, and this can happen in subsequent structural design courses in the curriculum at Oklahoma State University. The intermediate steel design course has been restructured to allow each student within the course to experience the concepts and methods employed in the design of a multi-story steel structure, and the restructuring has become successful in that the student's are more aware of the process required, and how to use the tools available to have the end result of a successful steel design project.

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