AC 2012-4638: AN EXPERIMENT IN PROJECT-BASED LEARNING: A COMPARISON OF ATTITUDES BETWEEN RUSSIA AND AMERICA

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An Experiment in Project Based Learning:
A Comparison of Attitudes between Russia and America

Abstract

As part of the Scientific School on "Higher Technical Education as an Instrument of Innovative Development", we gave a workshop on Project Based Learning using the "Build a Skyscraper" project to Russian educators from Kazan National Research Technological University. Subsequently this same workshop was given to a similar group of American students and educators from Western Carolina University. This project is intended for second year students in engineering. Skills to be exercised during this project include team building, interpersonal skills, project management, formation of customers' requirement and complex problem solving. An assessment tool was developed to gather feedback on the workshop and the experience. This paper concentrates on the assessment data and discusses interesting and surprising differences in attitudes as well as similarities between these two audiences.

The CDIO Skyscraper Exercise

The Skyscraper Exercise was created by engineering educators from Massachusetts Institute of Technology and United States Naval Academy and it contains all the major components of the conceive, design, implement and operate (CDIO) pedagogical approach in a exciting format[1]. The historical premise is based on the highly competitive expansion of very tall structures such as the Chrysler Building (New York City) in the early part of the 20th century (figure 1). This expansion was enabled by new structural materials and building processes. The exercise is to design, build and test a model skyscraper using a variety of foam blocks and pencils as the fasteners. Each size of foam block is priced such that the team must buy land, blocks, and fasteners drawing on a $2000 total budget. The structure is required to support a 0.5 liter bottle of water while being tilted on a 10% slope to simulate earthquake durability. Overall height and aesthetics are the principal evaluation factors. The full exercise is available at http://www.cdio.org/files/document/file/Skyscraper_Template_Full.pdf with both instructor guidance as well as the challenge elements for the students. The exercise requires that the teams:

- organize themselves to maximize efficiency,
- understand and interpret a detailed set of requirements and constraints,
- create a design meeting technical requirements and aesthetics appeal,

Figure 1. The Chrysler Building is used in the CDIO Skyscraper Exercise to illustrate both innovation and aesthetics in design.

- adhere to a cost budget and the imposed time constraints,
- provide technical data to support the adopted design by experimentation,
- build up construction documentation and adhere to the documentation during the build phase,
- subject their structures to final acceptance testing

Desired learning outcomes are quite extensive and outlined in the reference. These outcomes include exercising of basic disciplinary knowledge about structures, anticipating and mitigating risks through concurrent testing and development activities, maximizing team performance through organization and delegation of tasks, trading off technical performance within a defined and fixed budget and drawing quality of construction and aesthetics into design decision.

It occurred to the authors that this exercise might expose interesting differences and sensitivities for an American participant group compared to a Russian group of participants. The American group is a fifty three member senior capstone project class of traditional and non-traditional multidisciplinary students. The Russian group was composed of faculty and graduate students participating in a workshop held during a conference examining the impact of pedagogy on engineering education. The range of ages and the level of professional maturity in this group were much larger and higher than the American group. Additionally the disciplinary range was broader in the Russian group with educators and students from economics, sciences and chemical engineering. This paper is the first attempt to explore and discover cultural differences stemming from this exercise. It is recognized that the demographics of the participants in both maturity and age introduces additional factors to the investigation. Nevertheless the authors capitalized on the opportunities that presented themselves and sought to identify potential areas worthy of additional research.

Senior Capstone Projects for Department of Engineering and Technology, Western Carolina University students

Western Carolina University(WCU) , a regional comprehensive institution founded in 1889 with a distinguished history of teaching and learning for western North Carolina (figure 2). The Department of Engineering and Technology plays a key role in engaging the University in the growth of the region. The Center for Rapid Product Realization (Rapid Center) was explicitly formed to bridge and connect the resources of the Department of Engineering and Technology to the external community.

Figure 2 Western Carolina University is in the southern most extension of rural Appalachia.

The Department of Engineering and Technology at Western Carolina University is comprised of the Electrical Engineering, Electrical and Computer Engineering Technology, and Engineering Technology Programs with approximately 300 majors. Traditional lectures are complimented through hands-on laboratories for most subject areas where the CDIO model may be used to reinforce theory. In an effort to strengthen program outcomes and make the learning experience more relevant to industry practices, the Department adopted a project based learning pedagogy and restructured the senior capstone courses in 2008 to be the key stone of the program.

Figure 3 Nine towers were built by the American class. The tallest unit to pass earthquake test is fifth from the left. The tower voted overwhelmingly the most aesthetically pleasing was the last tower on the right.

The capstone curricular sequence combines project management, new product development, and interdisciplinary student teams. Our purpose was to produce engineering and technology graduates who are open to the injection of new ideas, comfortable in an environment that will nurture new product ideas from diverse disciplines and can mature promising ideas into actual business propositions. The Rapid Center provides a renewing flow of real projects sponsored by regional industry to create multi-disciplinary project for the teams to select and engage with the region. The senior capstone addresses both goals of engagement and real hands on experience for the students. The entire two semester senior capstone course is fully described in previous papers with numerous project examples in earlier papers[2,3].

Figure 4 The fifty four students formed nine teams for the activity.

The use of preplanned, closed ended, hands-on activities is a key part of the course and the Skyscraper project, described above, is one of the favorites in the course. Thus the group of U.S. participants was fifty three senior engineering students from all of the three aforementioned disciplines of study in the Engineering and Technology department. The towering skyscrapers and the teams proudly displaying the fruits of their efforts are shown in figures 3 and 4. The student demographics include traditional and non- traditional students such that a significant range in age and maturity existed. The class was divided into nine teams on a random basis and the exercise was executed over two class periods. A survey was conducted following the exercise as well as an opportunity to discuss what was learned and what was difficult/easy in the exercise.

By general consensus, the two most difficult aspects of the exercise was the adherence to a cost budget and achieving structural stability. The difficulty experienced with the cost budget was not simply coming under the cost limit. The difficulty was maximizing the use of the total budget to achieve the tallest structure.

Project Based Learning Workshop at Kazan National Research Technological University

Kazan National Research Technological University (KNRTU) is one of 29 Russian Universities with the status of National Research University. Situated in the Republic of Tatarstan, one of the regions of Russia with advanced industrial development and innovations, KNRTU is the leading Russian university in chemical engineering. Its history dates back to 1890 when the Ministry of Public Education of the Russian Empire enacted the resolution to establish the Integrated Industrial and Technical College. Today, KNRTU comprises 15 Institutes, including Chemical Engineering and Technology, Mechanical Engineering for Chemical and Petrochemical Industry, Administration, Economics and Social Technologies, Petroleum, Chemistry and Nanotechnology, Polymers, Food Engineering and Biotechnology, Light Industry, Fashion and Design, Automated Control Systems and Information Technologies, Life-Long Education, Project Design Institute "Souzhimpromprojekt", Research Institute "Speckauchuk", Corporate University (Institute), Institute of Additional Education, Institute of Military Education, Nizhnekamsk Chemical and Technological Institute.

Figure 5 The Republic of Tatarstan is located 500 miles east of Moscow as shown on the map of the Russian Federation

The Institute of Additional Professional Education is one of the structural subdivisions of KNRTU, where research in engineering education is very well developed. Following the traditions of this research, , an International Scientific School "Higher Technical Education as an Instrument of Innovative Development" was held October 5-7, 2011at KNRTU[4]. The School was organized by the International Society for Engineering Education (IGIP), the Russian Monitoring Committee of IGIP together with the Public Chamber of Tatarstan and the Ministry of Education and Science of Tatarstan. The high status of the School gave an opportunity to develop conceptually well-grounded recommendations for reforms in higher professional education consistent with the trends of social economic development in Russia and Tatarstan and the international integration of Russian education and science. Participants of the School were faculty, researchers and education administrators from different parts of Russia. Distinguished Russian and international experts in engineering education, including the founder of the International Society for Engineering Education (IGIP) Alolf Melezinek (Austria), were invited to the School to give lectures and workshops.

Figure 6 Fifty one conference attendees participated in the Skyscraper exercise in Kazan, Russia (the 8 towers are shown in the background)

As part of the School, two four hour workshops were given in which the CDIO Skyscraper exercise was demonstrated as a tool for project based learning to enhance the engineering educational experience. The fifty one participants in the workshop formed 8 teams and were led through the exercise template laid out above. The towering skyscrapers and the teams proudly displaying their fruits of their efforts are shown in figure 6 and 7. Following the exercise, a survey was conducted as well as an opportunity provided to discuss what was learned and what was difficult/easy in the exercise. Once again, the teams found that adhering to the budget was challenging. The team building aspect and the opportunity for big thinking were found to be the best aspects of the exercise while some of the participants found that the lack of engineering knowledge was a frustration.

Figure 7 One of the teams stands proudly with the fruits of their labor- a skyscraper with aesthetic attributes.

Survey of attitudes

Following the CDIO Skyscraper experiences, each participant from both groups was asked to complete a survey that focused on areas where the authors expected to find differences in the two cultures. Some of the questions were taken from the survey provided with the CDIO Skyscraper exercise template. Most of the questions stemmed from experience with learning outcome surveys developed for the senior capstone course. Finally the author perceived potential differences between the two cultures and added questions to explore issues of creativity, innovation, aesthetics, teaming and organizational approaches. The survey tool is shown in figure 8. Each survey issue was rated according to the ease and/or difficulty that the individual

Issue	A little		Somewhat		A lot
	1	2	3	4	5
Impact of R and D in generating successful design					
Opportunity for innovative concepts					
Role that aesthetics played in the design					
Utility of design documentation to construct skyscraper					
Project presented authentic tasks and conditions					
Concurrent activites were used in this project					
Changes required during construction					
Discipline required to follow design documentation					
Team openness to different ideas					
Effort required to achieve agreement on one design					
Effectiveness of this project to learn to work with team members					
Effectiveness of this project to develop design skills					
Effort required to establish leadership in the team					

Figure 8 The survey tool explored a broad spectrum of issues that could bring to the surface differences in management styles and attitudes.

felt in completing the aspect of the exercise on the scale ranging from “a little” to “somewhat” to “a lot”.

The survey results are shown in figure 9. A paired t-test was performed on the data from the Russian workshop and the ET 461 workshop. The significance level (α or alpha) was set at 95% or p-value = 0.05. The paired t-test is actually a 1-sample t-test on the pair wise differences. Therefore the pair wise differences must satisfy the 1-sample t-test assumptions, including normality. A normality test was performed on the pair wise differences (Russian – ET 461).

	N	Mean	St Dev	SE Mean
Russian	13	3.686	0.671	0.186
461	13	3.777	0.474	0.131
Difference	13	-0.092	0.443	0.123

T-Value = -0.74
P-Value = 0.471

Based on the p-value of 0.471, we fail to reject the null hypothesis and concluded that there is no statistical significant difference between the Russian workshop and the ET 461 workshop.
The authors realized at the initiation of the research that there was insufficient data to draw statistically valid conclusions. Nevertheless, the authors believe that the data suggests interesting areas for further exploration which was their goal.

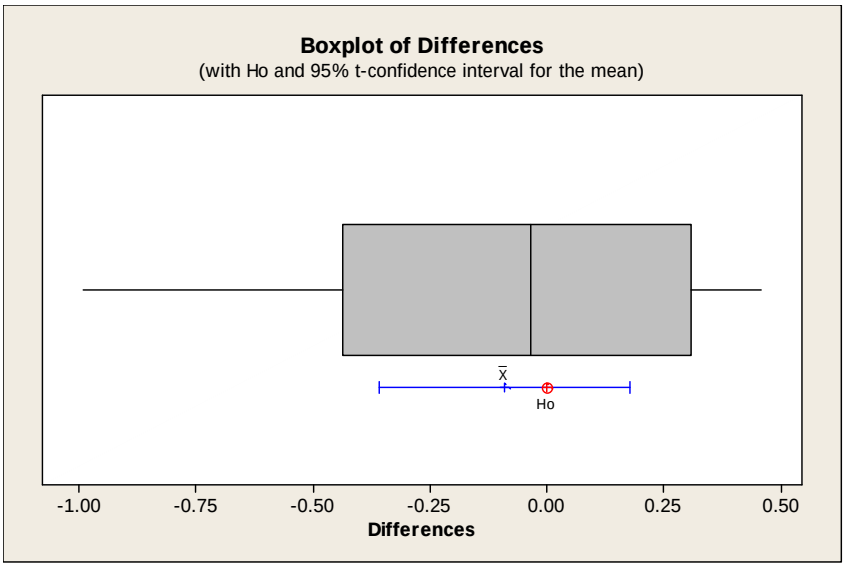

Figure 9 The results of the paired T test determined that the differences in the survey responses were not statistically different.

The largest difference in difficulty arose was in the establishment of team leadership with the Russian teams having less difficulty that the American teams. Two factors might influence this difference: 1) the Russian culture was more comfortable with a strong leader taking charge and 2) the American students were less

Issue	Russian mean	Russian sigma	ET 461 mean	ET 461 sigma	Difference in mean
Impact of R and D in generating successful design	2.91	0.89	3.53	0.70	-21%
Opportunity for innovative concepts	3.64	0.99	4.25	1.12	-17%
Role that aesthetics played in the design	4.00	1.15	3.62	0.69	10%
Utility of design documentation to construct skyscraper	3.78	1.33	3.82	0.68	-1%
Project presented authentic tasks and conditions	3.97	1.21	4.09	0.83	-3%
Concurrent activites were used in this project	3.97	1.02	3.94	0.75	1%
Changes required during construction	3.44	0.81	2.98	0.42	13%
Discipline required to follow design documentation	4.00	1.19	3.55	0.64	11%
Team openness to different ideas	4.58	1.71	4.53	1.37	1%
Effort required to achieve agreement on one design	3.03	0.69	3.29	0.46	-8%
Effectiveness of this project to learn to work with team members	4.55	1.71	4.31	1.07	5%
Effectiveness of this project to develop design skills	3.91	1.14	4.06	0.81	-4%
Effort required to establish leadership in the team	2.15	0.50	3.14	0.43	-46%

Figure 10 Survey results following the Skyscraper exercise

mature than the Russian participants leading to internal struggles for leadership.
During the exercise, instructors noted several American teams struggling with the issue of who was in charge. On the other hand, during the Russian exercise, team structure was quickly established but varied considerably between groups from highly authoritarian to communal leadership. Within this wide range of organizational types, the Russian teams were very efficient. One of the comments in the discussion from the Russian workshop was that the team building was one of best parts of the exercise.

An additional, and perhaps cultural, difference is that the Russian groups seemed somewhat better at ease with the discipline required to adhere to the design documentation. The Russian groups seem to follow the rules more easily than the American group who had a tendency to want to continue to experiment and change without documentation. This desire and openness to a trial and error, experimentation process was slightly stronger with the American group than the Russian group.

Lessons Learned and Future Directions

As stated earlier, the authors were simply taking advantage of the situation to explore cultural differences that this exercise might reveal. Going forward several changes are indicated. First, a careful review of the survey tool will be made to deal with any biases in the issues and language. This review should be done on the both the Russian and English versions of the survey tool. Specific attention will be given to avoiding biases that could contaminate the data particularly around leadership styles and preferred management structures. In addition supplemental questions will be added to quantify the potential biases. Secondly, the population to be surveyed must be more uniform. The authors will identify groups of equal age and similar technical background for the exercise and the survey. Students in second and third year of engineering programs will be selected. However it might interesting to also select groups of mature engineers and explore the issues of age and mature on cultural differences and similarities.

Conclusions

Using the CDIO Skyscraper exercise in two different cultures resulted in very similar outcomes. Additional exercises would be needed to more carefully control influential variables such as professional maturity and age. The survey suggests that differences in team leadership structures and styles could be an interesting area of research. Furthermore these leadership style differences could be relevant as to how to construct and enhance entrepreneurship in Russia as well.

Acknowledgements

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