International Journal of Engineering & Technology
CENTRE OF PROFESSIONAL RESEARCH PUBLICATIONS
ISSN 2049-3444

International Journal of Engineering and Technology Volume 5 No. 5, May, 2015

Project Based Learning – Virtual Lab: Heat Transfer

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ABSTRACT

Project-based learning-virtual lab (PBLVL) is a teaching technique that arranges learning around projects by using different engineering tools such as solid works and CFD. Project-based learning has been applied in heat transfer course. The projects were not assigned for the student. Each student chose a different engineering project. These projects are helping them connecting the theoretical content to that of real time world applications in the area of heat transfer. Also, the project-based learning improve and accelerate students understanding of heat transfer concepts and involve students in a constructive exploration. An exploration involves inquiry, and knowledge building. Also the objectives of PBLVL are to stimulate the initiation of fundamental research in heat transfer topics and to advance the knowledgebase in such a highly important area, to make all advantages provided by the PBLVL available to all the students across the US for the advancement of knowledge and elevation of engineering competitiveness and to offer both opportunities and challenges for the educational sector. Also the results of applying PBLVL show the increase in student's ability to apply the theory and identify the heat transfer engineering application.

Key words: *PBLVL, Heat Transfer, Engineering Project*

1. INTRODUCTION

1.1 Overview

The project based learning-virtual lab (PBLVL) is potentially expected to elevate the knowledge levels of students, researchers, and cooperating members in different areas and disciplines and in the heat transfer in particular. The project based learning can be applied by creating the virtual lab. The project is expected to elevate understanding of entry level engineering students of different aspects of engineering topics by helping them connecting the theoretical content to that of real time world applications, and consequently increasing their motivations and elevating their confidence in handling future problems. Students of disciplines other than mechanical engineering who are mandated to develop a good level of understanding of thermal sciences and solid mechanics would also advantage form the concept of project based learning-virtual lab through simplified presentation and demonstration of such topics. Higher level and graduate students will also advantage from the developed method of learning as it would provide a professional virtual platform for better understanding, deeper analysis, simulation and design of more complicated application they may encounter. On the other hand, Experimental results indicate that students who use the virtual laboratory prior to a physical laboratory are able to complete the physical laboratory in a much shorter time, require less assistance, and also report that they are very satisfied with their laboratory experience (2, 3, 4 and 5). There are some virtual labs that were established at different schools in the USA focused in specific areas (6, 7, 8, 9, 10, 11 and 12)

This paper aimed to show the importance of applying the project based learning in the form of a virtual lab to improve and accelerate students understanding of the heat transfer in general. This paper shows different projects have been done by the students using different tools in their projects to understand the theoretical aspects of heat transfer. On the other hand, the successfully developed the concept of project based learning-virtual lab would essentially elevate entry level students understanding of thermal engineering applications through simplified and yet efficient connection between the theory and real world application.

Furthermore, the project base learning-virtual lab would essentially assist higher level students in handling more complicated applications and research issues through providing an efficient, interactive and reliable simulation and design tool for a variety of thermal engineering applications. Project-based Learning has a well-established record of benefits, including increased retention of content and improved student attitudes towards learning.

1.2 The impacts of proposed activity

In the long term, the developed PBLVL is expected to provide the industry with more career ready, highly motivated and more confident mechanical engineering graduates ready to deal with the ever challenging and demanding industrial applications. Moreover, the developed PBLVL is expected to open other avenues to mechanical engineering student during their course of study by involving them in industrial projects for the private sector under the supervision of their institution staff, which in turns would elevate their technical and business skills and promote their future capabilities. Similarly, graduate students and researchers can advantage from using the developed tool in providing sound solutions and fundamental contributions to higher end and more challenging issues in thermal engineering core topics.

The PBLVL will help in improving the consideration of different perspectives, ability to think globally, and synthesis of issues and development of comprehensive solutions. The PBLVL will prepare students to change and develop life-long learning skills and be able to function and succeed in real world projects.

2. PBLVL DESCRIPTION

PBLVL has achieved an adequate level of development for it to be considered in innovative applications such as education, training, and research in higher education. PBLVL reality offers both opportunities and challenges for the educational sector. One of the challenges of virtual reality technology is the costs associated which have been unaffordable for educational institutes. However, in recent years, computer hardware and software development has made it more feasible to incorporate virtual reality technology into future teaching strategies. Despite the cost challenges, educational benefits of implementing virtual reality remain compelling (1).

Combining theoretical fundamentals and practical real world applications form an essential requirement in a successful engineering education process, as today's engineering students need to understand the theoretical engineering fundamentals they are taught and relate them to real time applications encountered in their future career. This requirement is usually fulfilled by complimenting the class material with simulated smaller scale applications in a laboratory environment. However, despite the amount, quality and nature of equipments and instruments provided in a laboratory environment along with the amount of efforts allocated to any laboratory, students in general may still encounter lack of appropriate understanding in relating the application being demonstrated through the lab with the theoretical class material. This is attributed to many reasons including the fact that introductory level students may in average not be at a level to develop enough knowledge and skills to digest the class material and more important to relate this material to real applications. Another reason is the fact that the lab is actually part of student's degree requirements and therefore it is bound limiting rules, timelines, and expectations, which in turn limit the students (especially entry level ones) interest in saturating their scientific curiosity. Saturating this curiosity, is indeed necessary, and the most efficient way to fulfill it is by providing enough time, access and more detailed and simplified demonstration that simulate the lab environment.

Similarly, higher level students would usually undergo situations such as term projects and involvement in institution-related contracts in which applied simulations, thorough demonstrations, and interactive design are required. In all of these situations, thorough understanding and visualization of actual applications and process flow are essential for the success of their mandates. Additionally, verification and validation of theoretical calculations and findings are also essential, and can be classically fulfilled by conducting experimental work in a laboratory environment. However, lack of enough access to such facilities besides other limitations including time slot availability and possible lack of equipments and devices in laboratory facilities may hinder the timely fulfillment of such tasks. A simulated laboratory environment furnished with an ample and yet scientifically sound simulation, calculation and design capabilities can well suite all the needs and fulfill all tasks mentioned above while, in the mean time, saves the institution all extra costs and space required to build a new or upgrade an existing laboratory facility.

3. SAMPLES OF PBLVL PROJECTS FROM HEAT TRANSFER COURSE:

Each student worked on different heat transfer engineering applications, the following projects are examples of students projects:

3.1 "Thermal Analysis of a CPU Heat Sink" (as shown in Figure 1),

The simulation has been done to show that CPU heat sinks are an efficient means of transferring heat away from the CPU. With the specific geometry used, the fin efficiency was 92.52% while the overall efficiency of the cooler was 92.67% which is quite high. Taking all the effective resistances into consideration, the heat transfer rate of the CPU was 50.95 W, or an equivalent heat flux of 1833.33 W/m2. This is a considerable amount of heat transferred given its small volume. The SolidWorks CFD simulation, despite providing inaccurate results for heat flux, provides a good visual representation of the system and proves the theory behind CPU heat sinks. The thermal cut plot in particular shows how heat dissipates from the CPU, through the cooler, and finally into the environment.

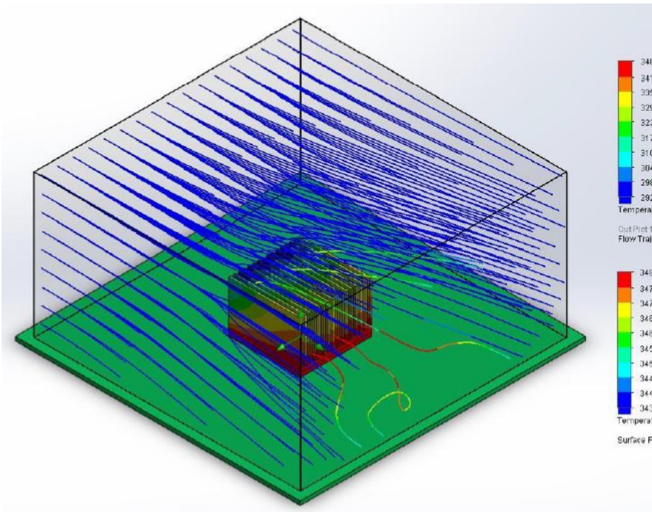

Figure 1. Thermal Analysis of a CPU Heat Sink

3.2 ""Heating greenhouse" (as shown in Figure 2):

Greenhouses are used in to give a farmer more control over the environment that the plants will be growing in. This environment include the temperature, the soil that the plants will be growing, or the amount of water that is the plants receive. The control of these elements increase the growing season
for the farmer and if the greenhouse can remain warm enough can produce can be growing all year long. In the winter it is important to make sure that the temperature remains relatively constant within the greenhouse. If the green temperature drops below 45°F or 7.2°C most commercial plants will not produce

fruits or vegetables. So in the winter most commercial greenhouses in northern climates require heaters to keep the temperature above that limit. Another key thing in greenhouses is that that the material it is made of must let in light for plants. In the past glass was used to let light in and trap the heat of the sun for a green house. However, modern industrial greenhouses use polyethylene plastic because of it light weight and transparency. The polyethylene will slowly break down due to ultraviolet rays but it has an average life span of about 4 years for Greenhouse purposes. It is typically purchases in large rolls about a meter in width and tightly draped over a steel or wooden greenhouse frame. To keep the heat inside the greenhouse from quickly entering the ground mulch or another insulator in generally laid on the ground before putting in tables for the plant to sit on. Analyze a greenhouses heat loss in the winter in order to determine the size of heater that would be needed keep the temperature at 75° F or about 24° C for optimum plant growth. The green house would be located in a field away from any other potential heat source so the heater inside would need to be able to handle the heating load of the green house at worst case temperatures. The analysis is for maximum heat loss. This means the case would be at night so no radiation to heat the greenhouse, high external winds and the lowest recorded temperature in February for Langhorne Pennsylvania where the green house is located. This heat lost at the worst case scenario would be used to purchase heater that would always be able to keep the green house warm in the winter.

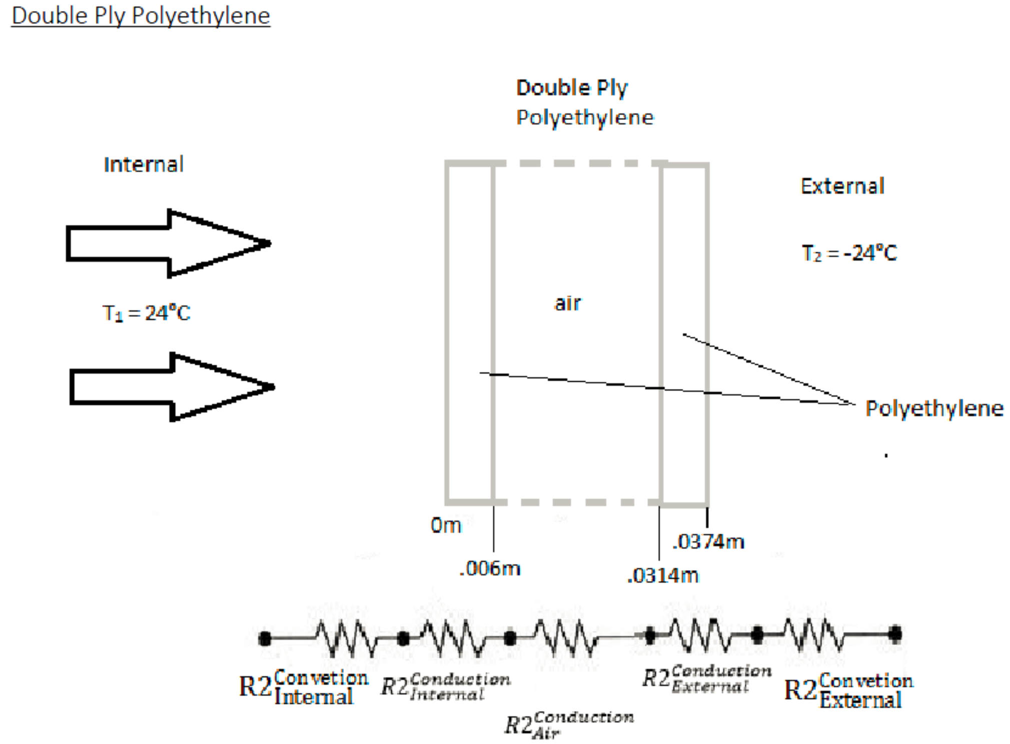

Figure 2. The double ply set up of heating greenhouse

3.3 "Analysis of Simple Snowmelt System" (as shown in Figure 3):

Winter in the United States can sometimes be particularly brutal and present residents,especially those in the northern states, with hazardous conditions outside. The average low temperature for Boston, MA during the winter months of December, January, February, and March is 28°F, while the average high is roughly 42°F. The average total amount of snowfall in these months is approximately 45.7". This requires snowplows to clear roads, and citizens must go out into these extreme conditions and shovel footpaths and driveways. Conditions are even worse in some areas of the country. For example, East Lansing, MI, the location of Michigan State University, experiences an average of 53.3" of snowfall during the winter months. This makes it very difficult and perhaps dangerous at some points for students, faculty, and staff to walk around campus. Michigan State employs a certain technology to help reduce the chance of injury while students and faculty are using certain walkways. This technology is known as a snowmelt system. Piping is buried in the concrete in a serpentine layout and hot water is pumped through it. Heat is transferred from the water eventually reaching the surface of the concrete. The heat at the surface of the concrete is enough to melt the snow on the walkway and prevent any further accumulation. This is used for approximately 160,000 ft2 of walkways on the campus of Michigan State. In order to conserve energy, sensors embedded in the pavement detect when snow begins to accumulate on the walkway and activates the snowmelt system. In this project, the heat transfer from water to the surface of the concrete was analyzed using a variety of different initial values including pipe size and initial water temperature. However, based on the amount of material that was taught during the course, the temperature of the surface will only be found as a function of the radius of the pipe and the concrete. Otherwise, the numerical method, which is a more thorough and difficult understating of the system, would need to be used.

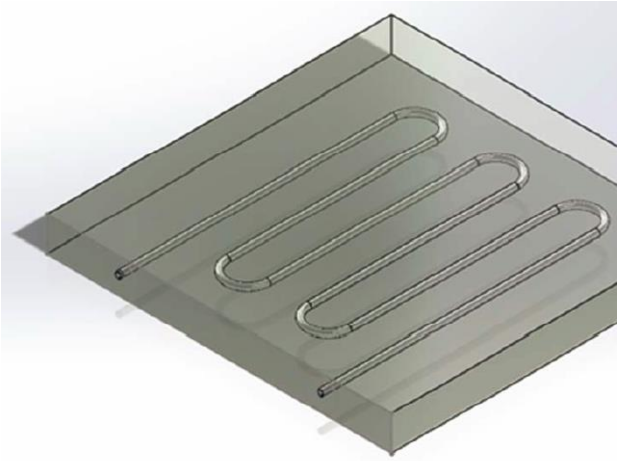

Figure 3. Schematic for Snowmelt System

3.4 "Heat Transfer through Wetsuits" (as shown in Figure 4):

Wetsuit technology has been continuously developing over the past 60 years. In this report different material additions were added to the neoprene and the performances were compared to see what produced the best thermal resistance. The conditions for this analysis is ocean water at atmospheric pressure and a temperature of 15 Celsius. The human body was assumed to generate a heat flux of 100 $W/m2$. The materials that were added to the wetsuit included aluminum, titanium, magnesium, Teflon, and Polytherm. It was concluded that none of the additions produce enough resistance to justify the combination with the traditional wetsuit.

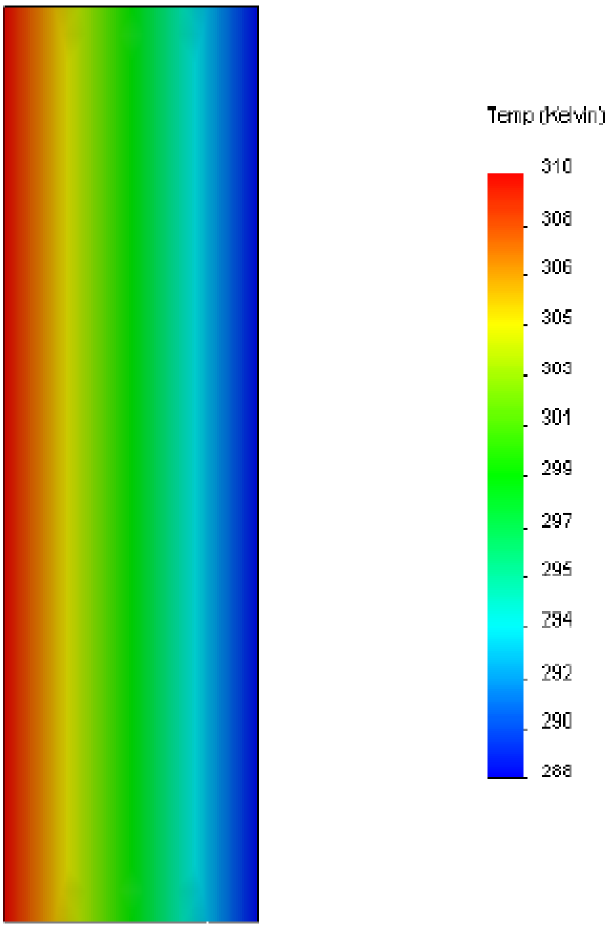

Figure 4. The heat transfer through the wetsuit materials

4. RESULTS

There are two points that support the Project-Based Learning. These points are: research on motivation, and technology. The students have the choice to choose their project to promote student's interest and motivate them to learn the research skills. Despite, some students are not motivated to do research even if they are interested in specific project, but it was the best way to insure that the students become proficient at inquiry and problem solving. Students working individually feel empowered when they understand the theory of heat transfer by applying it to solve engineering problems by creating solutions in relevant projects.

On the other hand, research has given the instructors ideas for enhancing students' ability to benefit from Project-Based Learning. Students who possess a motivational orientation that focuses on learning and mastery of the subject matter are more fitting to exhibit sustained engagement with schoolwork than students whose orientation is to merely perform satisfactorily or complete assigned work (Ames, 1992). The second point is technology, the application of technology has led to an interest in using computer, soft wares, design tools, the benefit of using the technology to make the theory explicit, thereby helping learners to become aware of the theory and how to apply it.

Figure 4 shows the evaluation score of the students in understanding the theory of heat transfer by using "PBLVL" during summer 2014 and it has been compared to the students score (Figure 5) took the same course during Fall 2013 without using project-based learning. "Using technology in project based science makes the environment more authentic to students, because the computer provides access to data and information, expands interaction and collaboration with others via networks, promotes laboratory investigation, and emulates tools experts use to produce artifacts." (Krajcik et al., 1994, pp. 488-489).

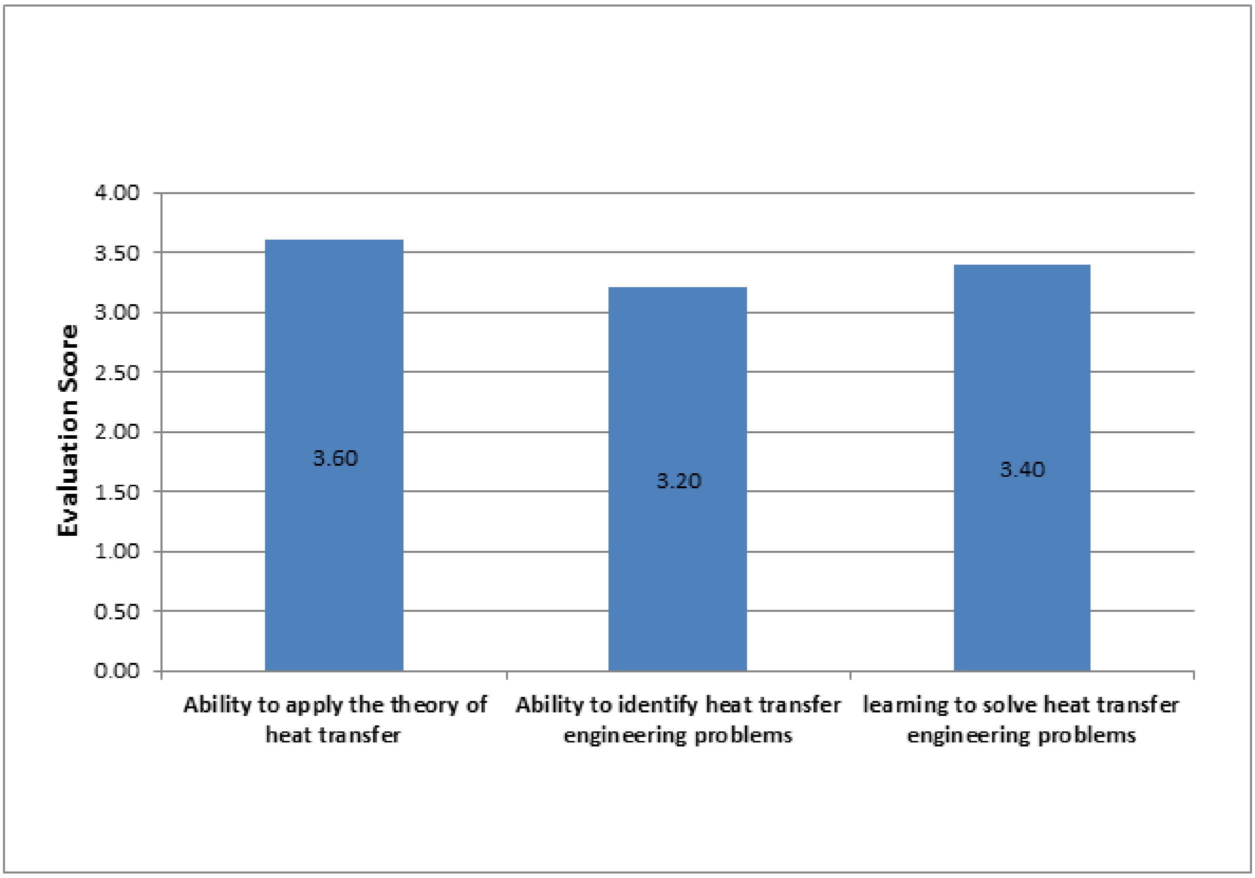

Figure 4. The outcome of using project based learning-virtual lab in heat transfer (summer 2014)

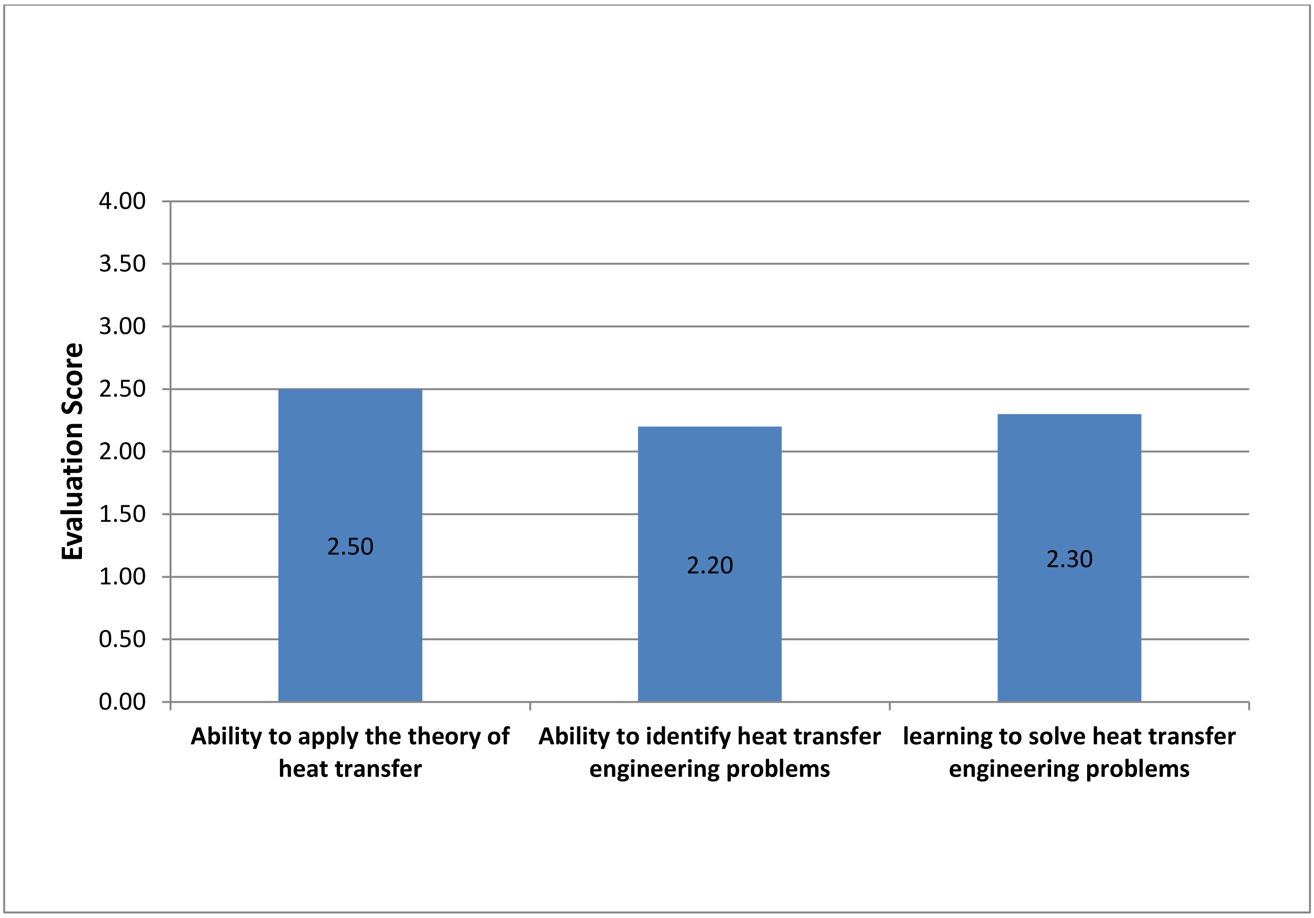

Figure 5. The outcome without using project based learning-virtual lab in heat transfer (Fall 2013)

5. CONCLUSION

PBLVL is better than other technique of teaching for creating advantages in general academic success. The results have been obtained by comparing two different teaching methods (by using PBLVL and without using PBLVL in heat transfer course) have shown the evidence that PBLVL is an effective technique for teaching students complex processes and solving problems. The project based learning movement is developing speedily and has many supporter in engineering areas. Wentworth Institute of Technology supports project based learning by encouraging the collaboration with the industry and the different disciplines of engineering

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