JTET

http://penerbit.uthm.edu.my/ojs/index.php/jtet
ISSN 2229-8932 e-ISSN 2600-7932

Journal of Technical Education and Training

Teaching and Learning of Practical Skills: Learning from the Pavement Laboratory Course

Mohammad Mehdi Khabiri[1*], Mohammad Javad Akhavan Bahabadi[1]

[1]Yazd University, Civil Engineering Department, University Blvd, Safeties, Yazd, 98195-741, IRAN

DOI: https://doi.org/10.30880/jtet.2019.11.02.002
Received 26th February 2019; Accepted 31st March 2019; Available online 30th June 2019

Abstract: Having the necessary technical skills is one of the issues faced by the community of graduates. Assessing the current status of engineering education at universities and adapting to other countries can provide policies and solutions to improve current programs and processes. Laboratory classes are an integral part of an engineering course designed to improve technical skills, provide opportunities for developing thinking skills and promote experience-based learning. The objective and topics discussed in this study are not limited to a specific topic of civil engineering laboratory course and include other technical disciplines as well. In order to achieve this objective, this study provides a framework of study that can also be used in other disciplines and laboratory courses. In this study, while evaluating the experiences of different countries in the application of laboratory training at universities, a primary proposed solution and strategy is provided. The present study is descriptive-analytical in nature using library and field methods together with questionnaire for data collection. The results show that the use of active teaching methods in the process of teaching a skill can promote effective teaching and increase students' satisfaction. Finally, some strategies are suggested to improve training and prepare the eligible graduates for working in industry.

Keywords: Laboratory-Based education, pavement engineering laboratory, learning a skill, university–industry cooperation

1. Introduction

Training for specialized and efficient human resource required by the general community and industries is one of the important goals and tasks of higher education in technical and engineering disciplines. Testing is one of the ways of learning the principles and general outcomes of science that can make students think, discuss, and conclude, and finally, make learning more desirable. In the current research, at first, experts' opinion about the importance of laboratory teaching and the way in which laboratory work is conducted at universities are presented. Additionally, the experience-based solutions used in the world are reviewed. One of the solutions which have been used in case studies is also investigated. In addition to increasing the sustainability of concepts learned, performing laboratory activities lead to acquisition of skills which are used in industrial activities and individual employment and cover the way for educators' innovation (Badrian et al., 2009).

Working and teaching in the laboratory are very important and engineering education in laboratories enhances a range of skills, including communication, knowledge, teamwork, ethics, and the encouragement of information acquisition, and the like. Certainly, electrical engineering students cannot learn to mount an electric circuit without going to the lab (Lyle et al., 2005). Nowadays, the active teaching of faculty members and educators is of increasing importance in the development of training at the Engineering Education Laboratories. However, education in conventional engineering laboratories is not enough to attain the goals of the lesson, increasing students' motivation to spend more time to test and improve their learning by challenging the traditional methods and designing new laboratory courses (Rathod and Kalbande, 2016). Feisel and Rosa, 2005, define engineering profession task as manipulating and

*Corresponding author: mkhabiri@yazd.ac.ir

creating changes in material, energy, and information, whose result is useful for human, and the engineers should have experimental knowledge to perform it successfully. This knowledge is beyond the theoretical knowledge which is obtained traditionally in educational laboratories. However, the nature of these laboratories has undergone change over years (Feisel, and Rosa, 2005).

In another study, it was stated that today, students can acquire scientific phenomena using tools, data collection techniques, scientific models and theories in physical laboratories that use the interaction of material world and virtual laboratories via simulations. Finally, the above mentioned research, compare and assess the value of physical and virtual experiments and the combination of these two experiments to strengthen scientific learning (De Jong et al., 2013).

Research and nonfiction literature indicate that using humour in lecture sessions produce conflicting findings, particularly among adult university students. Earlier studies stated that humour was positively associated with students' attendance, whereas some studies reported that humour interrupted learning sessions and distracted students' attention from education and learning (Masek, Hashim & Ismail, 2019). In another study conducted using modern laboratory approach which is a combination of traditional or real and simulation or virtual methods, researchers found that the effectiveness of each method differ depending on the educational goals. Therefore, though the use of modern (combined) laboratories is a challenge facing educators, it can be considered as a potential solution (Romanas and Krivickas, 2007). According to a recent survey, engineering students were found to perform badly in engineering mathematics due to poor prior knowledge and anxiety towards mathematics (Lohgheswary, Halim, et. al., 2018). As a solution, Lohgheswary, et al. create a new educational approach for engineering mathematics laboratory at the Malaysian National University (UKM) using computer programs (Lohgheswary, Halim, et. al., 2018).

Jiménez, et., al. (2015), highlights the experience of implementing the 5S methodology to optimize the work and safety of university engineering labs has been studied, so that the results can be extended to other similar centers. They refer to results that, the research project created an organizational culture of all resources in practical labs. Concomitantly, they defined working model to build a 5S structure and a process of implementation has been created (Jiménez, et. al. 2015). In the new proposed engineering teachings, the performance and skill-based education is presented such that the student has the right to choose a project or to solve a series of exercises, ask classmates to review the draft of lab reports exercises solution or even propose executive applied questions, and the teacher also uses these questions in the final tests (Felder, et al., 2000).

Civil engineering is a kind of knowledge which has received less attention from entrepreneurship and education appropriateness perspective despite its wide application in the field of industry and economy of the country. The main objectives of this study are increasing information and highlighting the importance of educational scientific applied courses in this technical field, especially the courses related to the country's road construction industry for employment and prosperity of the country.

In the conducted study or review of resources, no comprehensive scientific reference was obtained which compare the laboratory skills training subject in engineering fields in particular or comparatively with other universities of the world and country. The purpose of this research is to determine the effect of active education on students' satisfaction with training, with comparative statistical test. The significance of this study is that it can be considered in reviewing how to present laboratory courses at different educational levels and it can be useful in educational planning in providing the necessary infrastructures to present laboratory lessons.

2. Teaching and learning of pavement laboratory

Based on the developmental plans of the education level and the graduates' skill enhancement system, in addition to increasing the quality of theoretical learned materials, laboratory teaching also provides the grounds for learning skills to do applied tests for employment in the industry. Most of the failures of asphalt pavements are due to rutting, cracking and lack of material resistance to Ultimate tension and repetitive strains (Ziari et al., 2006). In order to measure the materials condition and their resistance for new material as warm mixed asphalt, standard laboratory methods have been designed which have been accepted nationally and internationally by the engineering community of different countries (FallahTafti, et. al., 2016). Since there is a lot of theoretical content in the pavement course and pavement technology, the basic learning of these subjects, along with the training in the independent course in the laboratory, is complete. The practical status and necessity of skill training in pavement laboratory (bitumen and asphalt) course in the civil engineering education program are introduced in the following.

2.2 The conducting experiments necessity

In accordance with technical guidelines, it is essential to control the characteristics of civil engineering materials to avoid the loss of national capital in road construction workzone and civil engineering projects execution place. Considering bitumen and asphalt, these materials control is carried out in pavement laboratories, whose technical and scientific methods are taught in civil engineering major at universities.

a. Asphalt mix design experiments

b. Factory produced asphalt control tests

c. Asphalt executive operation control tests at project location

In table (1), a comparative comparison between the ongoing educational curriculum and the industrial needs of today with regard to bitumen and asphalt are observed. The majority of the current affairs associated with pavement industry can be widely taught in university laboratories, and part of it is done, whose practicality and skill-relatedness depend on the correct and complete method of education.

Table 1- Adaptation of educational courses of bitumen and asphalt laboratory and the needs of road construction industry

Industry needs		Educational headlines at the university laboratory
Industrial-related process	**The required workzone Laboratory tests**	
Bitumen delivery step	The standard of bitumen when receiving and dispensing	Psycho-degree of penetration-elasticity of bitumen
Supply of aggregates	Aggregate production	Aggregate grading- abrasion and durability aggregate
Asphalt mixing plan	Determine the optimal percentage	Determine Marshall strength and Asphalt void
Produced asphalt control	Determine the bitumen content	Asphalt extraction test
Control the operation of asphalt	Sampling and determining the density	Marshall asphalt density and strength test

Given the results of table (1), the following materials can be stated:

- Skills required by industry are often taught in laboratory teaching of bitumen and asphalt course (except field sampling and core taking),
- Teachings related to using the learned skills and making students familiar with the process existing in industry to increase the scientific level of engineering and executive works is a point which has received less attention,
- Increasing the capability to analyse multiple field data and improve certainty and accuracy of the applied methods, and reinforcing self-confidence in implementation of the lessons learned are among the requirements for the completion of university teachings and the skill training of engineering students.

2-2 Pavement industry problems and laboratory teaching and learning in universities

Asphalt is one of the main components of road construction materials. Despite the low thickness of this layer, pavement, its quality and function play a decisive character in driving quality in the nation's roads. Due to many destructive economic and technical effects of the lack of proper materials in pavement, it is necessary to pay more attention to the level of technical knowledge and skills of civil engineering graduates on the identification and detection of the quality level of these resources. Non-university educational centre present many educational and technical courses in various forms and frameworks, namely in pavement industry which is the subject studied in this research, to meet skill needs of university graduates. Road quality control centres presents educational courses such as laboratory of aggregates, bitumen and asphalt, and laboratory interpretation sheets (level 1 to 3). Making a comparison between these educational courses and pavement laboratory, these drawbacks and solutions are seen in laboratory teaching at university.

a. Making new educational materials at universities and the non-compliance with the today guidelines and technical directives of the country (such as national standards for bitumen and asphalt tests or sampling guidelines)

b. Lack of access to some new and new laboratory equipment at universities, paying attention to the country industrial needs (such as strategic highway research program (SHRP) bitumen behavioural tests)

c. The inadequate mastery of some professors and educational experts in laboratories at universities in comparison to the owners of experience in non-university skill trainings (non-university technical professors are often the main users with technical and laboratory skill experience in other laboratory centres)

3. Research methodology

In addition to performance review study in collecting field data section and conducting comparative study, this research was independently carried out as two other steps:

- The research survey part which was conducted through observation and interview in the form of questionnaire filled by three dependent groups: professors, those associated with industry, and students who passed the course.
- The other part in collecting data, that is, the comparative comparison, was showed through operation of two different educational methods and assessment using questionnaire tool.

3.1 Teaching of civil engineering laboratory courses: Interview and observation data

The pavement lab course is an optional lesson, which can be presented at three bachelor, master and PhD level of civil engineering, indicating the special importance of the taught skill in this laboratory course. Considering the necessity of this lesson from the industry perspective, as well as the problems mentioned regarding the relation of the lesson with industry application, this research seeks to investigate the problems of university laboratory courses in the form of a case study. The main questions in this part of the study are categorized as follows:

1. Is the quantity of teaching hours is suitable to attain skill training goals in the studied laboratory courses?
2. Has the quality of the equipment and facilities been provided in the laboratory for skill guidance and training?
3. Have human resource educators been provided to guide and transmit applied materials to attain the goals associated with industry demands?

The above mentioned questions of the questionnaire were answered by three groups of teachers, graduates, and industry representatives in written form. Due to defining the studied area, the range of respondents to the above mentioned questions was not very wide, but the results can be generalized to other universities of the country owing to the same laboratory conditions and the similar educational curriculum at universities.

3.2 Comparison between different teaching methods: Effect of on students' satisfactions

This part of research was conducted as an experimental study on undergraduate students of civil engineering faculty, in two different semesters: the second semester of the academic year 2016 and the second semester of academic year 2017, that used two different educational methods (n=25). According to the approved curriculum, the pavement lab course is designed as a practical and optional unit based on the educational titles in seventeen 2-hour sessions during the semester. In order to teach the active method, at the beginning of the sessions, the students are familiarized with the experiment details, goals and applications as students and learners absorb more when they contribute in the progression of learning, whether it’s through discussion and argument, practice and exercise, analysis and review, or application (Grunert, Margaret, 2008). Of course, this method usually takes more time to teach and conduct tests. The current teaching method which is the common method is mostly based on discussions (question and answer and resolving problems) during class session by referring to students who are doing experiments. In the current method, learning the method to conduct the experiment was dependent on students studying prior to the class. At the end of each semester, a five-item questionnaire was used for professors' classroom assessment of web based method in a centralized way. The professors' classroom assessment and quality control questionnaire at Yazd University, used in this study, is known as "Golestan".The students' satisfaction level was measured using a reliable and valid questionnaire on the five-point scale (excellent-good-medium-weak-very-weak).

4. Results and discussion

4.1 Status on laboratory teaching and learning: Adequacy of teaching time and facilities and educators competence

In the first stage of the research, which was conducted by interviewing three main groups related to laboratory skill training. Questionnaires were printed and interviews conducted, about ten people from three main groups completed them, and the answers were summarized in the brief. Results are shown as in Table 2. As it can be observed, the need to assign time and a larger number of experiments, the increased experience and technical and up-to-date knowledge of professors and educational experts, improvement and adaptation of laboratory equipment with today needs of the industry and civil workshops are among the most important points obtained by this interview.

4.2 Comparison between the effectiveness of current and active teaching method

The statistical population of the current research consisted of civil engineering faculty students at Yazd University, who chose the pavement lab course in the first and second academic semester. Of this population, about 25 persons were selected as research sample using simple random sampling method and divided into two groups of control (n=12) and active teaching method (n=13). With respect to, the standard questionnaire of assessment and monitoring office existing in centralized system for teachers' evaluation was filled out by the students of this practical course at bachelor level and its results were utilized. Table 3 shows the questionnaire items and the results of comparing two teaching methods.

Table 2- Opinions of the interviewees on the status of the bitumen and asphalt laboratory and the industry need

Group of respondents	Questions to query		
	The quantity of teaching time	**Equipment and laboratory apparatus**	**Ability and methods of educators**
Laboratory Lecturers	-Some tests do not end in a formal academic time. -Review of standard and industrial laboratories requires time.	- It is necessary to change the technology and industry approach to supply the new laboratory equipment. - Calibrating and standardizing related equipment is essential	-Training instructors and experts with regard to changes in the rules and regulations and changes in the industry approach -Practical test can be effective in evaluating students' skills.
Graduates	-The limited number of tests defined in the training curriculum compared to the industry's need	-The use of equipment is associated with risks to students, which is essential for their safety.	-The presence of an educational expert colleague is required to have sufficient experience and knowledge to assist the teacher.
Industry representatives and employers	-Legal representative training is essential in relation to the testing process in the industry and construction workzones.	-Some laboratory facilities of the university have educational aspects and are not calibrated or complete and industrial use is not possible from them.	-Using industry experts working in laboratories can reduce some of the educational deficiencies.

After the implementation of two teaching methods, the students' satisfaction questionnaires were completed by them. The results obtained by comparison of the mean scores of the control group in two teaching methods using paired t-test showed that there was a significant difference between the two groups in the mean scores in most of the students' satisfaction components such that teaching methods had improved significantly (about 20%) in the view of students. This test method was used to compare the two educational groups and use the standard statistical test, it follows that the results are reliable. Additionally, in the next level, "transferring curriculum concepts power" increased by 10%. The only negative effect of this skill training method in laboratory was in "inclusive assessment method" and the "students' motivation improvement" during the semester. In their view the students' satisfaction level had reduced.

Table 3 – Comparison between current and active teaching methods

Items	Average scores (out of twenty scores)		Changes in the degree of satisfaction of active education with the current method (in %)
	Typical and current teaching methods	Active teaching method	
Power of conveying and transcribing lessons	16.4	18.00	9
Teaching method: Applying appropriate methods and using existing facilities	15.2	18.67	19
Presented titles and content alignment (lesson plan)	16.8	18.67	10
Master's ability to stimulate student creativity	17.2	16.67	4.5
Master's mastery of theoretical foundations and practical lessons	16.8	18.00	4.5
The teacher's desire to teach teaching material	17.2	18.67	5.5
Useful and sufficient explanations of the professor about the theoretical and practical basics of the lesson	17.6	17.33	-1.5
Assessment of student learning during the semester	16.8	16.00	-5

The output statistical table of SPSS software in Table 4 shows the mean and standard deviation of group performance in two educational systems (active-current). For the significance test, the univariate mean difference was used, and the hypothesis of the mean difference between the two methods of teaching and the higher mean in the active teaching method was confirmed with a significance level less than 5%.

Table4- Statistical test of independence analysis of two teaching methods (active-current)

One-Sample Statistics

Teaching method	N	Mean	Std. Deviation	Std. Error Mean
Active	9	17.77	.94	.31
Current	9	16.80	.69	.23

One-Sample Test

	Test Value = 0					
	t	df	p-value	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Active	56.51	8	.00	17.77	17.05	18.50
Current	72.74	8	.00	16.80	16.26	17.33

5. Discussions and solutions

From the above mentioned resources it can be concluded that there are problems in respect of university education and skill training of experiment techniques and quality control, and it is required to propose practical solutions by comparatively reviewing in different countries. Some practical solutions are introduced as follows:

5-1 Introducing laboratory- based educational (LBE) program

LBE program in engineering education is a program introduced by Japan country for some developing countries such as Egypt, Malaysia, Kenya, India, Indonesia and Association of Southeast Asian Nations. In Educational cone (Fig. 2), the faculty member is at the apex of the cone. The experts with PhD degrees (for example post-doctoral students) are in the second layer, and the higher education students (master and PhD students) are in the third layer, and the students of the 4-year period of bachelor are in the fourth layer (last layer). Indonesia had a successful experience of this educational system from 2012 to 2014. The steps of this educational system implementation in the country are as follows:

a. LBE guidelines educational development (making the criteria and definitions needed for this educational system)
b. Selecting laboratories proportional to LBE program which are consistent with its definition
c. Holding conferences and workshop courses and expressing LBE successful experiences
d. Investigating and assessing LBE (development and application of guidelines)
e. Encouraging top labs from the LBE perspective
f. Supporting the research activities of the licensed LBE lab (patent assistance, helping with submission of articles in international journals, helping with receiving research projects support, etc.).

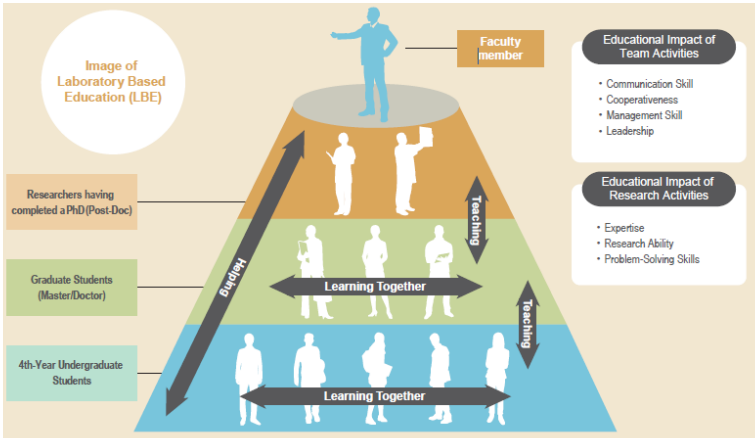

Fig. 1 - Process chart of modifying satisfaction level of laboratory skill training (Japan Brand ODA, 2018)

5-2 Retraining programs for pavement labs teachers

An example of retraining programs in this special course is related to National centre for Asphalt Technology (NCAT), which was specifically held for university professors and instructors of technical colleges in educational laboratory courses for 45 hours. These courses content include educational resources, scientific activities and discussion on all asphalt technologies to better understand asphalt behaviour and teach effectively at university laboratory. Of course there is no fee for registering in this course and the budget of transportation, accommodation and meals for teachers and instructors is arranged by this centre.

6. Conclusion

There is a course unit called laboratory in many course programs at bachelor level. The aim of this research was to assess the status and identify the problems with engineering students' skill training in laboratory, especially, pavement laboratory in civil engineering. The research was conducted using interview and comparative and practical studies. This research results showed that:

- Education and active teaching to students are effective factors in improving students' satisfaction. According to the current research results, it can be concluded that the actively teaching of professor and laboratory expert can pave the way for improving the course materials understandings and course concepts transfer power in the university skill training as well.
- Considering the practical recommendations, it can be stated that the main path of meeting needs of employers and industry in laboratory courses includes two solutions. For one thing, it is modifying the education method and upgrading the syllabus toward students' skill training and for another solution is creating the knowledge and skills of cooperation and teamwork in the workzones and practical locations for the economic optimization of industry and employer activities and the reduction of essential skill training courses for graduates in real-world and field environments.
- With respect to these results, it is suggested that another study investigate more precisely the relationship between field and workzone laboratories and different courses of engineering laboratory teaching and current programs of universities in order to make a comparison between industrial needs and adequacy of engineering teachings in the university's syllabus.

Acknowledgement

Thanks to the undergraduate students of engineering at Yazd University- pavement lab course- who participated in this study. Also, thanks to graduates, professors and Industrial staff who helped complete the questionnaires.

References

Badrian, A.; Shakrabaghani, A.S.; Asef, A.; & Abdinejad, T. (2008); Accreditation of an Effective Model for Performing Laboratory Activities; *Quarterly Journal of Educational Innovations*, No. 28, Seventh Year, Page 129-156.

De Jong, T., Linn, M. C., & Zacharia, Z. C. (2013). Physical and virtual laboratories in science and engineering education. *Science*, 340(6130), pp.305-308.

Federal Highway Administration (2009). "Welcome to the Turner-Fairbank Highway Research centre (brochure, FHWA-HRT-08-066)". Retrieved 2013-01-14, Pp: 1-6.

Feisel, L. D., & Rosa, A. J. (2005). The role of the laboratory in undergraduate engineering education. *Journal of Engineering Education*, 94(1), pp.121-130.

Felder, R. M., Woods, D. R., Stice, J. E., & Rugarcia, A. (2000). The future of engineering education II. Teaching methods that work. *Chemical Engineering Education*, 34(1), pp.26-39.

Gratchev, I., & Jeng, D. S. (2018). Introducing a project-based assignment in a traditionally taught engineering course. *European Journal of Engineering Education*, pp. 1-12.

Grunert, J. Margaret W. C. (2008). *The course syllabus: A learning-cantered approach*. Bolton, MA: Anker Publishing Co, Inc, Issn: 978-0-470-19761-5, pp: 1-127.

Japan's ODA,Official Development Assistance,(2018). *Development of human recuse in engineering field with practical skills through research activities in a team*, library Based Education (LBE)Pp:1-2.

Jiménez, M., Romero, L., Domínguez, M., and del.Mar. Espinosa, M. (2015). 5S methodology implementation in the laboratories of an industrial engineering university school. *Safety science*, 78, 163-172.

Karen E. Schmaltz (1998) “Expanding the Objectives of the lab experience,”*Int. J. Engng Ed*. Vol. 14, No. 6, pp. 419-425, Oct. 1998.

Lohgheswary, N., Halim, M. A., Nopiah, Z. M., Aziz, A. A., & Zakaria, E. (2018). Developing New Lab Base Teaching Approach for Linear Algebra subject in Engineering Mathematics Courses. *Journal of Mechanical Engineering*, 5 (3), pp: 220-232.

Masek, A. Hashim S.& Ismail, A. (2019) Integration of the humour approach with student’s engagement in teaching and learning sessions, *Journal of Education for Teaching*, doi: 10.1080/02607476.2018.1548169.

Rathod S.S.and Kalbande,D.R. (2016), Improving Laboratory Experiences in Engineering Education. *Journal of Engineering Education Transformations, Special Issue*, eISSN 2394-1707,pp1-9.

Romanas V. Krivickas, K.,(2007), Laboratory Instruction in Engineering Education. *Global J. of Engage. Educ.,*11, (2), 2007 UICEE Published in Australia, Pp: 191-196.

Tafti, M. F., Khabiri, M. M., & Sanij, H. K. (2016). Experimental investigation of the effect of using different aggregate types on WMA mixtures. *International Journal of Pavement Research and Technology*, 9(5), 376-386.

Ziari, H., Ameri, M., & Khabiri, M. M. (2007). Resilient behaviour of hot mixed and crack sealed asphalt concrete under repeated loading. *Technological and Economic Development of Economy*, 13(1), 56-60.