Determination of Skills Gap between School-Based Learning and Laboratory-Based Learning in Omar Al-Mukhtar University

Aisha Othman, Crinela Pislaru, Ahmed Impes

Abstract—This paper provides an identification of the existing practical skills gap between school-based learning (SBL) and laboratory based learning (LBL) in the Computing Department within the Faculty of Science at Omar Al-Mukhtar University in Libya. A survey has been conducted and the first author has elicited the responses of two groups of stakeholders, namely the academic teachers and students.

The primary goal is to review the main strands of evidence available and argue that there is a gap between laboratory and school-based learning in terms of opportunities for experiment and application of skills. In addition, the nature of experimental work within the laboratory at Omar Al-Mukhtar University needs to be reconsidered. Another goal of our study was to identify the reasons for students' poor performance in the laboratory and to determine how this poor performance can be eliminated by the modification of teaching methods. Bloom's taxonomy of learning outcomes has been applied in order to classify questions and problems into categories, and the survey was formulated with reference to third year Computing Department students. Furthermore, to discover students' opinions with respect to all the issues, an exercise was conducted. The survey provided questions related to what the students had learnt and how well they had learnt. We were also interested in feedback on how to improve the course and the final question provided an opportunity for such feedback.

Keywords—Bloom's taxonomy, e-learning, Omar Al-Mukhtar University.

I. INTRODUCTION

THE laboratory-based environment is a prime setting for the learning and teaching of science. It provides students with several options and opportunities for reflection and discussion, and involves them in solving real problems. Lab-based learning is conducive to performing experiments and it aids students by promoting active learning, allowing them to solve problems through hands-on experience [1]. It supports deep learning by encouraging learners to make effective decisions through critical thinking, and when working as group, learners can further improve their cooperative skills. There are several opportunities to enhance the laboratory experience by integrating theory and practice, and by combining strategies such as computer-based and web-based learning. The lab is an environment for finding data which can allow students 'brain space' to process information, and which enables them to follow and interpret results discovered

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through experimentation [2]. In prescriptive, 'cookbook' laboratories, however, the action is predetermined, with staff, demonstrators and technicians each having a clear understanding of the possible results and all that is expected to happen. Consequently, inappropriate results can be clearly identified by the demonstrators and rectified before the learners begin their lab work.

A laboratory is a place which is equipped for scientific experiments or medical tests. A laboratory is characterized by active interaction between ideas and experiments, [3]. It requires a pattern of thinking and performance in response to planning and reasoning, and laboratory activities involve solving problems through interpretation. Garratt [4] suggests that it is the one place where the teacher and his students can test their scientific hypotheses. It offers a great deal of practical experience.

Education through laboratory work fosters students' growing interest and develops their ability to watch and make accurate recordings, and to form conclusions based on facts. It enables them to develop valuable skills and techniques. Thus, the laboratory is fundamental to the educational process within the scientific field, making it easier for students to learn and allowing teachers an integrated approach, whereby they can explain their lessons and then allow processes to be meticulously tested. It is a place where students can fully absorb information. Therefore, an appropriate facility must be provided according to the educational stage in question and the scientific material being explored, which should be staffed by a laboratory technician and laboratory supervisor supported by science teachers and the school principal.

II. IMPORTANCE OF LAB-BASED LEARNING

Firstly, the laboratory enables students to develop experience and skills in conducting experiments, and to gain familiarity with the use of devices as well as the ability to define some of the materials used. Secondly, since laboratory experiments often rely on accuracy, students develop awareness of the need to be accurate in the weights of materials used and the importance of precision in operating conditions. Finally, laboratory experiments encourage students to think, discover and research, which helps to familiarize them with the methodology and design of scientific research [4].

There are five categories of aims that may be achieved by usage of the lab in science classes: [5]

Skills - investigative, organizational, manipulative, inquiry, communicative;

Concepts - for instance, taxonomic category, hypothesis, theoretical model;

Cognitive abilities - application, analysis, critical thinking, problem solving, synthesis;

Understanding of scientific learning - scientists, scientific enterprise and how it works, interrelationships between technology and science;

Attitudes - such as risk taking, objectivity, curiosity, interest, precision, responsibility, consensus, collaboration, confidence, perseverance, satisfaction and enjoyment of science.

III. THE COMPUTER SCIENCE LAB

The computer science lab is an academic place within the university for students who have already learnt the principles of computer use and followed preparation courses in the field of computers, as they will have studied in the information technology teaching lab for basic computer education classes. In the computer science lab, the computer can be used as a means to design research programs, print reports and undertake activities. Students can use the lab during leisure hours to gain further computing skills; it can also be used for team training if a particular school chooses to hold workshops in the computer lab [6]. The computer lab is a designated, separate room within the university department, and is designed to accommodate approximately 35 computers. Learners should have an understanding of the majority of the software in the computer science laboratory. The main goal is to gain practical experience and to learn teamwork through the use of a set of software programs, as well as to develop knowledge and skills. Such skills include the implementation and testing of programmable hardware; programming language; the design and testing of software and supporting tools which can be used to conduct practical work; research, and exploration of various aspects of computing knowledge. The lab can also be used to do homework.

The Computing Department of the University of Omar Al-Mukhtar has had a long journey. In the early 1990s, the Department of Computing Learning was established to provide a BSc degree in Software Engineering and Computer Science, and this department was responsible for all teaching of information technology and computer learning at the university. The University of Omar Al-Mukhtar's Faculty of Science provides technical services to the department as well as being responsible for access to information technology within the department. The technological provision at Omar Al-Mukhtar University then developed with the introduction of further computer applications and, as with all universities in the world, the availability of access to a computer lab for all students.

The computing department is based on a two-tier system of education, the two tiers being school-based learning (SBL) and lab-based learning (LBL) [7].

A. The Role of School-Based Learning (SBL)

The SBL element is based on the traditional lecture-based process of providing theoretical content. Experienced lecturers provide lectures based on traditional facilities, e.g. blackboard and chalk. The lecture material is presented on hard copy paper sheets and textbooks, and recorded by students in notebooks. Lecturers who provide practical modules present the theoretical aspects of this during SBL tutorials. SBL delivers theoretical materials such as data structures, linear algebra including calculus and the study of algorithms analysis, as well as modern programming methodologies and operating systems. The Computer Science programme continues with courses in programming languages and networks, computer graphics, databases and other modules in computer learning.

B. The Role of Laboratory Based Learning (LBL)

This is a subfield of the computing department and is focused on the application of empirical theories essential to the understanding, measurement and improvement of software processes. The main objective of LBL is to train students in techniques, technologies and equipment used in the computing learning course. Currently, the LBL and SBL system is not working well, so it is necessary for the faculty to change the teaching strategy. At present, students only have four hours each week of practical learning in LBL, the rest of time being spent on theoretical learning material. In addition, the new strategy must make effective use of school-based learning in order to prepare students before they go on to laboratory learning [7].

IV. FORMS OF ASSESSMENT

The Computer Learning course is an obligatory, two semester course provided to all undergraduates of the computing department. Students attend obligatory schoolroom laboratory exercises and tutorials. To gain an acceptable final mark, students must pass a written test at the end of the course of schoolroom lectures, complete all exercises in the LBL and pass a final examination in the form of a computer examination. Undergraduates are not permitted to pass the final examination unless they complete both the laboratory exercises, which are based on LBL, and the classroom tutorials based on SBL. The learners have classes and lectures (SBL) every week. The lectures, which are obligatory, involve the introduction of new concepts. Students are expected to prepare the programming exercises included in the LBL and to complete this in their own time. Naturally, the main assessment of the session takes the form of what is currently considered a closed book examination, containing a mixture of multiple-choice questions and written answers. The Computer Learning course is a difficult one, with an average examination pass rate of 50%.

However, more efficient educational environments tend towards blending technology with traditional education in a more integrated manner, which develops interaction between the teacher and student in a fun way and avoids situations where the student is not listening [8]. In such a situation,

technology and its application is a key part of the lecture, For example, before coming to a lecture, the students may have studied a CD which the teacher has prepared containing material in various forms, such as the use of sound for some aspects and images for others. In this way, the student already has a perception of the lesson, so that when the teacher explains and discusses his ideas with the students, the ideas are not presented to them for the first time. Because the students' minds have already taken the initial steps in terms of thinking, they are then able to develop their understanding and dig deeper during the lesson.

This type of approach is not yet common practice in Libya, where changes are needed in the current status of education. There are four pillars which represent the foundations of modern education, as stated in the report on learning issued by UNESCO [8]:

- It is vital to understand how the individual learns and acquires knowledge;
- For learning to take place, it is essential that the individual learns how something works;
- The individual must learn to live with others, by understanding others and interacting with them;
- Individuals must learn to be themselves and allow their personality to blossom in order to develop and expand their abilities and aptitudes.

It is clear to see that these four pillars cannot be achieved within the existing traditional Libyan educational framework. Othman [10] argues that students who learn superficially and simply recall information stored for tests cannot distinguish the principles of evidence, as schoolwork is regarded as a series of imposed instructions and they are not offered the opportunity to undertake exercises which would strengthen understanding. This is due to the fact that this type of education is non-interactive. There is agreement between a set of Libyan researchers, [9], [11] and [12], [13], that higher education in Libya suffers from the following difficulties:

1. Heavy reliance on government funding: All public higher education institutions (universities, community colleges and institutions of higher education) are fully reliant on government support more than 95% of the time. In 2003, the total expenditure on higher education amounted to about 21% of the education budget, which in turn represented about 21% of government spending, and it may be difficult to increase this further. It is therefore necessary to find additional sources of funding to support expansion and the improvement of quality within higher education, as well as to improve the efficient use of existing resources, since higher education must compete for limited state resources with other priorities in the field of education (e.g., basic secondary education). Given the current limited state resources, funding in the field of health and other service areas is not expected to increase significantly in the short term.

2. Limited capacity: The current situation in public universities does not allow them to accept more than 40-50 male/female students each year. This represents the maximum under the present form of teaching, and is restricted by the available seats in classrooms and laboratories. As a result, new

policies should be developed concerning the introduction of distance education and e-learning, and the establishment of a Libyan 'virtual university' which could function as a partnership between universities. Such new policies offer a futuristic vision for the establishment of universities and colleges working in collaboration with civil society, allowing the state to work in partnership with the private sector in order to achieve state objectives in the development of higher education. Consequently, the responsible bodies in Libyan higher education institutions should work on the adoption of an effective strategic plan with the aim of efficiently addressing the above issues.

Obviously, achieving such a plan requires Libyan higher education institutions to establish a network to improve the flow of information and deliver mutual support and cooperation. It is possible that e-learning may offer an important part of the solution to these concerns, and this increases the importance of using technology in the field of education. There are many other reasons for the adoption of such approaches. The first of these is the relatively low level of education in Libya, since the current educational system has become unable to keep pace with global developments. Secondly, the use of such technology would recognize the importance of self-learning and help to develop the capacity of the individual to think creatively. Lastly, it would address the issue of the large number of students per class, which has arisen due to the lack of schools, as well as the imbalance in geographical distribution of educational institutions as a result of a focus on areas with high population density.

Using lists of members of the computing department, the questionnaire was circulated to all participants by e-mail. An introductory letter was included, explaining that the data would be used both to improve the course and design a blended learning strategy for the improvement of teaching and learning methods, and as material for a paper. The letter also assured participants that all responses would be treated confidentially, and gave a date by which responses should be received. The survey was e-mailed to the seventeen students attending the two courses. In the end, due to data discard, nine responses were available for analysis. The data from the questionnaire and our analysis can be found in Appendix A.

V. CATEGORIZATION OF LEARNING OUTCOMES

Bloom's taxonomy was first described as a hierarchical model for the cognitive domain in 1956. Bloom's work was inspired by the fact that over 95% of test questions investigate students' knowledge at the lowest possible level – recall of information. In his study, Bloom identified six levels within the cognitive domain, from simple recall or recognition of facts at the lowest level, through increasingly complex and abstract mental levels to the highest order, which is classified as evaluation. The categories and choice of equivalent key words are listed below:

1. *Knowledge*: define, list, name, order, recognize, relate, recall, repeat;
2. *Comprehension*: classify, discuss, explain, identify, indicate, report, review, select;

3. *Application:* apply, choose, demonstrate, sketch, solve, use, write;
4. *Analysis:* analyze, calculate, compare, contrast, discriminate, examine, experiment;
5. *Synthesis:* assemble, construct, create, design, develop, formulate, prepare, propose, write;
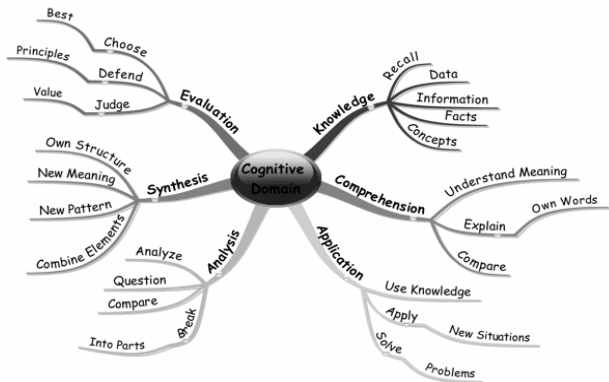6. *Evaluation:* assess, attach, choose, compare, predict, rate, select, evaluate.

Fig. 1 Bloom's taxonomy

A. Analysis of the Existing SBL Curriculum

- The analysis has been carried using the one learning taxonomy of Bloom. There was one learning outcome that has been selected from year 3 computer science department at Omer AL-mukhtar University.
- The outcome has been analyzed and reviewed by academic staff and specialists from Omer AL-mukhtar, conducted in Libya 7th January 2013.
- The outcome' activity is specified which evaluate student's, skills and knowledge.
- The aim was to identify the learning levels of the cognitive domain which covered in this exercise from SBL.
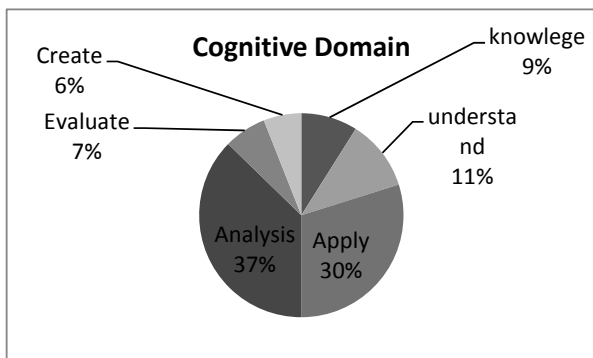

Fig. 2 Knowledge based – activities: the 4 exercises of SBL

- 30% of the measurement of learning activities students' ability to apply the theoretical background to practical reality.
- 37% of the measurement of learning activities students' ability to analysis educational materials,

Lower levels of learning are those in remembering, understanding, and application of simple learning levels of this category.

Usually low levels are suitable for: prepare students and comprehension activities, the strengths and weaknesses of students diagnosed, to review and summarize the contents of the learning.

Higher levels of learning are those that require the application of complex analysis and evaluation, and creation skills.

Usually the highest levels of the appropriate classification of encouraging students to be more important, independent problem solver and to think deeply, motivating students to get information on their own.

Cognitive Domain		
Learning Level 1	Knowledge	Lower levels
Learning Level 2	Understand	
Learning Level 3	Apply	
Learning Level 4	Analyse	
Learning Level 5	Evaluate	Higher levels
Learning Level 6	Create	

Fig. 3 The bloom has been used as a checklist for the analysis of educational materials for LBL and SBL at Computer Science Department, Omar AL-Mukhtar University [14]

The analysis illustrates that the exercises have been designed to focus on the higher levels of learning rather than lower learning levels of Bloom classifications through theoretical and practical courses in the SBL.

B. Analysis of LBL Programme: Student Attitude towards LBL Skills

In analyzing the qualitative data, the aim was to discover students' opinions with respect to all the issues and to map them into Bloom's taxonomy of learning. Based on the responses and our interpretation of Bloom's taxonomy, the results are given in Table I, below.

The 'stories' written by students provided valuable information for those evaluating our course. However, most of the comments received from students were the same. Around 60% of Libyan students expressed their praise for laboratory skills. The questions related to what the students had learnt and how well they had learnt. For this section, the questions formulated were:

"In your own words, what were the primary objectives of the programming course?"

"On the basis of what you have learned in this course, would you be able to plan and run an empirical investigation?" and "What is your attitude to laboratory exercises?"

There are many reasons for the insufficient theoretical knowledge of students attending the laboratory. As illustrated in Fig. 4, the students faced challenges in performing the
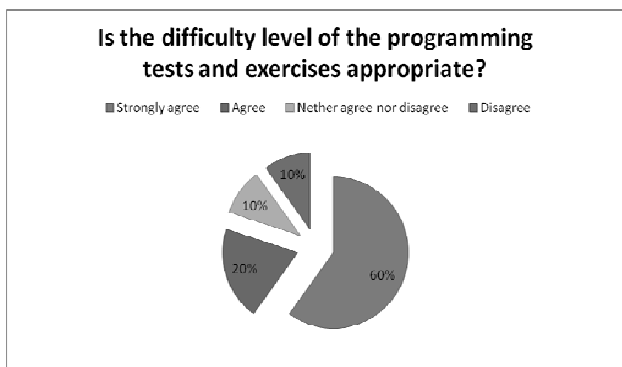
exercises and found them difficult.

Fig. 4 Student responses: difficulty level

The course is difficult; it requires a very good mathematical background, technical skills and methodical study.

Unfortunately, many students lack a sound mathematical background from high school.

Another factor is obviously that many students either fail to attend lectures, or do not study enough on their own. Nevertheless, as already stated, some modifications to teaching methods may help to eliminate these barriers. Our experience shows that in many cases students are unaware which aspect of the course it is necessary to use to perform an exercise. It seems that they need dedicated pre-lab tasks and online material, which can help them to gain better knowledge at any time without being reliant on teachers to verify whether they possess the required knowledge.

We have observed that in the case of exercises designed to verify students' computing abilities, they perform better during programming tests and practical work. The structure of the exercises prevents students from attending laboratory classes without having studied the theoretical background.

TABLE I
LIBYAN STUDENTS RESPONSES

Students' comments	Translated meaning	Bloom's taxonomy of learning levels
"I do not understand some theoretical aspects related to exercises and programming software"	Lack of understanding of theoretical issues that are necessary to perform exercises and analyse results	Knowledge: Students should be aware that there is always more to learn, and that they will encounter more in their professional careers, whatever they may have learned in school.
"Yes, but we need more concrete skills about how to design a big software programme and how to implement this programme in real work place"	Lack of experience of practical work (problems with assembling electric circuits)	Comprehension: The students should understand the software engineering process, both in the sense of abstract models and in the various instances of the process as practiced in industry.
"I do not have enough experience about new language programmes, like how to design webs by PHP language; it is so difficult for me"	Lack of material and lack of ability to analyse, synthesize and evaluate the implementation of small systems	Analysis: The students should be able to participate in technical reviews and inspections of various software products, including documents, plans, designs and code. They should be able to analyze the needs of customers.
"Not without more input, but I would have a better starting point for the mathematical background. A lot of the work in the software process needs a good back ground in mathematics, for example how to write a programme about calculations, so I should have a better understanding about the basic operations and where I could find out more about them"	Lack of knowledge	Knowledge: In addition to knowledge about all the material described in subsequent paragraphs, students should be aware of the existence of models, representations, methods, and tools other than those they learn to use in their own studies.

Lack of practical experience is quite common in the case of undergraduate students and there is no easy way to compensate for this. There is a limit to the number of laboratory hours available, and there are rarely extra spaces available for volunteers. Furthermore, laboratory exercises are carried out by individual students. This leads to problems when students are required to design a large software program or system, where they should be able to work as team, allowing them to gain experience quickly. 67% of students preferred to work as a member of a team (see Fig. 5).
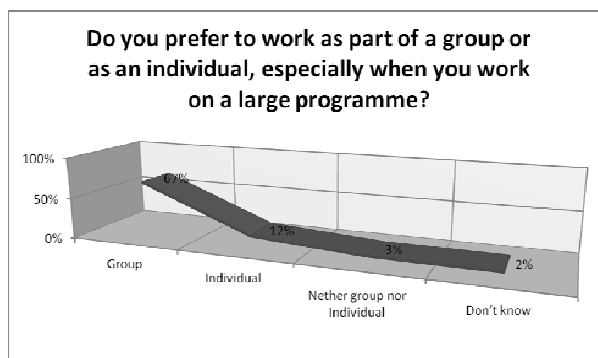

Fig. 5 Student responses: group work

VI. CAUSES OF LABORATORY FAILURE

Our observations and analysis, confirmed by the results of the student survey, allow us to indicate the following reasons for students' failure in the laboratory:
1. Lack of understanding of theoretical issues necessary to

perform exercises and analyze results;
2. Lack of experience of practical work (problems with assembling electric circuits);
3. Discouraged by rate of failure in the laboratory;
4. Lack of materials;
5. Lack of availability of teachers and demonstrators;
6. Poor standard of traditional laboratory facilities and conventional course.

The high rate of failure during programming tests discourages students from studying the course, as shown in Fig. 6. The tests are necessary, but students who are not prepared and do not expect correct results often waste time watching irrelevant signals, such as measuring noise instead of meaningful information. Therefore, it seems that both the subject matter of the programming tests and their level of difficulty should be reviewed.
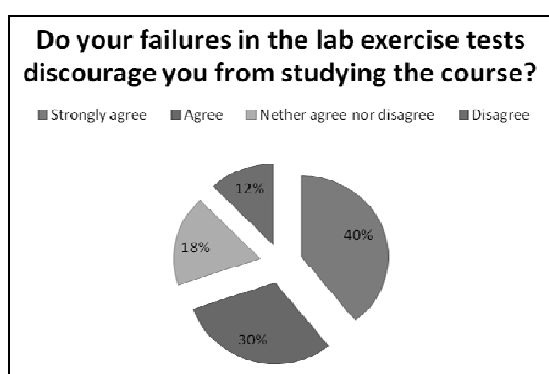

Fig. 6 Student responses: lab failures

In general, the failure to consider Bloom's pyramid structure is the leading cause of laboratory failure - the lack of lower level knowledge components inhibits application of medium level elements and therefore prevents successful execution of laboratory exercises.

VII. RECOMMENDATIONS AND FUTURE WORK

The university must change its strategies to adapt to students of this new era. With the advent of resources available today for use in the classroom, new learning technologies can enhance the delivery of instruction and learning materials in the laboratory. Given the availability of resources such as interactive software; digital imaging; audio and video creation tools; on-demand video libraries; computers with LCD projectors, and Moodle tools, the hardest task may be choosing which tool to use and how to integrate it into the learning process. It is the greatest time in history to be in a classroom because learning technology is changing at an exponential rate, and our students can thrive by embracing it. As a first solution, we will initiate the transformation of the computing course into a blended e-learning version. Knowledge delivery will be performed in a face-to-face manner, whilst the Moodle-based Learning Management System will be applied for coursework presentation, collection of students' work, formative and summative assessment and

communication through e-material. Lectures will be delivered by an experienced lecturer based on modern facilities, such as PowerPoint presentations. Lecture material will be available on the LMS course page and consist of an updated lecture program and conspectus, main definitions, terms and concepts, as well as drill problems. This will require a substantial commitment from the university in terms of supporting the design and implementation of Moodle and the formulation of e-material, but the adoption of blended learning will be a sound strategy for the future, the focus of blended learning is to support traditional classroom experiences. He notes that, "Teachers can take the more difficult math content, use interactive whiteboard captures with video and narration, and then post the resource for anytime student viewing. Students can also capture their whiteboard work and submit that presentation for assessment." Additionally, many participating districts can use wikis as authentic learning activities to measure student participation. Lake also describes an approach to providing a managed learning environment, identifying the different resources, such as facilitator, blended learning tools (e-Resources), ToolBook and video clips with Photoshop software that can be integrated within in the delivery mechanism. The use of resources is dependent on the nature of the teaching and learning methodology used.

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