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Evaluating Laboratory Skills of Students in the Department of Electromechanical Engineering according to Suggested Standards

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This study aims to evaluate the laboratory skills of students in the Department of the Electromechanical Engineering–Systems Branch according to suggested standards. The research tool consists of the (22) standard observation cards presented by researchers to a group of experts and specialists in the method of teaching Science and the ability to express opinions and observations in order to verify confidence and objectivity. The descriptive method was selected as appropriate to achieve the research aim . The sample consists of (65) students of the Department of Electromechanical Engineering- Systems Branch. Statistical analysis is conducted through IBM® software SPSS 25.0.The results indicate that the laboratory skills of electromechanical engineering students in the systems branch at the University of Technology, did not fully meet the suggested standards (NGSS-STEAM-GLP), when compared to the hypothetical mean. The researchers recommend the need to review the content of laboratory courses to take into account the standards, and activate the role of laboratory supervisors as well as the need to train professors who prepare practical experiments and teach practical aspects within the laboratory concerning necessary laboratory skills and familiarise students with laboratory teaching methods and standards .

Keywords: *Evaluation, Laboratory skills, Suggested standards, NGSS, STEAM, GLP.*

Introduction

Given the importance of laboratories and laboratory work in Scientific disciplines as well as their importance in linking theoretical and practical aspects, as well as the key role in the

development of various skills, in addition to the importance of the suggested standards (NGSS - GLP - STEAM), and availability of electromechanical engineering in laboratory work, undergraduate researchers have found the need to evaluate laboratory skills. The evaluation process is systematic based on relevant foundations , therefore evaluation requires accurate and objective judgment about the inputs and outputs of any educational system and identifying strengths and weaknesses in preparation for making the appropriate decision for the reform process (Morakinyo 1984).

The study aims to evaluate the laboratory skills of students in the Department of Electromechanical Engineering - Systems Branch according to proposed standards. The research tool consists observation cards consisting of (22) criteria and presented by researchers to a group of experts and specialists in the methods of teaching Science and the ability express opinions and observations to foster confidence and objectivity, while the descriptive method is selected as appropriate to achieve the research goal . The sample consists of (65) students from the Electromechanical Engineering Department - Systems Branch.

The findings show that there are concepts and skills of evaluation based on strengthening the links between the assessment of student learning and the educational process and assessment of all types of structural, diagnostic methods as a means to improve learning (Hidalgo 2019).

Evaluation is an organised process through which data is collected and analysed to determine the extent to which educational aims have been achieved and decisions have been taken to improve them and to address deficiencies in order to provide a sound educational environment for the individual, family and the educational institution. Moreover, it controls the direction of teaching and analysis to determine the extent to which educational goals are achieved, decisions are taken to improve them and address their shortcomings to provide a sound educational environment for the individual, the family and educational institute. Moreover, it controls the direction of teaching (Gronlund 1976).

Laboratory skills are realised through experiments, and exercises which help them to distinguish between theories the results of experiments (KhalafArat et. al. 2018). The laboratory is the setting where students conduct experiments, practical workshops and mental activities by using the equipment and tools necessary for each experiment. Laboratory skills refer to students' ability to perform laboratory experiments flawlessly and efficiently during practical courses (Hofstein and Rachel 2007). In general, standards determine the appropriate and desirable level of mastery of skills (Hamilton Ekeke, 2017). The standards need indicators that describe the performance of students to achieve them (Wenglinsky, 2002).

The researchers followed the descriptive approach as it is appropriate for the type of research that aims to evaluate students' laboratory skills in the Department of Electromechanical Engineering - Systems Branch at the University of Technology according to proposed

standards (NGSS-GLP-STEAM). In order to achieve the research goal, the researchers used the evaluation method and which requires preparation of the research tool which consists of the direct observation card in the light of which students' laboratory skills are evaluated. The sample consists of (65) students from the Department of Electromechanical Engineering - randomly chosen branch of systems. The researchers drafted (22) criteria, and presented them to a group of experts and specialists in teaching methodology in Science and the quality of teaching to express their opinions and observations to verify confidence and objectivity. Three types of standards are selected to achieve the research objective: NGSS Science learning standards (NGSS) focuses on a deeper understanding of content and focuses on fewer key learning ideas through intensified training, practical activities and the use of comprehensive concepts. These standards are designed to prepare students for their careers and to be responsible citizens, emphasising that all students receive a solid Science education and can provide the required content. NGSS has a solid foundation for students to join the diverse fields of Engineering, Mathematics, Science and technology. However, many teachers choose the right content to provide additional and advanced expectations from students (Scruggs et. al., 2013). NGSS Science standards developed so that content and practice are rich and coherently arranged in various disciplines and grades to provide Science education to all students. NGSS is based on the K-12 framework for Science education developed by National Research Council (NRC). Researchers attribute this to a number of reasons, including the lack of Faculty resources and technicians through local and international courses and workshops due to the effective impact of students' mastery of laboratory skills , and lack participation in practical experiences . Moreover, a large number of students is difficult to divide into small groups. Each group adopts one experiment within the laboratory and works to draw their results in co-operation.

Based on the results, researchers recommend taking these criteria into account regarding f educational materials provided to students. Periodical workshops are held for laboratory supervisors to ensure the quality of laboratory skills for students and mastering laboratory practices to prepare students to choose future careers (Hidalg 2019). NGSS standards play an important role in increasing Scientific knowledge of contemporary youth in culturally diverse circumstances highlighting the importance of scientific literacy in the modern academic environment (Wendt &Rockinson-Szapkiw 2014), in order to match the curriculum with increasing demand for scientific skills such as model development and building interpretations of phenomena. Moreover, these standards are designed to meet the needs of today's youth and provide students around the world with an internationally standardised education by expressing expectations of cross-performance and in-depth conceptual performance (Haag &Megowan 2015). Teaching can be used to explain phenomena and solve problems by engaging in Scientific practices, engineering and adopting these practices to what we know about the survey to focus on asking questions from students or improving problems to investigate and analyse data and build models and arguments based on evidence to build explanations and

refine our understanding of the world (Asowayan et. al. 2017).

STEAM standards is global trends have incorporated five different fields of study (Science, Technology, Engineering, Arts and Mathematics). They revolve around providing meaningful learning experiences by linking education to the daily lives of students and developing skills for the labour market such as problem-solving and critical thinking. (DeJarnette 2018,1–9). STEAM standards have received growing attention as they integrate multiple disciplines concurrently and enhance learning experiences that allow students to explore, research, investigate and develop practical skills. Researchers recommend the need to review the content of laboratory courses to observe standards and activate the role of laboratory supervisors, as well as the need to train professors who prepare practical experiences and teach practical skills within the laboratory and familiarise them with methods and standards for laboratory training and how to take them into account through the content (Ozkan and Unsal 2017). STEAM focuses on creativity and innovation, enhancing student participation in the educational process and opening various types of thinking, such as scientific , critical and logical . Research has shown that laboratory expertise and practical learning positively affect the perceptions and directives of students towards choosing their future career based on their abilities and inclinations (DeJarnette, 2018).

Good Educational Laboratory Standards (GLP), represent genuine and practical laboratory standards through the design and implementation of studies and assures stakeholders that results are accurate and reliable and the experiment can be reproduced accordingly at any time in the future. Technically, this is the cornerstone of all laboratory activities in any Organisation that prides itself on quality. The mission of the Laboratory for Quality Assurance for Good Laboratory Education (GLP) practice is to: Identify and monitor regulatory activities through the application of GLP standards within global requirements as well as promoting (GLP) standards and compliance through information exchange and interaction with regulatory authorities and other stakeholders including. These including testing, archiving of records and materials, containing equipment, materials and reagents, conducting relevant study , recording the study results and conducting standard procedural work for all activities within the laboratory (Akyar 2011, 38).

There are three distinct types of business activities in (GLP) Laboratories that can be identified as follows: experiments that aim to give students a sense of truth that can be observed during the performance of the experiment, exercises designed to develop practical skills and techniques, ensuring quality laboratory education and identifying and monitoring organisational activities by applying GLP standards within global requirements in addition to promoting GLP standards and compliance by exchanging information and interacting with regulatory authorities and other stakeholders. These include testing and archiving records and materials, which contain equipment, materials and reagents, conducting the relevant study and

recording study results. Verifications provide students with the opportunity to tackle more open problem-solving tasks (KhalafArat et. al., 2018).

The evaluation of quality within (GLP) laboratories is carried out by internal or external quality authority within the provisions of reliable educational institutions to be evaluated. These include laboratories, monitoring results and their impact on graduate competence through objective assessment of all educational outcomes. GLP standards represent the true and practical laboratory standard by designing and implementing studies and assuring stakeholders that results are accurate and reliable and the experiment can be reproduced accordingly at any time in the future. Technically speaking, it is the cornerstone of all laboratory activities in any Organistion that prides itself on quality.

The Laboratory's mission is to ensure quality laboratory education (GLP) by identifying and monitoring organisational activities by applying GLP standards within global requirements as well as promoting GLP standards and complying by sharing information and interacting with regulatory authorities and other stakeholders including testing and archiving records and materials which contain equipment, materials and reagents, conducting relevant studies, recording study results, and conducting standard procedural work for all activities inside the laboratory (Al-Zaidi & Amer 2015, 11).

A good educational laboratory is the quality system for organisation processes in laboratories according to necessary planning conditions. Performance, monitoring, recording, archiving and reporting in the laboratory are undertaken to achieve the objective of certifying that each step of the analysis is valid and accurate (Kumar, 2018).

The research problem can be formulated by asking the following question:

What is the extent to which Suggested Standards (NGSS - GLP - STEAM) are demonstrated in the laboratory skills of students in the Department of Electromechanical Engineering–Systems Branch?

Methodology

The researchers followed the descriptive approach as it is appropriate method for evaluating students' laboratory skills in the Department of Electromechanical Engineering–Systems Branch at the University of Technology according to suggested standards (NGSS-GLP-STEAM), and for achieving the research aim , which requires the preparation of a research tool consisting of a direct observation card, based on which student's laboratory skills are evaluated. The sample consists of (65) students from the Department of Electromechanical Engineering–Systems Branch randomly selected. The researchers formulated (22) standards, and presented teaching methods for Science and expressing opinions and observations to verify confidence and objectivity to a group of experts and specialists.

Before the start of observation and data collection process, all laboratory supervisors, professors and students were notified and no student or Professor could be penalised whether they participated or not. The data collected is only used only for scientific research purposes in line with the University's ethics. Students are also informed that they can withdraw from the data collection process at any time.

Researchers made multiple visits to the Electromechanical Engineering–Systems Branch and the observation card form was applied to the target sample of (65).

Research results were obtained through statistical processing after unloading in the IBM® software SPSS 25.0 prepared for this purpose, using statistical methods that are commensurate with the nature of the research, including arithmetic mean, standard deviation, hypothesis, T–test.

Results and Discussion

Mean and standard deviation of the laboratory skills of electromechanical engineering students systems at the University of Technology in Baghdad, and the T–test was used to discover if there were statistically significant differences at the level (0.05). The grades for laboratory skills of Engineering students consist of five categories: Excellent, Very Good, Good, Poor, Very Poor. The distribution of scores for each criterion is outlined in Table 1.

Table 1: Distribution of scores for Suggested Standards categories

Grades	*Criteria*
5	Excellent
4	Very good
3	Good
2	Poor
1	Very Poor

Source: Author

Based on the data analysis and trends for the five criteria presented, the highest score a student can achieve in laboratory skills is (110) and the lowest is (22). The results show that the arithmetic mean of research sample scores of (65) students regarding laboratory skills scale was (49.38) and a standard deviation of (15.77). Furthermore, the significance of the difference between the arithmetic and hypothetical average which was (66), it was found that the difference is statistically significant at the level (0.05), as the T–calculated value is (25.24), which is greater than the T–tabular value (1,66) and the degree of freedom (64). The

Significance of Differences between Arithmetic, Hypothesis and T–Values is described in Table 2.

Table 2: The Significance of Differences between Arithmetic, Hypothesis and T-Values

Mean	*Standard deviation*	*Hypothetical mean*	*T– Calculated*	*T– Value*
1.66	25.24	66	15.77	49.38

Source: Author

The above table shows that the difference is statistically significant at the level (0.05), as the T– calculated value (15.77), which is greater than the T–value table (49.38) and the degree of freedom (35), which indicates that the laboratory skills of Engineering students at the Electrochemical–Systems Branch are at a lower level than the hypothetical mean.

Conclusion and Recommendations

Subjecting students' laboratory skills to these proposed global standards may help achieve the goal of making students more effective in the educational laboratory. Furthermore, the standards aim to integrate Science, Technology, Engineering, the Arts and Mathematics. However, laboratory supervisors tend to use other means to ensure that learning and teaching can occur despite a lack of capacity within laboratories. The researchers attribute this to a number of reasons including: lack of technical and teaching staff through the introduction of local and international courses and workshops due to the effective impact of students' mastery of laboratory skills, not participating individually in practical experiments as this leads to mastery of laboratory skills. Moreover, the large number of students is difficult to divide into smaller groups. Each group adopts one experiment within the laboratory and works to draw their results collaboratively.

Based on the results, the researchers recommend that these standards be taken into account in the content of teaching materials provided to students. Also, periodic workshops have been offered for laboratory supervisors to ensure quality standard of laboratory skills for students and accurate mastery of laboratory practices to prepare students to choose future careers. Moreover, the study has been limited to students from the Department of Electromechanical Engineering - Systems Branch in Baghdad, therefore the researchers suggest conducting a similar study in other Iraqi Universities.

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