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Engineering Education Development using Advanced Systems and Equipment for Assessment and Evaluation in Egyptian Universities

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Abstract

Assessment and Evaluation are important processes to ensure education quality and development. Assessment has many different techniques such as computational, electronic, mechanical, and traditional written tests. The research objectives are to demonstrate both short-term strategies and long-term strategies, which have been early started in Egyptian universities (EUs), and to investigate the opportunities of development in assessment and evaluation for engineering education. This article focuses on the importance of building up more centers and units for assessment and evaluation in the EUs. The research methodology consists of demonstrating how to insert new systems and equipment either in assessment or in evaluation using both short-term and long-term strategies. Most of these presented methods and tools are depending on newly engineering technologies such as optical marking recognition, user-friendly software, communication networks either wired or wireless, and mechanical engineering systems to ensure better and more safe working conditions. The results present these engineering technologies. The results also compare the initial cost and the execution time for each of the proposed systems. The analysis of results indicates the effectiveness of currently used methodologies to ensure rapid development in engineering education generally and in mechanical engineering education specifically.

The conclusions and recommendations are reported at the end of this paper. It is highly recommended to design and construct a few number of Regional Measurement Centers (RMCs) in each university in Egypt to examine the expected number of students in all faculties during summative exams either at full capacity condition, or at part occupancy conditions due to the COVID-19 precautionary measures. The conclusions show that the EUs are accelerating their strategic plan in education development to rapidly fulfill Egypt vision 2030 in education quality and to carefully alleviate the worst impacts of the COVID-19.

Keywords: assessment, evaluation, higher education development, educational systems, educational equipment, Egyptian universities, COVID-19.

1. Introduction

Recently, the assessment and evaluation processes have been employed to detect the intended learning outcomes (ILOs). These ILOs can be classified into two main groups, as listed in Bloom Taxonomy, which has classified them into Lower-order thinking skills (LOTS) and Higher-order thinking skills (HOTS) (Bloom et al., 1956; Anderson and Krathwohl, 2001; Hoy, 2007; Armstrong, 2016). The LOTS are classified into i) knowledge and understanding, ii) intellectual skills, however, the HOTs are classified into iii) professional skills, and iv) general skills. Bloom's taxonomy is a set of three hierarchical models used to classify educational learning objectives into levels of complexity and specificity. The three lists cover the learning objectives in cognitive, affective, and sensory domains. In the 2001 revised edition of Bloom's taxonomy, the levels are slightly different: remember, understand, apply, analyze, evaluate, create rather than synthesize.

The HED has a vision and a mission which focus on the gain knowledge, excellence and competition, leading development, and creativity and innovation. Recently, the continuous development in assessment and evaluation has been highly observed. The strategic planning for higher education development (HED) has been classified into two main group which are the short-term strategies (STSs) and the long-term strategies (LTSs). These strategic plans include how to enhance the impact of Assessment and evaluation centers (MECs), and units (MEUs) in higher educational development in several faculties and universities. The intended outcomes of these MECs and MEUs are mainly to monitor, review and audit the performance of both assessment and evaluation processes among both the students and staff members, respectively, in several universities either in developed or developing countries.

Mahjabeen et al. (2017) focus on the quality of multiple-choice questions (MCQs) by analyzing the difficulty index (DIF), discrimination index (DI), and distractor efficiency (DE). They conducted their results in the department of Pathology, Islamabad medical and dental college. Data were entered in Microsoft Excel 2010 and SPSS 21. Karimi and Manteufel (2014) conducted a study on how to assess the fundamental concept in thermodynamics curriculum among engineering students. Wang (2007) discussed and compared different effective strategies for formative assessment in an e-learning environment. Armenski et al. (2013) focused the importance on how to use the E-assessment cloud as a solution to perform electronic exams, on basis of the architecture, organization, and cost model. Vuma and Sa (2017) compare the integrated clinical-scenario (case cluster) multiple-choice questions (CS-MCQs) in a problem-based learning PBL environment and stand-alone MCQs in undergraduate medicine. Mouneer (2019) conducted a comprehensive study on how the newly methods of assessment and evaluation can be disseminated among different department of engineering by performing a number of research based projects to help assessing process and remarking tools by undergraduate students. Vuma et al. (2015) conducted their descriptive analysis of pre-testing outcome in hematology as an indicator of performance in final examination among third-year medical students. Al-Zain (2017) conduct a study to detect the effectiveness of training programs for the faculty members in the development of designing and producing skills of the electronic assessment tools, and their level of satisfaction towards it. For the past few decades, many medical education programs and licensing authorities either at the undergraduate level or the postgraduate level have allocated tremendous efforts to ensure the authenticity of assessment and competency of trainees (Taib and Yusoff, 2014; Epstein, 2007; Barman, 2005; Gulijers et al., 2004).

Assessment and evaluation are independent concepts (Ajuonnma, 2006). Evaluation is a process that uses measurements. The assessment process is the first step in evaluation; an improved measurement leads to an accurate evaluation. Assessment and evaluation are considered a part of the teaching/learning process. Ajayi, (2018) stated that the assessment is any of a variety of procedures used to obtain information about student performance includes traditional paper and pencil tests as well as extended responses such as essays and performances of authentic tasks such as laboratory experiments. They defined that the assessment is the process of gathering the data and fashioning them into an interpretable form for decision-making.

The educational assessment provides the necessary feedback that is required to maximize the outcome of educational effort. The three modes of assessment are rational mode, formative mode, and summative mode. Ajayi, (2018) also reported that the evaluation is the process of observing and measuring a thing to judge it and of determining its added value, either by comparison to similar things or to a standard. They classified the evaluation into two types which are formative evaluation and summative evaluation. Formative evaluation is such evaluation which is conducted before giving final shape to an educational policy or program, curriculum, teaching method, teaching aid, or evaluation method. However, summative evaluation is such evaluation that is conducted to test the utility of an already existing educational policy, planning or program, curriculum, teaching method, teaching aid, or evaluation method. Recently, the literature review includes several researches explored the effects of outline teaching-learning mechanism in higher education during lockdown period of COVID-19 pandemic in many countries (Villalba and Useche, 2021; Mishra et al., 2020). More recently, Mouneer and Elshaer (2021) conducted an assessment and evaluation study on using Hybrid Education for Mechanical Engineering students by item analysis of summative assessment on firefighting systems during the COVID-19 Pandemic.

Since the literature review showed no comprehensive study on the influence of development and services provided to either MECs and MEUs which recently established in most of the EUs and their faculties. The question paper is still the main method that is used in theory examination, with four characteristics such as relevance, objectivity, reliability, and validity. A question bank is a planned library of test items designed to fulfill certain predetermined purposes. The purposes of these question banks are to improve the teaching process and the evaluation process, and to generate an items pool that can be used either in formative or summative assessments to measure the developing in the student’s performance. The question banks can be used to evaluate the collective knowledge for training teachers.

The objectives of this research is to present a comprehensive study of the assessment, and evaluation terminologies and techniques, which have been recently performed on the short-term scale (2-3 years) and long-term scale (5-10 years). Also, a comparative study is carefully performed to compare short-term strategies (STSs) and long-term strategies (LTSs).

This research aims to present a comparative study between the short-term (2-3 years) and long-term strategies (5-10 years) to be followed in Egyptian Universities (EUs) for their continuous development in Assessment and Evaluation (M&E). The research discusses the review performed on the Assessment and evaluation venters (MECs), and units (MEUs), attached to the EUs and their Faculties. These proposed strategies for HED especially in Assessment and Evaluation are classified in this current work into two main strategies which are Short-term Strategies (STSs), and Long-term Strategies (LTSs).

2. Methods and Tools

This research presents the most followed in the EUs as Short-term Strategies (STSs), which can be finalized successfully within a short period, which may take from 2 to 3 years. This research aims to study the benefits and the current costs of running costs and the continuous development in assessment and evaluation (M&E) by using assessment and evaluation centers (MECs), and assessment and evaluation Units (MEUs), to be attached to the EUs and their faculties. The authors demonstrate how staff members can develop their assessment and evaluation process. The main objectives of this current research are to promoting a positive culture between all students and staff members, in all Faculties either of Benha University (BU) or Helwan University (HU). However, most of the experimental work currently presented in this article is purely performed in Benha University (BU). Besides, the intended objective also can be extended to disseminate the importance of switching to newly assessment and evaluation to develop the higher education moreover all of the Egyptian universities (EUs).

2.1 Research Methodology

The current work is conducted to promote the positive culture among both staff members and students in all faculties in all universities in Egypt. The research methodology have three main pillars with different techniques, which can are i) to switch most of engineering curriculums into E-learning and E-Testing , ii) Experimental work to investigate the possibility of produce an portable and low cost tools and devices to facilitate electronic assessment in an easy watt either for students during exams or for staff members during assessment and evaluation process, and iii) Preliminary Electromechanical design well-coordinated with assessment and measurements spaces, centers, and buildings which are necessary to be attached into each faculty in all of the

Egyptian universities to also facilitate the examination, assessment, evaluation processes for both students and staff members. These techniques can be expressed and grouped as following:

- Performing automated remarking exams using hybrid assessment consists of both multi-response questions, and open response questions. The open response questions consist of hot spot questions, mathematical problems, and/or drawing questions either in thermodynamics, heat transfer, heat and mass transfer, refrigeration and air conditioning, firefighting (Mouneer and Elshaer, 2021) and industrial safety.
- Experimental work by design, construct, and testing for an automated optical mark recognition machine (OMR), using optical radiation concepts and machine design basis. This experimental investigation was performed by 3rd year mechatronics students as early highlighted by Mouneer, (2019) that this experimental investigation has been launched in 2019.
- Experimental work by design, construct, and testing a closed system (wired system) of smart examination and correct system (SEC system), using electronic circuits and system components. This experimental investigation was performed by 3rd year mechatronics students as early highlighted by Mouneer, (2019) that this experimental investigation has been launched in 2019.
- Preliminary Electro-mechanical designs for new designs of MEUs, MECs, ETLs, and MECUs (MEU c/w ETL), to serve the faculties staff members and students, during the performing different types of the formative and summative assessment process. This design work was performed by 4th year mechanical power students during their B.Sc. graduation project 2019, (Mouneer, 2019).

It should be clear that most of the used techniques can be assumed as transitional stage between the switching from the traditional written exams to the suggested electronic exams, which are shortly expected to be widely used for all basic sciences curriculums, and for all engineering and medical curriculums, inside all of the EUs, as intended in HED plan, during current years up to the year 2030, or earlier. Three of these performed techniques are presented herein this section as can be seen below.

2.2 Using Item Banking for Multi response Questions

The tests can be classified as follows: i) computational, using item banks soft wares to generate the exams on printed paper (transitional stage), ii) electronic, using electronic labs (E-Test labs, mechanical remarking exams using optical mark recognition machines/techniques, and iii) traditional written tests using pen/pencil and papers. The test can be defined as an instrument or systematic procedure for measuring a sample of behavior by posing a set of questions uniformly. The test type selection shall be based on the requirements, equipment, tools, software packages, and staff and students' training techniques. To perform the automated exams, several Item banking systems have been constructed to cover the contents of curriculums, by both the formative and summative exams applied on those samples of students with total number may reach to 1791 students, in those different subjects and listed in those different departments.

Figures 1-a, b demonstrate the used test design for thermodynamics curriculum (for 180 students and the full mark of 75 marks), and heat and mass transfer curriculum (for 350 students and the full mark of 90 marks), performed during three academic years. Figure 1-c presents the used test design for industrial safety curriculum (for 1261 students and the full mark of 30 marks) performed during three academic years. Figures 1-d, e demonstrate the using of multi response questions, such as: matching, ranking, and short answer questions during the summative test which designed using a closed type (secured) item banking system and performed successfully during current semester, in thermodynamics curriculum, among 180 students with full mark of 75 marks. The evaluation process of these exams was carefully performed, and their feedback is implemented on the next the formative and summative exams for these curriculums, and some recommendations are driven for science curriculums in engineering. It should be noted that there are two pilot exams have been performed early using the same technique for those students, during their mid-term exams, and during their experimental/oral exams, before they have performed these summative exams at the end of the semester.

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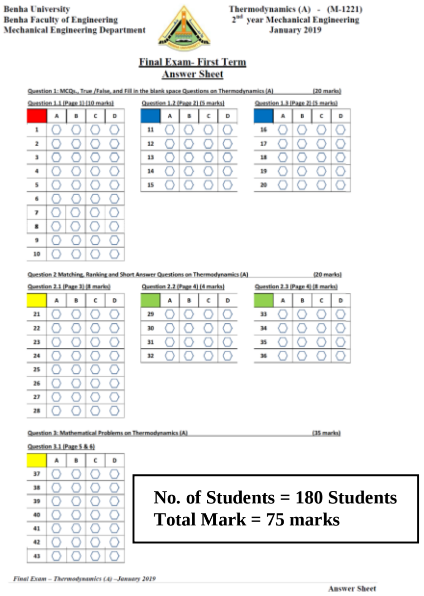
a) Thermodynamics b) Heat and mass transfer c) Industrial safety


Benha University
Benha Faculty of Engineering
Mechanical Engineering Department

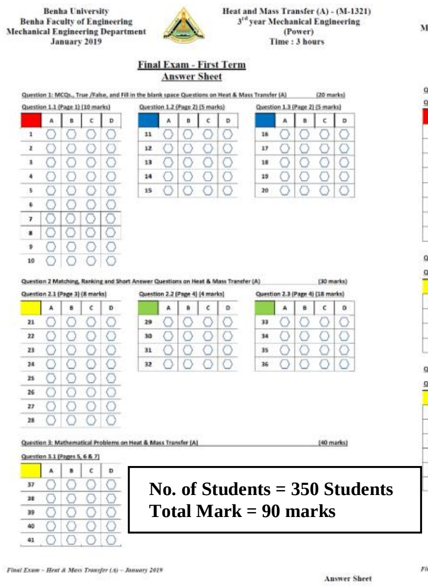
Thermodynamics (A) - (M-1221)
2nd year Mechanical Engineering
January 2019

Final Exam- First Term
Answer Sheet

No. of Students = 180 Students
Total Mark = 75 marks

Final Exam – Thermodynamics (A) –January 2019

Answer Sheet

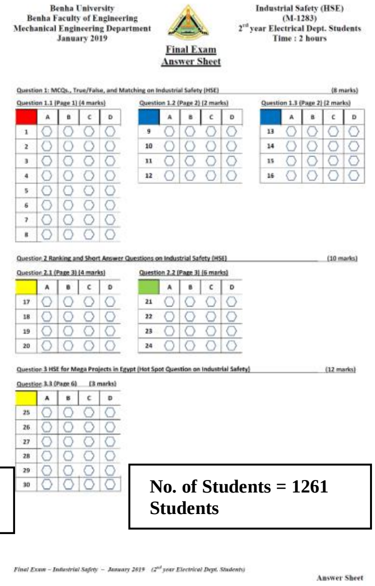

Benha University
Benha Faculty of Engineering
Mechanical Engineering Department
January 2019

Heat and Mass Transfer (A) - (M-1321)
3rd year Mechanical Engineering
(Power)
Time : 3 hours

Final Exam - First Term
Answer Sheet

No. of Students = 350 Students
Total Mark = 90 marks

Answer Sheet


Benha University
Benha Faculty of Engineering
Mechanical Engineering Department
January 2019

Industrial Safety (HSE)
(M-1283)
2nd year Electrical Dept. Students
Time : 2 hours

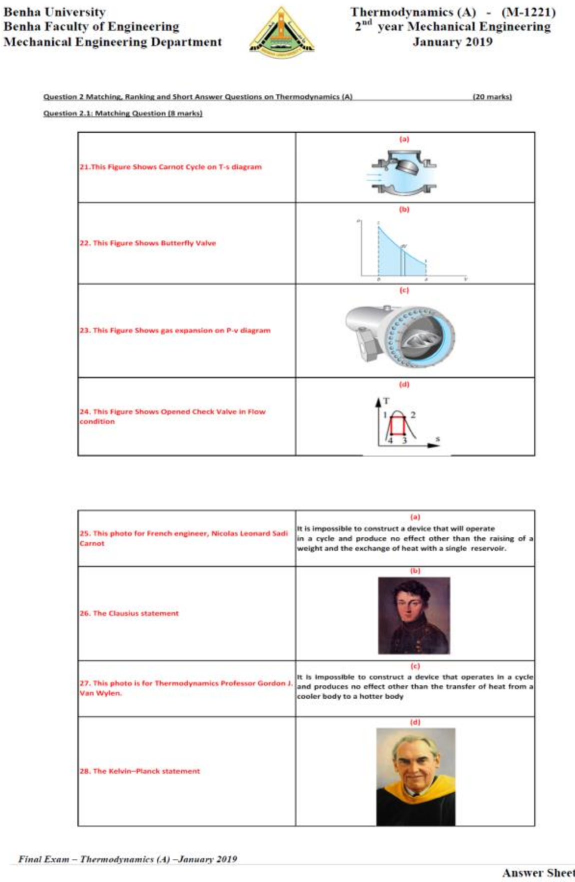
Final Exam
Answer Sheet

No. of Students = 1261
Students

Answer Sheet

d) Matching Questions in thermodynamics.

e) Ranking and short answer questions in thermodynamics.


Benha University
Benha Faculty of Engineering
Mechanical Engineering Department

Thermodynamics (A) - (M-1221)
2nd year Mechanical Engineering
January 2019

Question 2 Matching, Ranking and Short Answer Questions on Thermodynamics (A) (20 marks)

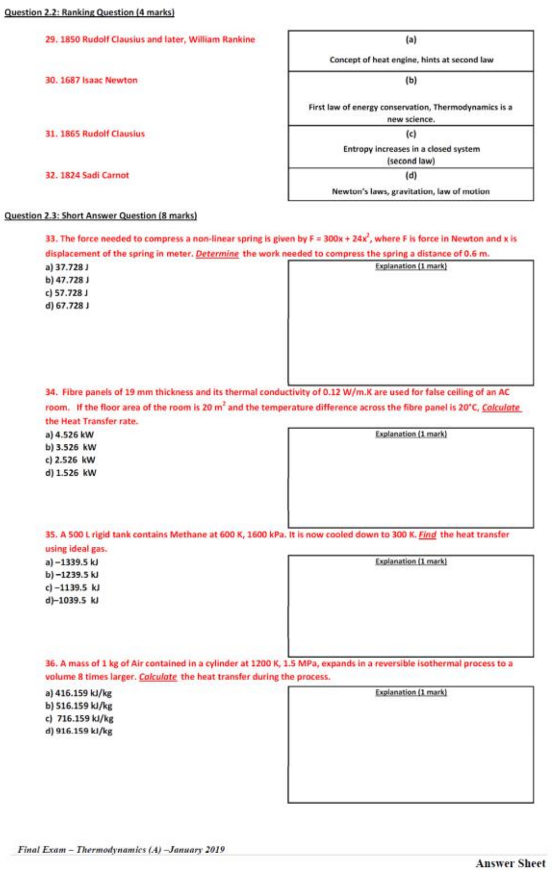
Question 2.1: Matching Question (8 marks)

21.This Figure Shows Carnot Cycle on T-s diagram	(a)
22. This Figure Shows Butterfly Valve	(b)
23. This Figure Shows gas expansion on P-v diagram	(c)
24. This Figure Shows Opened Check Valve in Flow condition	(d)

25. This photo for French engineer, Nicolas Leonard Sadi Carnot	(a) It is impossible to construct a device that will operate in a cycle and produce no effect other than the raising of a weight and the exchange of heat with a single reservoir.
26. The Clausius statement	(b)
27. This photo is for Thermodynamics Professor Gordon J. Van Wylen.	(c) It is impossible to construct a device that operates in a cycle and produces no effect other than the transfer of heat from a cooler body to a hotter body
28. The Kelvin–Planck statement	(d)

Final Exam – Thermodynamics (A) –January 2019

Answer Sheet


Question 2.2: Ranking Question (4 marks)

29. 1850 Rudolf Clausius and later, William Rankine	(a) Concept of heat engine, hints at second law
30. 1687 Isaac Newton	(b) First law of energy conservation, Thermodynamics is a new science.
31. 1865 Rudolf Clausius	(c) Entropy increases in a closed system (second law)
32. 1824 Sadi Carnot	(d) Newton's laws, gravitation, law of motion

Question 2.3: Short Answer Question (8 marks)

33. The force needed to compress a non-linear spring is given by $F = 300x + 24x^2$, where F is force in Newton and x is displacement of the spring in meter. *Determine* the work needed to compress the spring a distance of 0.6 m.

a) 37.728 J
b) 47.728 J
c) 57.728 J
d) 67.728 J

Explanation (1 mark)

34. Fibre panels of 19 mm thickness and its thermal conductivity of 0.12 W/m.K are used for false ceiling of an AC room. If the floor area of the room is 20 m^2 and the temperature difference across the fibre panel is 20°C, *Calculate* the Heat Transfer rate.

a) 4.526 kW
b) 3.526 kW
c) 2.526 kW
d) 1.526 kW

Explanation (1 mark)

35. A 500 L rigid tank contains Methane at 600 K, 1600 kPa. It is now cooled down to 300 K. *Find* the heat transfer using ideal gas.

a) −1339.5 kJ
b) −1239.5 kJ
c) −1139.5 kJ
d)−1039.5 kJ

Explanation (1 mark)

36. A mass of 1 kg of Air contained in a cylinder at 1200 K, 1.5 MPa, expands in a reversible isothermal process to a volume 8 times larger. *Calculate* the heat transfer during the process.

a) 416.159 kJ/kg
b) 516.159 kJ/kg
c) 716.159 kJ/kg
d) 916.159 kJ/kg

Explanation (1 mark)

Final Exam – Thermodynamics (A) –January 2019

Answer Sheet

Figure 1: Sample of summative assessments papers (a) answer bubble sheet of thermodynamics, (b) answer bubble sheet of heat and mass transfer, (c) answer bubble sheet of industrial safety, (d) matching questions on thermodynamics, (e) ranking and short answer questions on thermodynamics.

2.3 Using Electronic Testing Labs in Faculties

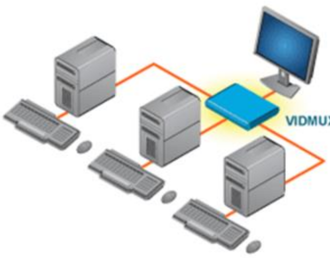
This research presents the recommended long-term strategy to be followed in the EUs as Long-term strategies (LTSs), which may take from (5-10 years). This research aims to study the benefits of design and construction of E-test laboratories with high capacity of students, to perform summative tests, overall the Egyptian universities using web-based tests, as can be defined as on-line prequalification exams. It is highly recommended to design and construct regional measurement centers in each of the regions, served by Egyptian universities. Mouneer (2019) stated that a work group consists of eleven students at B.Sc. graduation project has started to review and develop the MECs, MEUs, and ETLs, which will be provided to serve the faculties staff members and students, during performing different types of the formative and summative assessment process, either using multi-response questions on printed papers, or by performing pilot E-tests, and summative E-test. These E-tests can be performed either using web-based tests (on-line exam /using clouds) or computer-based tests (off-line exams). Several conceptual designs of these MEUs, MECs, and ETLs are presented in this current article, as can be seen in Figure 2-a. However, figures 2- b demonstrates an arrangement of E-test labs, with different capacities upon the available lab area. Several types of recommended wiring diagrams are displayed in Figure 3. Figures 3-a, b, c illustrate the different configurations to be used to interconnect between the used electronic devices of E-tests system components. Figures 3-d,e demonstrate the local instrumentation to be attached on each student desk, included separate monitor with 14-inch size, the keyboard and/or keypad test kit. The proposed test kit for keypad is designed and presented in this current article to carry out the newly developed E-tests, inside most of the Egyptian universities either before the COVID-19 pandemic or after it, to fulfil during their current mission 2030 in HED. The importance and the novelty of the current research purpose involves a newly simple technique that can be used on a low specific cost basis per student per exam.

a) E-Testing lab (ETL-84)

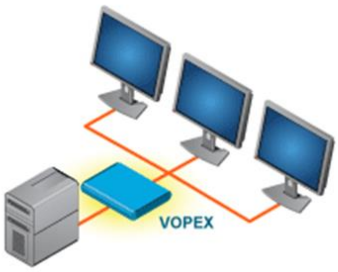
b) E-Testing lab (ETL-15)

Figure 2: Electronic test labs with main screen for all students, and individual key pads for each student a) E-Testing lab (ETL-84), four Iles, capacity 84 students, b) E-Testing lab (ETL-15).

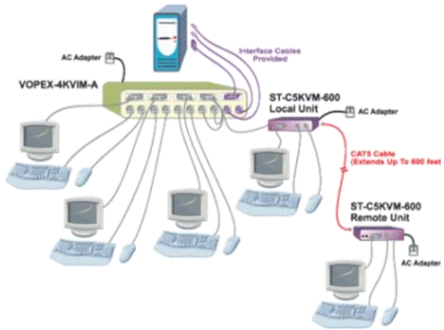
a) One screen monitors the multi-computers arrangement.



b) One computer connected to multi-screen with the same contents.



c) Methods of connection of local and remote screen sets.



d) Typical examination station equipped with monitor, keyboard, mouse, and answer lists keypad.

e) Typical keypads with 3x4 keys (0-9) , and 4x4 Keys (0-9), and (A,B,C,D).

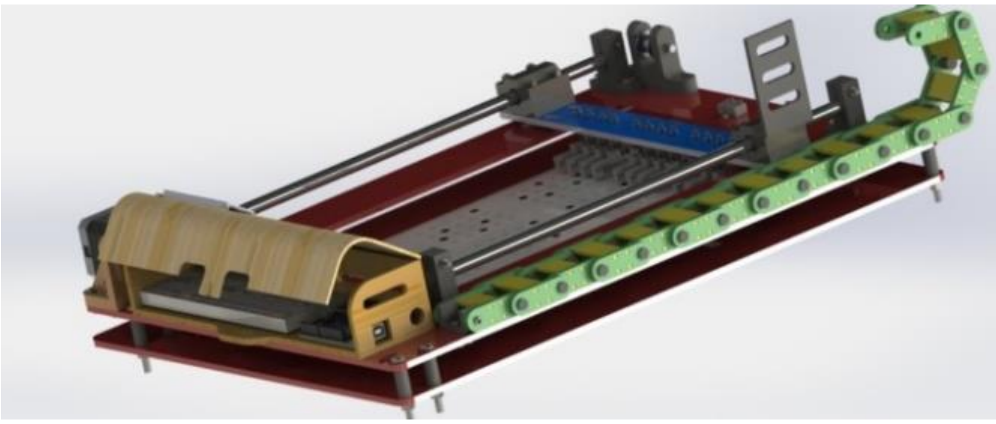
Figure 3: Typical system components to be used as necessary hardware to perform an electronic test inside E-Tests labs, with different connection methods and configurations.

3. Experimental Setup and Instrumentation

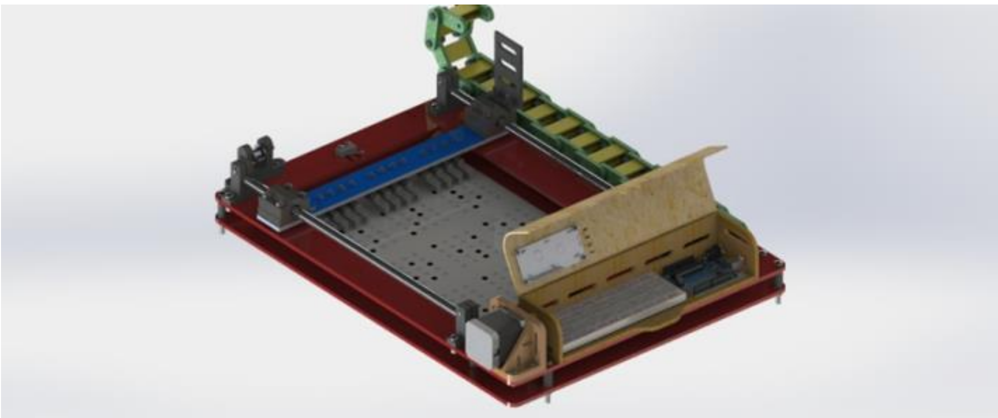
This section demonstrates the experimental setup and instrumentation which were used in current experimental work. The experimental work is classified into three main categories which are i) design and construction for optical marking recognition (OMR) machine to be used for MCQ assessment electronically, ii) Design and construction for measurements circuit to be used to collect the students answers in electronic testing labs (SEC), and iii) design for electromechanical works and coordination with building architecture for MEUs, MECs, and E-testing Labs with various students' capacities. The results and discussion of these experimental work are presented in in next section 4. The discussion of these results reveals how to assess the advanced systems and system components which are highly recommended in this article. Besides, the design basis and initial costs for each of the proposed MECs and MEUs are depicted in the discussion in section 4. *Design and Construction of Portable OMR machine*

An experimental investigation focused on mechanical design and construction for portable OMR machines which can be used by each staff member to electronically measure the students' performance in either formative or summative assessment process. A design of an OMR for A4 paper size model is preliminary designed using solid work software, as can be seen in Figures 4-a, b, c. A team work group, consists of seven students of third-year mechanical students in mechatronics department, has carried out the design stage, construction stage, testing and operation stages for the proposed OMR, as displayed in Figures 4-a, b, c. The students have carefully studied and reviewed the opportunity of using of optical recognition techniques to successfully complete the OMR with highest accuracy and error free design. Figures 4-a, b demonstrate the preliminary design for the OMR under design stage in bird views from two different perspectives. Figure 4-c display the side view for the OMR to indicate the handy size and its portability and its light weight which are about 3 kg. The constructed OMR is presented in several positions and working condition in subsection 4.2, in results and discussion section. The OMR is used to detect the number of correct answers and wrong answers to exactly estimate the total marks for each of the corrected answer sheets. The OMR is associated with sensors, control head, driving mechanisms and A4 paper holder during automated answer sheet correction process. The design was consisted with conveying mechanisms to move the optical recognition sensor along the paper length and width to scan all students answers either correct or wrong answers inside the bubble sheet as can be seen in both Figures 4-a, b.

a) Preliminary design for the OMR.



b) Bird view for the proposed design for OMR.



c) Side view for the proposed design for OMR machine, during design stage.

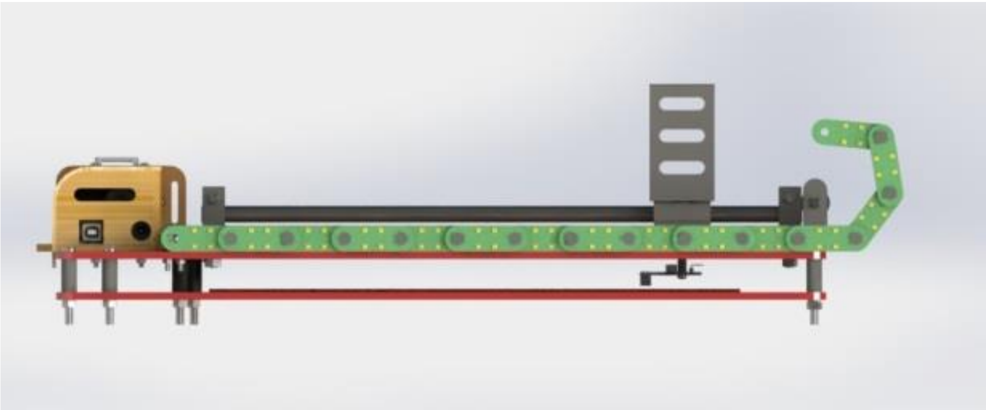
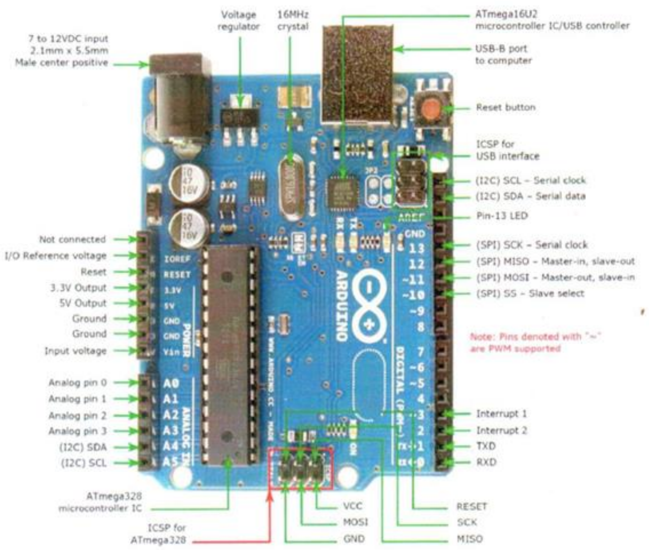


Figure 4: Preliminary design for the proposed OMR machine using Solid works software in conceptual design stage, (a) developed design stage, (b) bird view during design stage, (c) side view.

3.1 Design and Construction of test Kit for Students

Another experimental investigation focused on electrical wiring design and construction for sample test kit to be used as a modular element of newly smart examination and correct system (SEC). Figure 5 demonstrates this newly proposed experimental setup to be used to collect the selected answers of each of the multi-response questions involved in E-tests either on multi-screens configuration as can be seen in Figure 2-a with different exam models, or on one main screen using overhead projectors as can be seen in Figures 2-b and 3-a. Figure 5-a shows the pin log out of the used board of Arduino Leonardo which is the most suitable tool to be used in this purpose of students' answers collection and comparator centralized system. Figure 5-b demonstrates a screenshot of the code used to compare the students' selections, with the correct answers, to calculate the percentage of the correct answers received by each of the examined students. A team work group, consists of eight students of third-year mechanical students in mechatronics department, has carried out the design stage, construction stage, testing and operation stages for the proposed SEC systems, as displayed in Figure 5-a and Figure 5-b. The students have carefully studied and reviewed the opportunity of using of Arduino Leonardo to successfully complete the SEC system with intended accuracy and error free design. Figures 5-a demonstrates the anatomy of Arduino Leonardo as a main hardware system component to be inside the core of the proposed SEC system. Figure 5-b displays the used code as a main software system component which is carefully selected to detect the number of correct answer. The constructed SEC system and its system components are presented in working condition in subsection 4.3, in results and discussion section. The SEC system can be used to both students' answer collection and evaluating the students; scores upon the number of correct answers they selected during either formative or summative assessment process performed using E-testing method. The SEC system is associated with keypad test kit, wiring, control head, and screen for readouts the students' scores.

a) Anatomy of Arduino Leonardo .



b) Screen shot from the used code for detecting the number of correct answers by students.

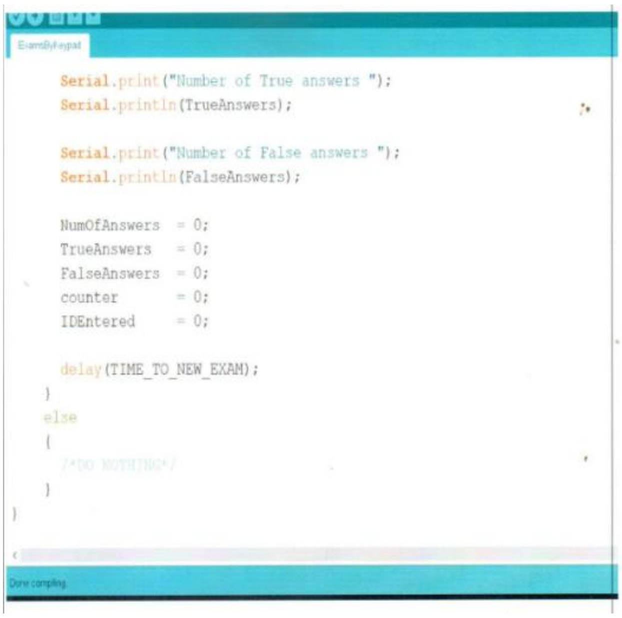


Figure 5: Proposed experimental set up consists of both hardware and software for proposed keypad test kit and measurements configuration, (a) anatomy of used Arduino Leonardo (Hardware), and (b) the used code to detect the number of correct answer (software).

3.2 Design for Electro-Mechanical Systems and Equipment for MEUs, ETLs and MECUs

The current research investigated the using of electromechanical works for several number of MECUs, MEUs, MECs, and E-testing Labs which were carefully coordinated with the architectures drawings presented in this article. Figures 6 displays a proposal MEU complete with Item Banking Lab (QBL), Automated Remarking Lab (ARL), and server room (SER). Besides, the proposed MEU design is equipped with typical E-test lab (ETL-50) can carry up to 50 students per electronic exam either formative, or summative exam. These proposed typical configurations either for MEUs or ETLs, should be carefully designed and furnished to carry out the mission of performing E-tests, and item banking in several faculties either in Benha University (BU) and Helwan University (HU) or in all faculties of EUs. All of these architecture spaces are equipped with Electromechanical works such as lighting systems, air-conditioning systems, firefighting and fire alarm systems, and information technology (IT) for data transfer and storage (Abbas et al., 2021-1; Abbas et al., 2021-2).

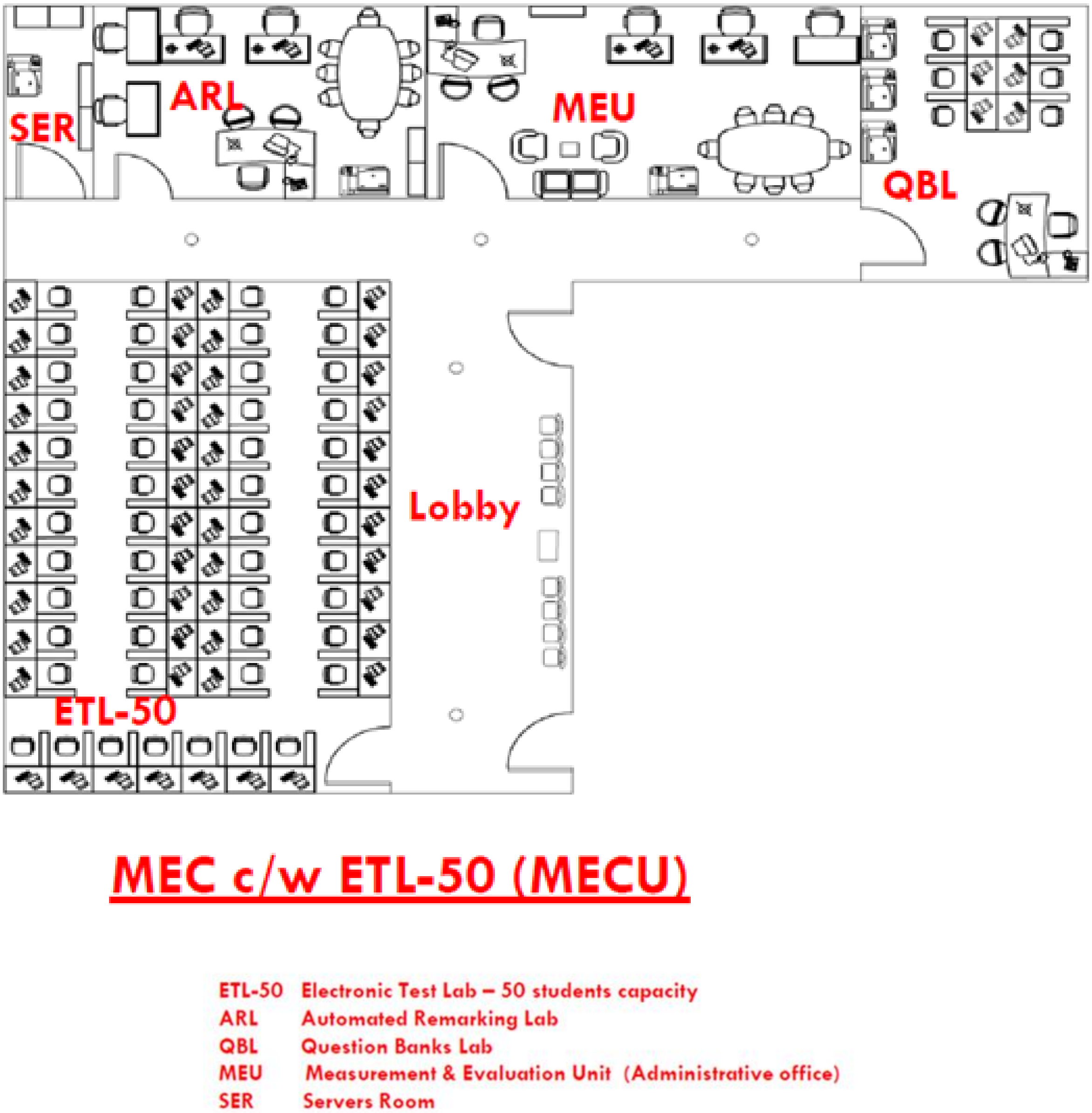


Figure 6: Typical architecture design for MECUs consists of MEU, QBL, SER and ETL-50.

4. Results and Discussion

This section presents the results of the comparative study between the short-term and long-term strategies (STSs) and (LTSs) which is followed in the Egyptian universities (EUs) to in their strategic plans for higher education development (HED) generally, and specially in assessment and evaluation (M&E) development.

4.1 Item analysis for Performed Formative and Summative Exams

In parallel work to the current study several item analyses have been performed to evaluate the summative assessments for mechanical power engineering student, Which measure and assess the students' level in thermodynamics, heat and mass transfer, heat transfer, industrial safety, and firefighting systems (Mouneer and El-Shaer, 2021). Most of these item analysis studies have performed on the results of assessment for second and third-year students, in three different departments, mechanical, electrical, and civil departments. These summative exams have been designed and evaluated to fulfil the ILOs of these studied curriculums in the three different engineering programs in Benha faculty of engineering of Benha University, in Egypt. Table 1 depicts the item analysis for multi response questions on firefighting summative exam recently performed in August 2020, after the COVID-19 lockdown. These multi response questions consist of multi choice question (MCQs), true/false question (T/FQ), and fill in space question (FSQs) which are numbered Q 1.1, Q 1.2, and Q 1.3, respectively. Table 1 depicts the extended matching question (EMQs) and ranking question (RANQ), numbered as Q 2.1 and Q 2.2 respectively. Table 1 gives item analysis for several free response short answers question FRSAQ (Q 2.3) on design issues such as estimate the fire water demand for different kind of non-residential building as per applied codes, and authority having jurisdiction.

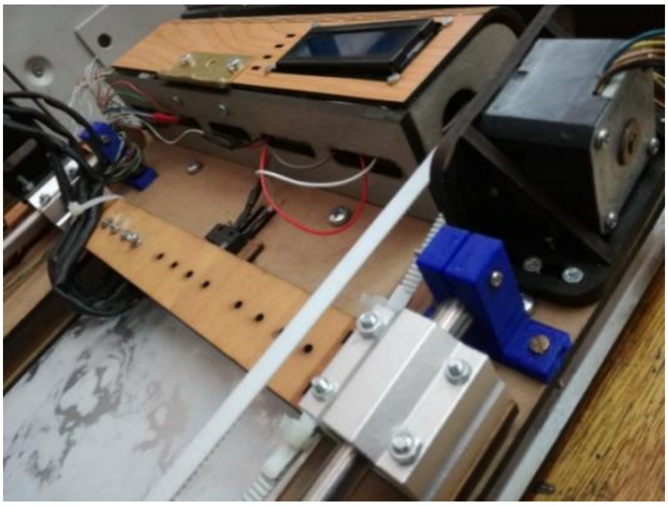
Table 1: Mean values for students' score in firefighting summative assessment performed early in August 2020after the COVID-19 lockdown, for Difficulty index (DIFI), Discrimination index (DI), and Distractor efficiency (DE) of both multi response questions (MRQs), and problem based questions (PBQs), presented by Mouneer and Elshaer, (2021).

Question No.	Question Type	No. of items	Full Mark	Mean Score	Mean DIFI %	Mean DI %	Mean DE %
Q 1.1	MCQ	10	10	7.70	0.76	0.19	46.2
Q 1.2	T/FQ	5	5	3.38	0.68	0.12	100
Q 1.3	FSQ	5	5	3.36	0.58	0.12	79.8
Q 2.1	EMQ	8	8	5.05	0.63	0.33	58.2
Q 2.2	RANQ	3	3+9	8	0.58	0.34	66
Q 2.3	FRSAQ	4	4+6	9.8	0.97	0.02	0
Q 3	PBQ	6	40	28.21	N/A	N/A	N/A

4.2 ***Portable OMR machine for staff members***

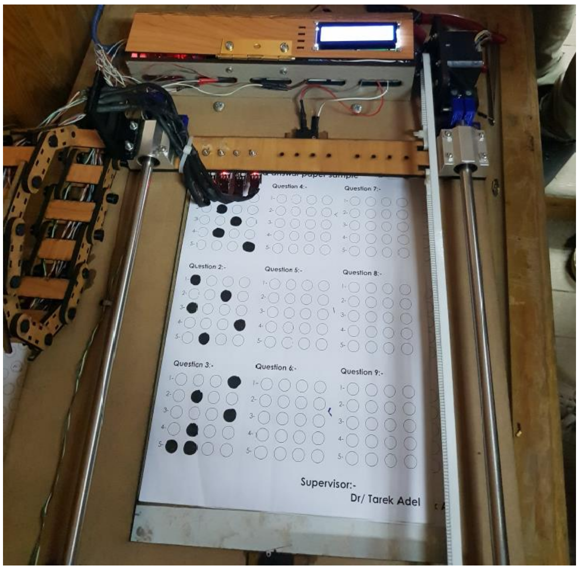
Figures 7-a, b, c, and d display the results of the constructed OMR machine, which was designed, constructed, and tested experimentally investigate the possibility and the importance of inserting low cost OMR machines as rapidly constructed and portable device to facilitate its uses by all staff members to carry out the assessment process easily. Figures 7-a shows a close view to the control head contains the digital read out screen, servo motors for movement of the scanning system, and the guide rail for scanning optical sensors used to detect the correct answer and the wrong answer, based on the predetermined model answer to be fed to the data entry ports. Figure 7-b illustrates an end view for the OMR machine form control head end, with the cover is opened to demonstrate the wiring, connecting boards, and the selected print circuit boards to carefully carry out the OMR performance. Figures 7-c,d depicts the OMR during the operation process complete with sample of marked bubble sheets to detect the number of correct answers and wrong answers for each student bubble sheet, after comparing with the model answer to be predetermined by examiner easily. These experimental work results reveal the accuracy of the designed OMR machine after comparing its results with other ready-made imported machines, and also using primary methods of calibration by detecting the score by operator eyes, as primary method for calibration process in this detection process.

a) OMR machine control head with screen



b) Internal wiring with open head cover.

c) front view OMR machine



d) during testing and calibration stage

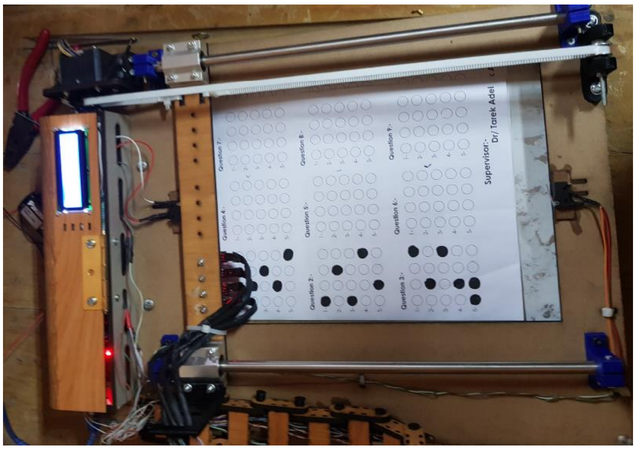
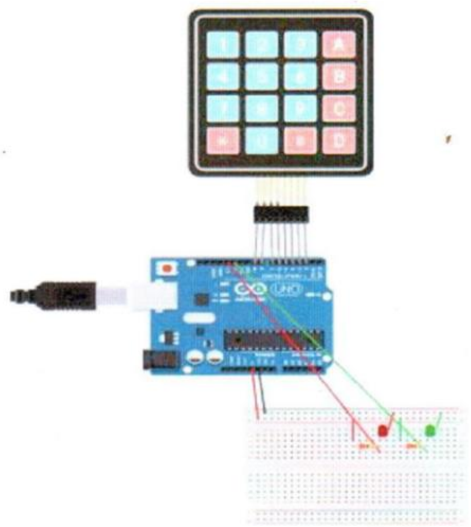


Figure 7: Experimental Set up for the constructed OMR machine, (a) OMR machine control head with screen, (b) internal wiring with using Arduino Uno, (c) front view, and (d) during testing and calibration stage.

4.3 Smart Examination and Correct System (SEC) for Students

Figure 8 demonstrates the results of newly proposed experimental setup to collect the selected answers of each of the multi-response questions in heat transfer E-tests either using multi-screens configuration with different exam models as shown before in Figure 2-a, or using one main screen as well as overhead projector as shown before in Figure 2-b. Figure 8-a shows experimental setup of proposed test kit consists of local keypad of 4x4 keys for receiving students answers which then connected to the used print circuit board of Arduino Leonardo. Figure 8-b shows the local keypad of 4x4 keys for receiving students' answers.

a) Test kit for local keypad of 4x4 keys



b) Local keypad of 4x4 keys

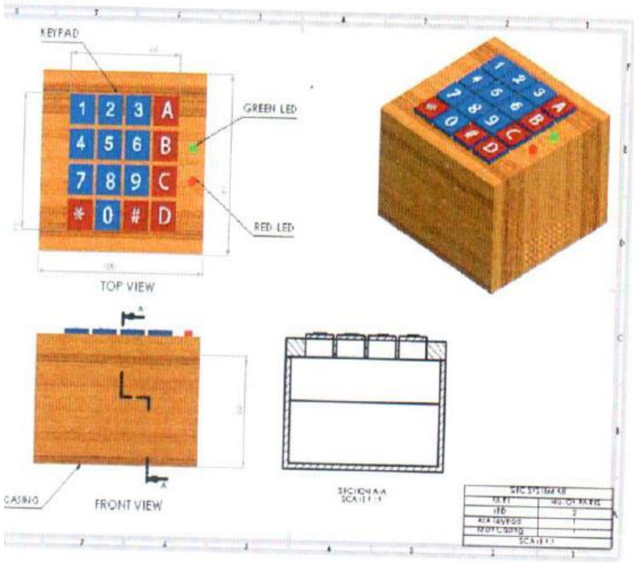


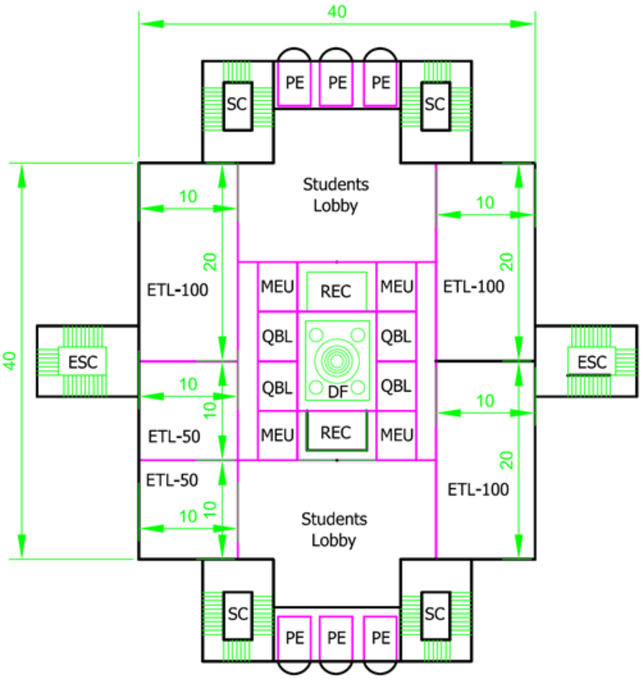
Figure 8: Results of the experimental setup of proposed test kit for smart examination and correct system (SEC) (a) local keypad of 4x4 keys connected to Arduino Leonardo (b) proposed local keypad of 4x4 keys configuration.

4.4 *Design and Construction Activities for new MEUs, ETLs and MECUs (MEC c/w ETLs)*

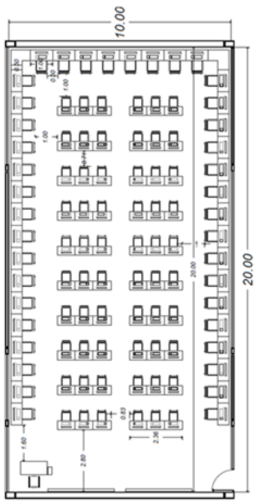
Figure 10-a depicts a new architecture for regional measurement building consists of a certain number of E-testing labs for students' electronic exams either in formative or in summative assessments. The current research presents a typical design for high capacity E-testing Labs (ETLs), which is designed to carry out students' capacity of 100 students per each E-test lab, tagged as (ETL-100), as can be seen in presented in Figure 10-b. A number of ETL-100 can be grouped to serve a larger number of students up to many hundreds, and thousands of students. The proposed conceptual design for the regional measurement centre (RMC) is presented in this current research work, as can be seen in Figure 10-a. The detailed design stage is performed to estimate the construction (initial) cost for mechanical, electrical, and plumbing Works. The building is predicted to carry out the assessment process and to serve both the staff members and the students in their faculties and universities based on the designed students' capacity during performing either the formative or the summative assessment process. Figure 10-a displays that the total building foot print area (L = 40 m, and W = 40 m) is equal to 1600 m^2 and each floor consists of four ETLs-100. Therefore, for G+4 building the total number of students are 4 x 400 =1600 students for all building floors.

However, Figure 9-b displays an enlarged plan for ETL-100 with students' capacity of 100 students and with total area of 200 m^2, where L = 20 m, and W = 10 m.

a) RMC with 400 students capacity per typical floor



b) ETL-100 with 100 students capacity (Typical E-Test lab)



ETL-100	Electronic Test Lab – 100 students capacity
ETL-50	Electronic Test Lab – 50 students capacity
QBL	Question Banks Lab
MEU	Measurement & Evaluation Unit (Administrative office)
SER	Servers Room
REC	Reception Area
DF	Dancing Fountain
PE	Panorama Elevators
SC	Entry Stair case
ESC	Exit Stair Case

Figure 9: Typical architecture designs for regional measurement building and E-testing labs, a) proposed design for typical floor for regional measurement center (RMC), b) typical architecture for E-Testing Lab (ETL-100) (all dimensions in meters).

4.5 Comparative Study between STSs and LTSs

Table 2 depicts the specific cost analysis computed to evaluate the feasibility study performed on different strategies on short-term (STSs) and long-term (LTSs). The total number of served students for each alternative of these compared strategies is taken into account during the current research work, to present this economical comparative study. The results of Table 2 show that for STSs Alternatives, MECs, and MEUs provide the service of item banking systems and it is also equipped with OMR machines for Electronic remarking processes. However, ETLs are not included except for those MECUs, as presented before in Figure 6. It should be clear that the MECUs recorded the highest specific cost, which may reach 700 EGP/student/year, however, the lowest cost has been observed for those of MECs, and MEUs, with 200 and 400 EGP/student/year, respectively. However, the standing-alone ETLs alternative has recorded a moderated range (about 500 EGP/student/year) of the study alternatives of STSs, as listed in Table 2. Figure 10 and Table 2 summarizes the comparative economical study performed between STSs alternatives and LTSs alternatives.

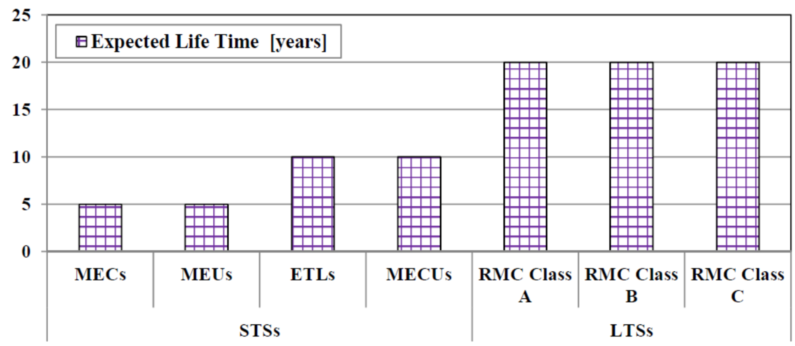
Table 2: The results of the comparative study performed between the short-term (STSs) and long-term strategies (LTSs), as used in Egyptian universities (EUs), on cost basis using specific Egyptian currency in EGP/Student/year.

Strategy	Units Type	Specific Annual Cost	Expected Life Time	No. of Served Students	Max No. Students	Required Area
		EGP/Student/year	year	Students	Students/E-Test	Square Meter
STSs	MECs	200	5	5000	0	75-80
	MEUs	408	5	16000-25000	0	75-80
	ETLs	512	10	5000	100	200
	MECUs	704	10	5000	100	300
LTSs	RMC Class A	140	20	16000	1600	1600
	RMC Class B	100	20	16000	1600	1600

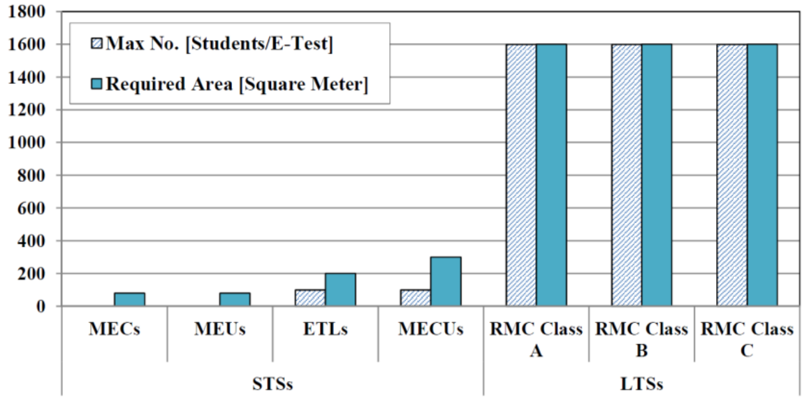
	RMC Class C	80	20	16000	1600	1600

Figure 10 demonstrates the comparative economical study performed between STSs alternatives and LTSs alternatives for life time (Figure 10-a), Maximum number of students and required area (Figure 10-b), and specific annual cost (Figure 10-c). For LTSs alternative, RMC can provide all the necessary services to perform E-tests, for a large number of students, which may reach up to 1600 student in the same exam duration for the proposed RMC (G+4) with Ground floor plus four typical floors, as can be seen in Figure 10-b. As can be seen in Figure 9-a, that each floor of RMC can be equipped with the necessary built-in MEUs complete with the item banking systems for each faculty to be served by this RMC inside BU, such the proposed typical floor area can be equipped with four MEUs, one per each of the served faculty. It should be noted that the alternatives of LTSs can be classified with the class of finishing, and equipment specifications, which will be equipped in the proposed RMC. Those classes are classified during the current comparative study with three classes: Class A, Class B, and Class C, as listed in Table 1, and labeled in Figure 10. It should be clear that Class A is the highest specifications class and it has recorded the highest specific cost, which may reach 140 EGP/student/year, however, the lowest cost has been observed for those of Class B, and Class C, which has recorded 100, and 80 EGP/student/year, respectively. However, the use of any alternatives of these proposed for LTSs is always with less cost than those alternatives of STSs. Standing-alone ETLs alternative has recorded a moderated range (about 500 EGP/student/year) of the studies alternatives of STSs.

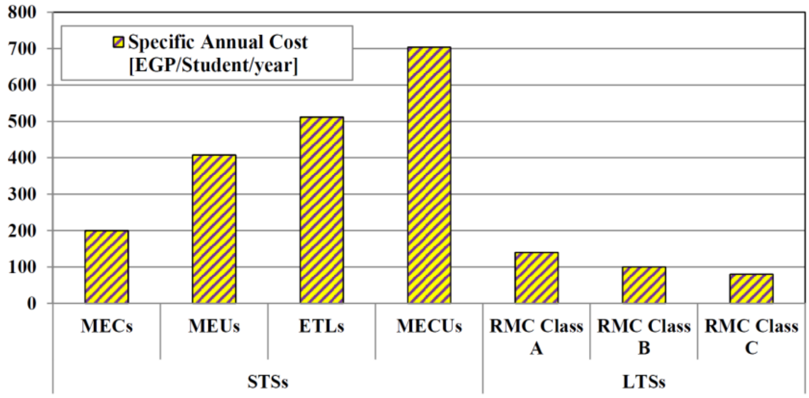
a) Life Time [Years]



b) Max No. of [Students/E-test] and Required Area [m^2]



c) Specific Annual Cost [EGP/Student/year]



<u>Figure 10:</u> The results of the comparative study performed between STSs Alternatives, and LTSs Alternatives a) Expected Life Time in Years, b) Max. No. of Students per E-test, and Required Area in square meters, and c) Specific Annual Cost in EGP/Student/year.

*4.6 **Suggested Location for Regional Measurement Center (RMC)***

Figure 11 displays the proposed location for the RMC of BU, on the plot plan of Benha city focus on downtown area. This proposed location is carefully selected to be at centralized point regarding the locations of most faculties of BU, located in Benha City such as Faculty of Arts (FOA), Faculty of Applied Arts (FOAA), Faculty of Commerce (FOC), Benha Faculty of Engineering (FOE), Faculty of Medicine (FOM) and Faculty of Science (FOS). Each of these faculties is located inside Benha city as can be seen in Figure 11. The proposed location in this present investigation is selected to be nearby the BU main building to be under continuous supervision from all university top management and to be nearby all the IT services, technical supports, medical care facilities of BU hospitals. Besides, this carefully selected location for RMC, shown in Figure 11, will be capable to serve several thousands of BU students either they live inside Benha city or from outside Benha city but students in any of BU faculties.

About 10 faculties from the 15 faculties of BU are located in Benha city, which are around the main building of BU. The conclusion can be driven at the end of this paper, which recommends starting the design and construction processes for a number of Regional Measurement Centers (RMCs) in each zone to serve EUs, and to carry out the missions of Egyptian universities in M&E development under the supervision of country mission (EGYPT 2030) in Higher Education Development (HED) field up to the year 2030.

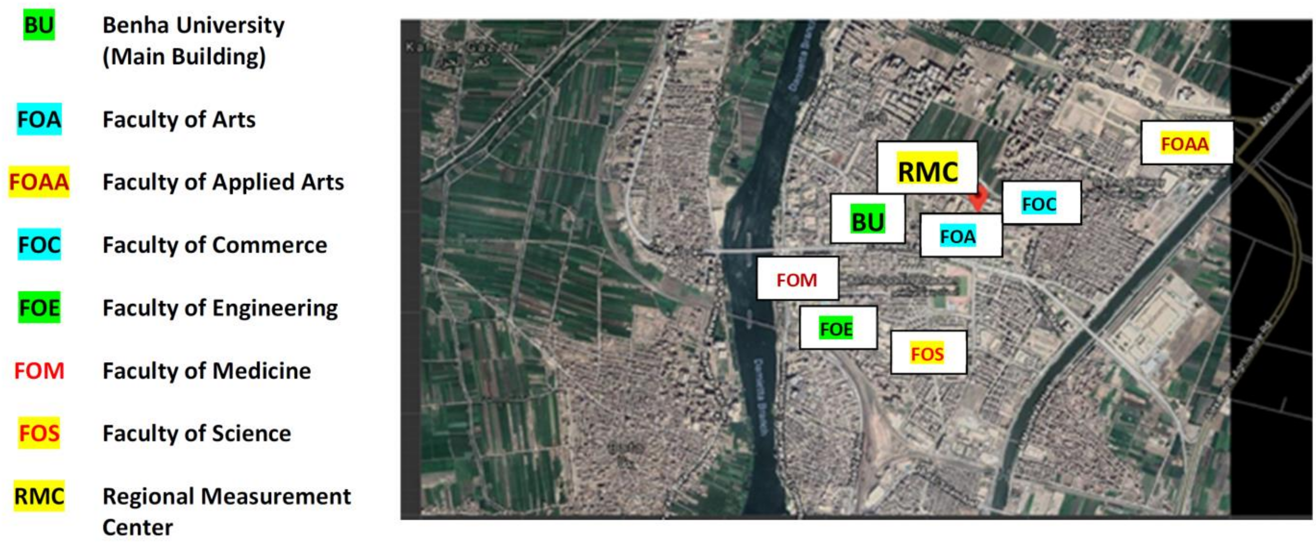


Figure 11: The recommended location of proposed RMC of BU inside Benha city mid-town, on Benha city plot plan, to serve all the faculties of BU, located inside Benha City.

5. Conclusion and Recommendations

This research helps the experts of M&E to make their decisions during the comparison between the short-term strategies and long-term strategies to be applied in Egyptian universities (EUs) for continuous development in Assessment and evaluation processes. The benefits of the assessment and evaluation process using centers (MECs), and units (MEUs), in the EUs, are also highlighted to staff members, and students during this current work, and it has started to promote the necessary positive culture which helps the development process of M&E, for the time being, and against the expected resistance hazards in this manner.

It should be also clear that the rapidly use of long-term strategies will help the higher education development process within the incoming few years, (up to 3-5 years), with the lowest specific costs, and with a longer lifetime up to 20 years, or more. These proposed long-term strategies can help also the EUs mission to carry out the country mission (EGYPT 2030) in Higher Education Development (HED) field up to the year 2030.

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