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Industrial Engineering and Metrology in Kuwait:

knowledge gaps and practical applications

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Abstract

Metrology is a necessary component of the scientific method and manufacturing. It provides the means to accurately measure and assess quality-related parameters, ensure compliance with standards, and facilitate process control and improvement. By utilizing metrology principles and techniques, engineers can achieve and maintain high levels of quality in engineering processes and products. The College of Technological Studies (CTS) at the Public Authority for Applied Education and Training (PAAET) in Kuwait provides a course in metrology and measurement. The graduates of this program service many sectors in Kuwait and are an integral part of the workforce. This paper outlines the importance of the metrology program at PAAET, the current knowledge gap, and how modification to the curriculum will better equip and prepare graduates to enter the workforce.

Keywords

metrology; manufacturing engineering; virtual laboratories; Kuwait; PAAET; public authority for applied education and training; CTS; college of technological studies; curriculum; GSO; GCC standardization organization; ISO; international organization for standardization; computerization methods.

Introduction

Metrology is the science of measurement and the attempt to obtain measurement results with precision and accuracy. Metrology, an essential part of the scientific method and manufacturing, consists of three basic elements: the object to be measured, the measuring device (comparator), and the reference (*Basic Principles of Engineering Metrology | Bartleby*, no date). These elements eventually lead to the measured quantity as shown in

Figure 1.

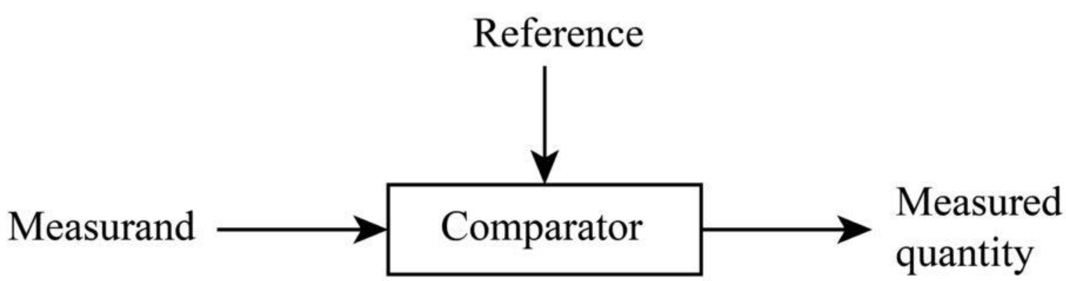

Figure 1. Basic elements of measurement

A wide variety of tools, such as concepts and terminology, are included in the field of geometric metrology. These tools are used to make linkages between the numerous stages that are involved in the design, manufacture, and functionality of a product. These stages range from the very beginning, when an idea for a product is conceived, all the way through its completion, when it is a fully operational and ready-to-use entity. The control and management of design, manufacture, and functionality are all supported by geometric metrology, which acts as the underlying underpinning for these activities.

The economic aspects of metrology are subjected to a significant amount of examination on a regular basis, and there is an occasional notion that metrology represents an unnecessary and needless cost. Despite the fact that the presence of measuring equipment in advanced mass production industries such as the automobile, medical device, and computer sectors gives evident proof of the economic benefits of metrology, detailed economic cost-benefit evaluations are frequently lacking. The economic benefits that are linked with the application of metrology in production are well demonstrated by the automobile manufacturing industry as a notable example. These firms have made significant investments in a number of coordinate measuring machines and other pricey metrological equipment within their facilities, despite the fact that they place a strong emphasis on reducing the costs associated with the manufacturing process. In manufacturing, metrology plays an important and pervasive function by enabling the enhancement of machine tool precision by reducing systematic geometric errors. This is one of the many ways that metrology contributes to the manufacturing process. The fact that the absence of embedded metrology in machine tools would result in a large rise in the cost of those machine tools further substantiates the evidence of the productivity advantages associated with metrology in the manufacturing industry (Savio, E., et al.2016).

In recent years, metrology has undergone vast changes in its methods and techniques. This is mainly due to the rapid developments in technology, specifically in the field of electronics and microprocessors. The versatility of these tiny devices (or computers in the chip as it is commonly described), their extremely fast performance, and low cost have made them not only effective but also desirable. Integration of tiny devices in metrology tools improves performance by making the tools more user-friendly, enhancing measurement accuracy, and improving the collection and storage of data. Furthermore, the software that accompanies the integrated metrology devices gives the advantage to the operator in the sense that no prior knowledge of programming is required.

Instruction in the discipline of metrology and measurement may be found in Kuwait, and it is offered by the College of Technological Studies (CTS), which is housed within the Public Authority for Applied Education and Training (PAAET). PAAET has garnered a strong reputation as a preeminent educational institution not only in the state of Kuwait but also throughout the wider Middle Eastern area as a whole. PAAET offers a wide variety of programs to students with the objective of providing them with the knowledge and abilities necessary to successfully enter the workforce in Kuwait as well as in other countries. These programs cover a wide range of subjects, including engineering, industrial training, telecommunications, and construction training, among others. PAAET's metrology program provides students with in-depth teaching in fundamental mathematical principles as well as hands-on experience with a variety of measuring equipment and instruments.

This study elucidates the significance of the metrology course that is offered at PAAET, highlights the present lacuna in knowledge, and offers curricular revisions that are intended to enhance the preparedness and competence of graduates for their transition into the profession.

Usage of metrology in industrial engineering:

Metrology plays a crucial role in the toolkit of industrial engineers. The proper comprehension and application of metrology by industrial engineers can lead to enhancements in the quality, reliability, and efficiency of industrial processes and products.

- The implementation of metrology in quality control processes serves the purpose of verifying the quality of products through the measurement of their dimensions, qualities, and performance in relation to established standards.

- Process control is the utilization of metrology as a means to effectively oversee and regulate industrial processes. This is achieved by the measurement and management of vital process parameters, including temperature, pressure, and flow rate.
- The utilization of metrology in product design enables the creation of goods that effectively cater to the requirements and preferences of clients and users. One illustrative use of metrology involves its utilization in the design process of items, wherein it facilitates the attainment of optimal dimensions, form, and mass.
- The utilization of metrology in production planning and control include the application of measurement techniques to effectively estimate demand, schedule production activities, and monitor inventory levels.
- Maintenance: The application of metrology in the context of industrial equipment entails the utilization of measurement and monitoring techniques to assess and track the extent of wear and tear, hence facilitating the timely replacement of components as required (Mercader-Trejo, et al .2013)

Metrology at PAAET

The curriculum of metrology and measurement contains both theoretical and practical activities that are distributed in three forms: lectures, tutorials, and laboratory sessions. The tutorial and laboratory sessions may be combined to have a total of 28 hours, while the lectures cover 14 hours. This course is essential for the student to complete as it is a requirement for graduation. In the metrology curriculum, it is imperative to include traditional metrology topics such as uncertainty, error evaluation, and geometric quantities, while simultaneously introducing measurements applied in the industry. Students are also introduced to inspection processes using a variety of instrumentation and equipment, thereby acquiring the necessary skills for measuring instrumentation. This course enables the understanding of reading manufacturer manuals and instrument sheets, which builds the student's confidence in the correct use of methodology results and analysis in the future. The contents of lectures and laboratory sessions are shown in detail in Table 1.

A single instructor is responsible for both the delivery of lectures as well as the facilitation of tutorials and lab sessions. In the beginning of the semester, students receive a full explanation of metrology and the applications it has, which is then followed by hands-on measurement activities that take place in laboratory settings. The employment of measuring devices like the ruler, vernier caliper, Vernier protractor for angular measurements, and the micrometer are included in the aforementioned instruments. Although it has been observed that students retain information better when participating in assessment activities on their own rather than in a group setting, it is essential to keep in mind that the professional realm of industry requires individuals who are capable of excelling both independently and collaboratively within a team. The issue at hand is covered during the second half of the semester, which is also the time when students become acquainted with the dynamics of working environments that involve collaboration.

As a consequence of this, the activities that are carried out during the second half of the semester consist of collaborative projects that center on the investigation of the many different types of fits used in engineering, tolerancing, and the classification of limit gauges. When it comes to the process of obtaining results from members of a team, the employment of tolerance calculations and word puzzles creates a collaborative attitude and promotes individual accountability among the members of the team. Because it is such an important factor in determining whether or not students are successful in the workforce or in their continued education, the importance of accountability is highlighted in educational environments such as classrooms and laboratories.

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Table 1. Lecture and lab content of Metrology and Measurement course at College of Technological Studies at PAAET.

	Curriculum Of Lecture	Hrs	Curriculum Of Tutorials/Labs	Hrs
1	Introduction to metrology. Engineering metrology and measurements. Differentiate between the three concepts. System of measuring system. Objectives of engineering metrology. Differentiate between units and dimensions. Primary international unit system. Primary dimensions and their relative units. Secondary dimensions. SI prefixes. Unit conversions.	2	SI units. SI prefixes. Metric Unit conversions.	2
2	Measuring instruments – general information. Linear Measurement: ruler.	1	Exercises on reading ruler.	1
3	Linear Measurement: vernier calliper. Definition. Types of callipers. Uses. Parts. different types of calliper accuracy. Reading calliper of 0.1, 0.05mm and 0.02 accuracy.	2	Practice on specifying vernier accuracy and reading vernier callipers with different accuracies.	2
4	Linear Measurement: micrometre. Definition. Uses. Parts. different types of micrometre accuracy. Reading calliper of 0.01mm accuracy.	2	Practice on specifying micrometre accuracy and reading micrometre.	2
5	Angular measurement: Vernier Protractor. Definition. Types of callipers. Uses. Parts. Reading vernier protractor scale.	1	Practice on reading vernier protractor.	1
6	Types of fits: introduction to tolerances, common tolerances terminologies. Minimum and Maximum Limit of Hole and Shaft. Types of Fit: Clearance Fit, Interference Fit, and Transition Fit.	4	Hole shaft schematic. Shaft hole system. differentiate between types of fits. Word Problem practices.	3
7	Introduction of Limit gauges. Advantages of gauging. Limitations of gauging. Classification of Limit Gauges. The Taylor Principle. Description of some commonly used gauges.	2	Practice The Taylor Principle: Double ended plain gauges have “GO” and “NOT GO”. Plug gauge. Snap gauge. Screw pitch gauge.	2

Standardization and Real-World Application

The Gulf Cooperation Council Standards Organization (GSO) is a regional organization that includes the national standards bodies of member states within the Gulf Cooperation Council (GCC) (*Standard Preview - متجر المواصفات - GCC Standardization Organization*, no date).. The Gulf Standardization Organization (GSO) is responsible for the development of the GSO ISO 10012:2007 standard. This standard was developed in compliance with the principles that were established by the International Organization for Standardization (ISO). The requirements for measurement management systems (MMS) are the primary emphasis of the GSO ISO 10012:2007 standard. These criteria are especially related to measurement processes and measuring equipment. This standard seeks to explicate the practical implementation of metrological theory and practice, providing businesses with a structured framework for effectively managing their measuring processes and equipment. This standard was developed by the International Organization for Standardization (ISO). By adhering to the norms and criteria defined in this standard, organizations will be able to improve their quality control, enhance the reliability of their measurements, and meet the expectations of customers and stakeholders who rely on accurate and trustworthy measurement data. These benefits will allow the organizations to fulfill the expectations of those who depend on accurate and trustworthy measurement data.

Table 2 provides a summary of the most important components of the GSO ISO 10012:2007 standard.

Another international standard is ISO/IEC 17025, which sets out the general requirements for the competence of testing and calibration laboratories. It is applicable to all types of laboratories, including those in the fields of chemistry, biology, physics, engineering, and more. ISO/IEC 17025 provides a framework for laboratories to demonstrate their technical competence, impartiality, and ability to consistently produce valid and reliable results. Compliance with ISO/IEC 17025 demonstrates that a laboratory has implemented a robust management system, follows standardized procedures, and operates with a high level of technical competence. It provides confidence in the laboratory's ability to deliver accurate and reliable results, which is essential for laboratories involved in testing and calibration activities. Key points of ISO/IEC 17025 are outlined in

Table 3.

GSO ISO 10012:2007 and ISO/IEC 17025 are two standards that complement and support one another. The structure for the management of measurement processes is made available by the standard ISO 10012:2007, which is sometimes referred to as GSO ISO 10012:2007 on occasion. This standard provides a broader and more thorough framework. In contrast, ISO/IEC 17025 zeroes in on the specific requirements that should be met by laboratories that conduct testing and calibration. Both a standalone implementation of one standard and a combined application of both standards, which would result in the establishment of a comprehensive measurement management system, are both options that are available to organizations.

Table 2. GSO ISO 10012:2007 Key Points.

Key point	Details
Measurement Management System	The standard outlines the requirements for establishing, documenting, implementing, maintaining, and continuously improving an MMS within an organization. It provides a framework for managing measurement processes and equipment throughout their lifecycle.
Measurement Processes	The standard focuses on managing measurement processes to ensure accuracy and traceability. It covers areas such as selecting appropriate measurement methods, validating measurement procedures, and ensuring proper calibration of measuring equipment.
Measurement Equipment	Emphasizes the importance of maintaining and controlling measurement equipment. It addresses the selection, identification, verification, calibration, and handling of measuring instruments to ensure their accuracy and reliability.
Measurement Uncertainty	The standard highlights the significance of evaluating and reporting measurement uncertainty. It provides

	guidance on identifying and assessing factors that contribute to measurement uncertainty, and how to communicate and interpret measurement results with associated uncertainties.
Metrological Traceability	GSO ISO 10012:2007 stresses the importance of establishing metrological traceability, which involves establishing a documented chain of measurement comparisons to an international or national measurement standard. It helps ensure the reliability and accuracy of measurements by providing a traceable reference to a known standard.

Table 3. ISO/IEC 17025 Key Points.

Key point	Details
Scope	General requirements for the competence of testing and calibration laboratories. It covers various aspects such as the laboratory's management system, personnel competence, equipment and traceability, testing/calibration processes, quality assurance, and reporting of results.
Management System Requirements	The standard requires laboratories to establish and maintain a management system that ensures their operations are carried out effectively. This includes establishing policies and objectives, document control, managing resources, implementing a risk-based approach, and continually improving the system.
Personnel Competence	ISO/IEC 17025 emphasizes the importance of competent personnel in laboratories. It sets requirements for the qualifications, training, skills, and experience of personnel involved in testing and calibration activities. The standard also requires laboratories to maintain records of personnel competence.
Equipment and Traceability	The standard requires laboratories to have appropriate equipment, calibrated and maintained to ensure accuracy and traceability. It emphasizes the use of validated methods and procedures, proper handling, and storage of samples, and maintaining appropriate environmental conditions for testing and calibration.
Quality Assurance	ISO/IEC 17025 emphasizes the need for laboratories to have quality assurance procedures in place. This includes establishing quality control measures, proficiency testing, inter-laboratory comparisons, and internal audits to ensure the validity and reliability of results. The standard also addresses the handling of non-conforming work and customer complaints.
Reporting of Results	The standard sets requirements for the reporting of test and calibration results. It specifies the information that should be included in the test/calibration reports and the format in

	which results should be presented. It also emphasizes the need for impartiality and confidentiality in reporting results.

Since GSO ISO 10012:2007 is adapted from ISO 10012:2003, it is imperative to include these standards and that of ISO/IEC 17025 as part of the curriculum at CTS and PAAET and understand how they are applied in the workplace. Through practical applications of metrology methods and national and international standards, CTS graduates will enter the workforce with the necessary foundational experience needed in industries and sectors using measurement systems. They will also be able to carry out, maintain and improve quality control protocols in the workplace, resulting in high-level productivity and efficiency. This benefits and promotes CTS as a stronghold and central institute in the State of Kuwait and the GCC for metrology and measurement management system.

It is absolutely necessary for businesses in Kuwait to adhere to the quality assurance and control methods defined in the aforementioned standards in order to ensure that proper operating procedures are put into place. Implementing a number of essential measures and methods will help improve quality assurance and control procedures in Kuwait. This improvement can be accomplished through a variety of means. The regulatory framework should be strengthened, procedures for certification and accreditation should be implemented, opportunities for training and education should be provided, continuous improvement methodologies should be adopted, appropriate technologies should be leveraged, decisions should be data-driven, public awareness campaigns should be conducted, and the government should provide support.

In a variety of industries, the government of Kuwait possesses the capability to improve the regulatory framework that is related to quality assurance and control. This includes the creation and execution of rules and regulations that compel organizational obedience, as well as the conduct of periodic audits and inspections to ensure compliance with those rules and regulations. Promoting the attainment of international quality certifications and accreditations, such as ISO 9001, is one strategy that might be implemented in order to strengthen the reputation of a firm and demonstrate its commitment to excellence. It is necessary to develop training and education programs in Kuwait directed at professionals in order to improve professionals' grasp of quality assurance and control principles, which would make it easier to issue certificates at the individual level. It is absolutely necessary to encourage lifelong learning in order to maintain awareness of the practices that are currently considered to be the most cutting edge and fruitful ones.

Streamlining at the organizational level may also be achieved by adopting continuous improvement methodologies like Lean, Six Sigma, or Total Quality Management (TQM). These approaches emphasize the systematic identification and elimination of waste, defects, and inefficiencies in processes and promote a culture of ongoing improvement. Organizations in Kuwait should also collect and analyse data related to their products or services to identify areas for improvement. This can include customer feedback, performance metrics, and defect rates. The use of technology, such as quality management software (QMS) and data analytics software, streamline quality control processes, track quality-related data, facilitate compliance with quality standards, and aid data-driven decision making.

The government of Kuwait may play a key role in improving circumstances in the country by creating incentive programs that reward companies that demonstrate great performance in quality assurance and control. These programs are in addition to the regulatory and oversight tasks that fall under the government's purview. The viewpoints and expectations of members of the general public offer an important and influential method for guaranteeing the accountability of organizations. Therefore, there are benefits to pushing for enhanced public understanding on the relevance of quality in both products and services. This is because consumers who are well informed have the potential to exert influence on businesses, which compels businesses to uphold higher standards.

The improvement of quality assurance and control in Kuwait calls for a concerted effort on the part of governmental bodies, regulatory authorities, educational institutions, and commercial businesses working together. In order to effectively respond to developing market dynamics and adhere to international quality criteria, the process should be examined and modified on a constant basis.

Computers in the field of metrology and workplace

Teaching traditional methods in metrology allows students to understand the fundamental principles of measurement. However, with the advancement in technology and rapid growth of its use in so many sectors, teaching computerization methods in metrology has become a necessity. Modifying the curriculum to include computerization methods will result in improved metrology and tolerancing techniques that are compatible with computer aided methods used in the workplace such as CAD, CAM, CAQ, and CIM systems. The importance of modifying and modernizing metrology curricula have been discussed and implemented in other countries such as Poland, Nigeria and Portugal (Bialas, S. et al. 2000; Ibrahim,S.M et al.2017) Regionally, the significance of metrology education, practice in industry, and future steps to improve the field of metrology were discussed at the First Middle East Metrology Conference and Exhibition in Bahrain (Carpenter *et al.*, 2002).

In the course that is provided by CTS, traditional methods of measuring are carried out without the assistance of computer-based instruments. In order to improve and perfect the educational program, the incorporation of digital tools and techniques for computer-assisted measurement is required. Because of this, graduates will be guaranteed to acquire the knowledge, abilities, and self-assurance necessary to successfully traverse businesses that rely significantly on digital technology.

The application of computers in metrology makes it easier to oversee the operations of measuring equipment and to analyse the results of measurements. For example, by using digital vernier callipers in the classroom, students are able to become familiar with measuring instruments of this kind, which is beneficial in preparing them for use in professional contexts. In spite of the prevalence of contemporary computer-based metrology methods, the aforementioned source recommends that it is necessary to still educate students on the use of traditional callipers. This is the case even though such methods are available. (*Computers in Metrology (Metrology)*, no date) . The result of this integration is a cohort of graduates who are equipped with the knowledge, motivation, and capacity to competently confront metrology techniques, regardless of whether or not technology is present. There are virtually no limits to what may be accomplished when computers are used to process the data that is produced by measuring instruments. It is possible to save the results digitally on a computer system, which will make data storage much simpler and will make subsequent analysis possible.

Knowledge gap in Kuwait

There are many knowledge gaps in the subject of metrology in Kuwait. The following are included:

- Within the realm of industrial engineering, as well as among other professionals, there is a lack of acknowledgment and comprehension of the significance of metrology. This is the case both in and out of the field.
- Now more than ever, Kuwait is suffering from a shortage of qualified metrologists.

- There is a shortage of facilities and equipment that are up to date in the field of metrology.
- The lack of productive collaboration between researchers and practitioners is one of the most significant issues that slows down progress in the field of metrology.

Because of the existence of these gaps, the area of industrial engineering in Kuwait is subject to a variety of different practical implications. Instances in which the relevance of metrology is not adequately recognized can lead to quality and dependability issues with products that do not meet standards. There is a shortage of skilled metrologists, which presents difficulties for businesses in putting in place and maintaining effective metrology systems. Measurements that are exact and reliable might be difficult for businesses to carry out when they do not have adequate access to modern metrology equipment and facilities. It's possible that the lack of effective collaboration between researchers and practitioners in the field of metrology could slow down the progression of new metrology technologies and procedures, which will in turn slow down overall acceptance.

A questionnaire concerning the technical and computer abilities and knowledge of graduates from the CTS program was distributed to three chief executive officers (CEOs) representing distinct sectors, namely service, industrial, and private industries. The questionnaire was designed to assess the graduates' technical and computer abilities and knowledge. The comments that were given by the CEOs displayed a degree of diversity on various elements, which was influenced by the particular work context as well as the individual perspectives of the CEOs. Nevertheless,

Table 4 offers a condensed summary of the major topics that were generally agreed upon by the CEOs. As opposed to being seen as a form of criticism, this feedback ought to be interpreted as a priceless opportunity for one's own growth and improvement. CTS graduates can receive significant insights from receiving constructive criticism from CEOs or industry leaders. This input can enable them to gain a full grasp of the expectations that are placed on them by the industry. This feedback acts as a catalyst, prompting graduates to proactively investigate avenues for enhancing their technical and computer proficiency and, as a result, fostering their prospects for future accomplishments.

Table 4. Summary of CEO responses.

Knowledge/skills Gap	**Details**
Skills Gap	Concerns over the skills gap observed among engineering college graduates in terms of technical and computer knowledge. Graduates are not adequately prepared to meet the practical demands of industry, which can impact the overall productivity and efficiency of the organization.
Need for Continuous Learning	Importance of continuous learning and professional development for engineering graduates. Graduates are encouraged to proactively update their skills, stay abreast of emerging technologies, and seek opportunities for ongoing education to bridge the gap between academia and industry requirements.
Importance of Adaptability	Significance of adaptability in the rapidly evolving technological landscape. They may highlight that graduates need to be agile in learning new technologies and tools, as it directly affects their ability to contribute effectively to the organization's success.
Collaboration and Communication Skills	In addition to technical skills, it is important to develop strong collaboration and communication skills. Graduates need to work on enhancing their ability to effectively communicate ideas, work collaboratively with teams, and leverage technology for seamless communication and collaboration.

Virtual laboratory and Simulations

Another impact of technological advancement on the field of metrology is the introduction of virtual laboratories and simulations.

When compared to traditional laboratory exercises, the benefits of participating in laboratory activities online are numerous. These benefits include the following:

- Improved accessibility: The use of virtual laboratories and simulations makes it possible for individuals to access these resources from any location with an internet connection. This makes them extremely appropriate for aiding distance learning and remote teaching because of their portability.
- When compared to more conventional laboratory configurations, the use of virtual laboratories and simulations presents the opportunity for cost savings. This can be of particular benefit to groups who only have a limited supply of resources at their disposal.
- Through the employment of virtual laboratories and simulations, enhanced safety measures can be implemented, successfully limiting the possible hazards and dangers associated with the handling of dangerous materials or hazardous equipment.
- Enhanced adaptability: Virtual laboratories and simulations have the flexibility to be customized in accordance with the specific needs of individual students. There are a number of potential components that may be included in this method, including a variety of difficulty levels, the provision of feedback, and the possibility for learners to repeat trials.

(Marxer et al., 2011) advocate for a blended learning approach, with a virtual laboratory as a core component, in order to achieve economic, environmental and social sustainability. Virtual laboratories and simulations allow institutions with a large number of students and limited resources to provide students with the necessary hands-on measurement and laboratory work experience needed to succeed in industry (Ballu *et al.*, 2016). Setting up virtual laboratories and simulations at PAAET will provide an enriched educational environment, offer students access to advanced technological and measurement procedures, and produce graduates of higher calibre.

Guidelines and examples of virtual laboratory and simulation set-up are available in the literature to aid in establishing similar ones at PAAET (Restivo *et al.*, 2009; Zvacek and Restivo, 2018).

Conclusion

The incorporation of computerization techniques into metrology education at CTS is important in order to effectively bridge the knowledge deficit among Kuwaiti labor forces. Currently, upon entering the workforce, graduates demonstrate a lack of proficiency in effectively utilizing computer aided measurements and tools. In order to enhance the proficiency and self-assurance of its graduates, CTS has the potential to address the existing knowledge gap through the implementation of certain modifications. Specifically, the metrology curriculum can be revised to incorporate multimedia approaches inside lectures and tutorials, while also introducing computer aided measurements in the laboratory setting. It is recommended that the allocation of time in the laboratory be evenly distributed between conventional and computerized measurement techniques. The integration of virtual laboratories and simulations into the curriculum of PAAET is imperative due to its significant value in teaching, training, and skill enhancement. Metrology experts are able to acquire, practice, and improve their measuring abilities in a safe, accessible, and efficient manner through the utilization of these tools. Additionally, the use of these tools helps to minimize expenses and mitigate potential dangers that are typically connected with the use of physical equipment. The proposed alterations to the curriculum will result in the development of graduates who possess advanced proficiency in executing manual operations and configuring fundamental instruments, alongside their adeptness in utilizing computerized measuring tools, data storage, and analysis software. The enhancement of the metrology curriculum and laboratory facilities will contribute to the elevation of PAAET's prestige, positioning it as a preeminent institution within the State of Kuwait, the Gulf Cooperation Council (GCC), and the wider Arab region.

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