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Development of an Information Quality Framework for Mechanical Engineering Modules with Enhanced Treatment for Pedagogical Content

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ABSTRACT

The technology based learning systems have capability to comply with diverse requirements of all the stakeholders in the modern education system. In technology based modules, such as those taught in Mechanical Engineering courses, the psychomotor content takes precedence over other domains of teaching and learning. Effective integration of pedagogical content within the Mechanical Engineering modules is of utmost importance for effectiveness in teaching and learning processes in these modules. Published literature is limited in this regard, and hence, the present study focuses on developing a novel an information quality framework for Mechanical Engineering modules, through which an enhanced treatment has been provided to the pedagogical content, in order to meet the educational goals and the industrial requirements worldwide. The novel information quality framework developed in the present study can be used as a guideline for measuring the effectiveness of Mechanical Engineering modules.

KEYWORDS

Bloom's Taxonomy, Information Quality Framework, Mechanical Engineering Modules, Pedagogical Content, Technical and Vocational Education

INTRODUCTION

Technical and Vocational Education (TVE) systems are common throughout the world as they deliver specialised skills required by the modern industry. The primary focus of these systems is on practise based teaching and learning, and generally very limited importance is given to the pedagogical content. This leads to limited transfer of analysis, evaluation and creating skills within the teaching and learning process. Consequently, the newly trained engineers become restrict the fundamental conceptual and product development in modern industries. Alseddiqi et al (2010) has also pointed out the same issues in context of Engineering Education courses. It has been reported that Technical and Vocational Education systems are facing a number of challenges regarding the delivery of appropriate courses and skills required in the industry. It has been further observed that both the industry and the academia are suffering from lack of pedagogical content in engineering courses. An information

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quality framework has been proposed by Alseddiqi et al (2010) that takes into account some basics of pedagogical domain contents from Bloom's Taxonomy. However, the proposed framework lacks in addressing the essential skills required in a professional engineer, which have been identified above as analytical, evaluation and creation.

Alseddiqi (2012) extended the information quality framework in order to evaluate the content of e-learning packages in engineering education courses with respect to two aspects, pedagogical and technological. This framework incorporates specific pedagogical and technological aspects as per modern industrial requirements. The e-learning system content from the technological aspect considers the following quality factors: intrinsic information quality, contextual information quality, and accessibility information quality. These factors are combined from existing information quality frameworks. The pedagogical aspects in the e-learning system content are represented as information quality factors, incorporated from the literature (interpretability, ease of understanding, representational consistency, and concise representation) as well as modern industrial needs (depth of knowledge, personal attributes, motivation, and integration of skills). Furthermore, one pedagogical quality element (interactivity) was added to accessibility information quality.

From the literature survey presented here, it has been identified that the pedagogical content in the existing information quality frameworks is severely limited, which restricts the fulfilment of the goals set by these models. In the present study, Alseddiqi's (2012) extended model has been modified by increasing the quality dimensions, and providing an enhanced treatment to the pedagogical content for Mechanical Engineering modules. This next section presents educational and industrial requirements that must be satisfied by a suitably designed teaching and learning system.

Modern Industrial Requirements from TVE Systems

Industrial requirements need to be fulfilled in order to increase the employability of the engineers in industry. It has been observed that engineers graduating from TVEs seem to lack in higher level cognitive skills such as analytical, evaluating and creating skills. Brown (2002) has reported that engineers should understand the fundamentals of employability skills required in the industry. Students attain knowledge skills in the classroom environment and practise specific skills in practical workshops. It was worth mentioning that teachers have become master practitioners to help students in the learning process and adapt their teaching style according to students' needs.

The Economic Development Board (EDB) and the TVE system conducted a benchmark study of the existing educational systems (TVE, 2006). The study pointed out that substantial demand exists for vocational skills in the industrial market, which should be integrated effectively in the learning process. The study compared three educational systems in order to propose the most suitable TVE system, as shown in Figure 1.

Even though the existing educational system has its advantages and drawbacks, the study highlights the important issues to be considered in a TVE system. Table 1 summarises the modern industrial requirements from existing TVE system, and what the new system may offer to improve the standard of employability skills required by the industry to be integrated into educational courses. Quality Assurance Authority for Education and Trainings' report points out the areas of main strengths and the areas for development in the existing TVE system (Quality Assurance, 2011). The main strengths are:

- Technical skills learned (psychomotor skills);
- Health and safety procedures.

Figure 1. Comparison of three TVE systems

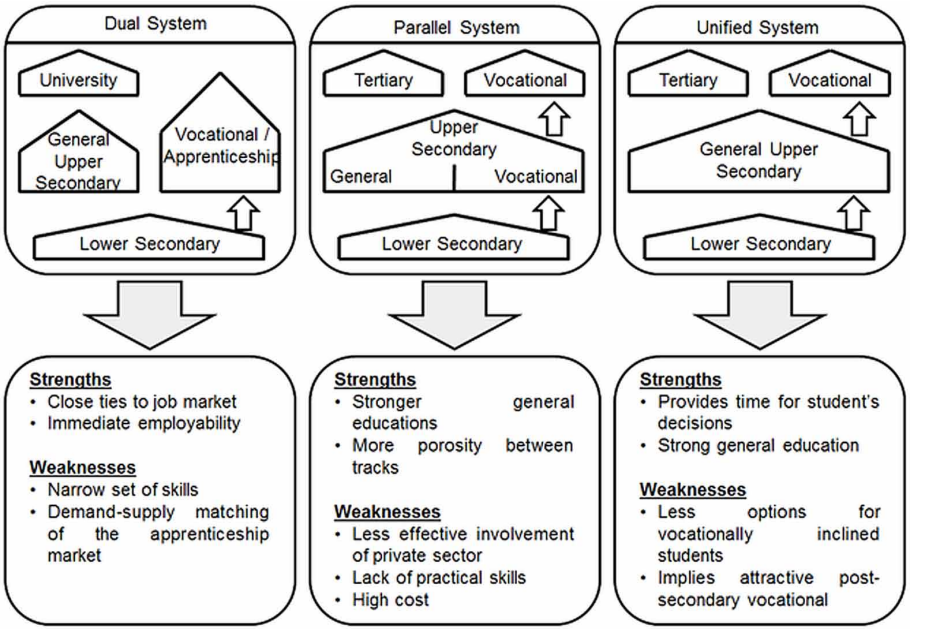


Table 1. Modern industrial requirements

From	To
Insufficient Practical Skills	➢ Significant WBL providing • Up-to-date training • Strong practical experience
Limited contact with private sector	➢ Students are trained by the private sector
	➢ Schools in permanent contact with private sector through flow of WBL programmes
Unsatisfactory work ethics	➢ Early work experience improving graduate's work ethics
	➢ Sustained contact with work life increasing student's maturity
Low employment rate	➢ Strong practical skills
	➢ In-school education in-line with private sector's expectations
	➢ Stronger work ethics

However, the areas for development include:

- Students' performance and involvement in theoretical modules;
- Students' motivation, self-confidence and analytical skills;
- Extra-curricular activities and training programmes to respond to industrial requirements.

The modern industrial requirements can be categorised into three domains, i.e. knowledge proficiencies, personal attributes and specific technical skills. In an international education system, where multi-cultural aspects of teaching and learning process become important, e-learning system should be internationally compatible. Hence, a structured pedagogical content is necessary in

information quality frameworks for the effective evaluation of e-earning system. Furthermore, the review of published literature has indicated that the modern industrial employability skills components requirements could be categorised using various skills elements from Bloom's taxonomy (Anderson & Krathwohl, 2001). The authors suggest employing Bloom's taxonomy to make the Mechanical Engineering modules more compatible with the modern industrial requirements in light of the aforementioned areas of development.

The next section discusses the integration of technological aspects in the TVE system and its influence in improving Mechanical Engineering modules being delivered using e-learning environment.

e-Learning in the TVE System

e-learning has been identified as a possible solution to bridge the gap between the needs of modern industry and the skills provided through teaching and learning process from a TVE institute, where these gaps have already been identified as skills belonging to the higher levels of the cognitive domain in Blooms' taxonomy. Information technology was adopted in mid 80s for teaching and learning purposes in TVEs. Computer laboratories were setup in TVEs throughout the country. More recently, learning resource centres have been initiated with personal computers linked to the World Wide Web (Ministry of Education, 2011). Specialised courses were run for the instructors for effective teaching and learning using computers. The primary purpose of integrating e-learning was to achieve the educational goals.

A new project has been started to make considerable improvements in the outcomes of educational process. It is expected to meet the immediate needs of national development and modern industry. Investments have been made in information technology to achieve efficiencies in the delivery of engineering modules and to develop an e-learning culture within the institutions. Students will be provided with the values and skills necessary for the information society and knowledge economy. Furthermore, curriculums are being developed for various modules, including Mechanical Engineering modules. Instructors' and students' training in the use of e-learning system is part of the project.

e-learning can be adopted to introduce a new culture of teaching and learning in TVEs. Theoretical modules can be integrated and taught in a manner which motivates TVE students. e-learning content for theoretical modules contain videos, links, animations, aphs and numerical representations, as well as demonstration of employability skills that should be attained during practical modules in laboratories and/or workshops. TVE curriculum should be adapted to meet the needs of information technology integration in the teaching and learning process, and hence modern industrial requirements. Curriculum itself should be modified to support internet, interactive multimedia and software in order to develop TVE students' self-learning and self-assessment skills.

TVE specialists are aware of the fact that the curriculum content, teaching and learning methodologies and assessment strategies must be evaluated and adapted to support the integration of technology in the teaching and learning process. This can be achieved by adapting the teaching and learning resources/materials based on the needs from industry. However, national and international industries should be considered as well. Moreover, a great deal of attention should be paid towards modern needs for employability skills. It has been noticed that work ethics skills, cultural awareness and language skills are considered beneficial by the local industries, and should be vital aspects in designing the curriculum.

It is evident that the focus is on improving the contents of the modules in TVE, and to integrate the appropriate technology in order to meet modern industrial needs. Pilot studies have been implemented in order to achieve this; however, it is noteworthy that an information quality framework needs to be developed, with an enhanced treatment for the pedagogical content. The purpose of this is to evaluate the effectiveness of the engineering modules, especially Mechanical Engineering modules. This will help improve the existing modules on a continual basis. The next section therefore reviews the available literature on information/data quality frameworks for e-learning system content.

Existing Information Quality Frameworks

The available published literature indicates that the development of an e-learning system has three fundamental aspects, i.e. institutional, pedagogical and technological. These aspects include user-analysis, knowledge/information analysis and communication, pedagogical and technological structures, pedagogical and technological representations, interface and navigation design. The primary goal is to provide a quality framework that evaluates an intelligent e-learning system so that students can access this to learn case studies, and it can be tested in ways that best match their educational needs and requirements. It is obvious that most of the work is concentrated on developing an effective learning curriculum, using different teaching and learning methodologies and up-to-date information technology.

Wang and Strong (1996) initiated a pioneering work for establishing standards for data/information quality frameworks. The purpose was to critically evaluate users' viewpoints towards the content of e-learning systems and give priority to quality as an evaluation of excellence. For example, in TVE developmental projects, top priority is given to restructuring the learning content, adopting new teaching and learning methods, and integrating technology in the learning environment. On the other hand, less attention is given to evaluating the effectiveness of the newly developed projects and their characteristics. It has also been indicated that a specific framework for evaluating e-learning systems in TVE is essential in evaluating their effectiveness.

It is evident that pedagogical and technological aspects could not continually improve without a quality evaluation process. Educators believe that using an information quality framework would assist TVE to measure e-learning content effectiveness and provide motivation for creating innovative content that meets modern and local industrial needs. Table 2 summarises various information quality frameworks from the original work of Wang and Strong. It is apparent that the frameworks have the same four quality factors as presented by Wang and Strong; however, differences appear in the quality dimensions. The justification was that each framework was formulated as per specific requirements. Various quality dimensions have been found in the literature. The authors believe that these frameworks are generic and could be used for evaluating any e-learning systems' content. In

Table 2. Comparison of data/information quality frameworks

Data/Information Quality Framework	Quality Factors																		
	Intrinsic Quality Dimensions					Contextual Quality Dimensions						Representational Quality Dimensions				Accessibility Quality Dimensions			
	Believability	Accuracy	Objectivity	Reputation	Consistency	Value-added	Relevancy	Timeliness	Completeness	Amount of Information	Verifiability	Interpretability	Ease of Understanding	Representational Consistency	Concise Representation	Accessibility	Access Security	Response Time	Availability
Wang & Strong (1996)	X	X	X	X		X	X	X	X	X		X	X	X	X	X	X		
Gertz (1996)		X					X		X	X									X
Redman (1996)		X	X				X		X	X	X	X		X	X				X
Zeist & Hendricks (1996)		X					X	X		X			X			X	X		
Jarke & Vassiliou (1997)	X	X			X		X	X	X			X		X			X	X	X
Chen et al (1998)		X					X	X	X	X								X	
Alexander & Tate (1999)	X	X	X	X				X	X	X				X		X			
Dedeke (2000)		X			X		X	X	X	X			X			X		X	
Zhu & Gauch (2000)	X		X				X	X								X		X	
Leung (2001)		X					X	X	X	X						X	X	X	
Khahn et al (2002)	X		X		X			X	X	X			X	X		X		X	
Klein (2002)	X		X				X	X	X	X									
Mecell et al (2002)		X			X			X	X										
Liu & Han (2005)		X		X	X		X	X	X					X		X		X	
Besiki et al (2007)		X		X			X		X		X					X	X		
Alkhattabi et al (2007)	X	X	X	X	X		X		X	X	X		X	X		X		X	X

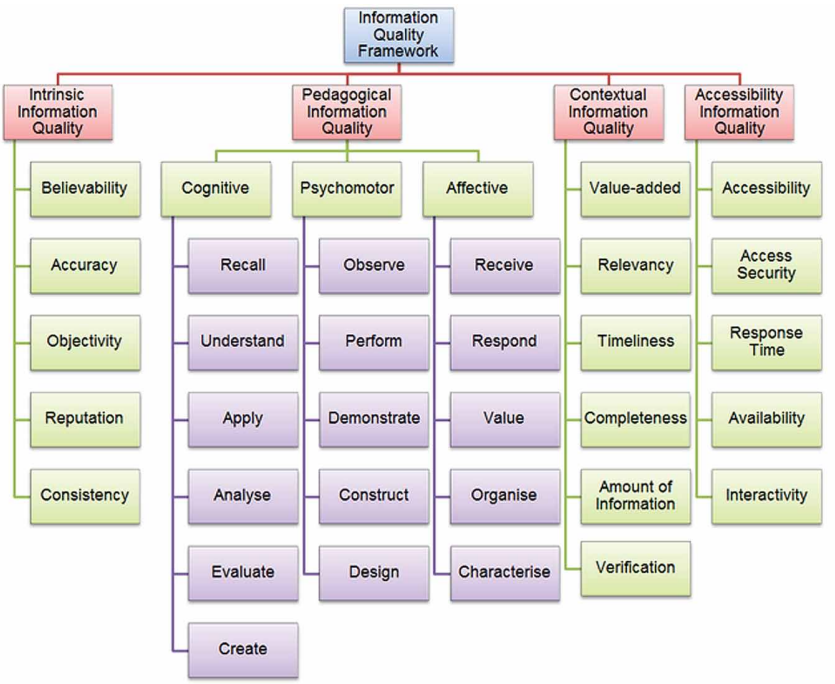
the present study, specific elements have been added to measure pedagogical issues that are related to specific industrial needs. The next section presents the extended information quality framework developed in the present study. A closer scrutiny of this model suggests that it does include quality of the e-learning content corresponding to pedagogical requirements.

Extended Information Quality Framework

An extended information quality framework has been developed in the present study where the pedagogical content of the model has been given enhanced treatment. This model is shown in Figure 2. It incorporates specific pedagogical aspects, based on Bloom's Taxonomy, where the three domains have been added i.e. cognitive, psychomotor and affective, as per modern industrial requirements. The e-learning system content from the cognitive aspect considers the following quality factors: Recall, Understand, Apply, Analyse, Evaluate and Create. Similarly, for psychomotor aspect, the following quality factors have been identified: Observe, Perform, Demonstrate, Construct and Design. The affective aspect has the following quality factors: Receive, Respond, Value, Organise and Characterise. These quality factors are combined with the existing information quality frameworks.

The quality dimensions of the framework should be critically integrated and considered while developing the content of EECs in a TVE system. The framework should be used as a guideline to evaluate the effectiveness of the content of the e-learning system. Furthermore, some quality dimensions, which are related to pedagogical aspects, have been added to extend the existing quality information framework. The purpose was to meet the identified specific industrial needs. Also, the extended model should assess the integration of pedagogical and technological aspects of EECs.

Figure 2. Extended information quality framework



CONCLUSION

An extended information quality framework has been developed with an enhanced treatment for the pedagogical content (Alkhattabi et al., 2010). The developed framework could be used to measure the effectiveness of e-learning content for EECs in TVE systems. The model has been developed on the basis of educational goals (TVE goals), modern industrial requirements, and existing information quality frameworks. The model is consistent with both educational objectives and industrial requirements. The extended information quality framework will be used to evaluate the effectiveness of EECs in TVE system. The framework will be used as a diagnostic quality tool to benchmark the EECs for future improvement.

REFERENCES

Alkhattabi, M., Neagu, D., & Cullen, A. (2010). Information Quality Framework for e-Learning Systems. *Knowledge Management and e-Learning International Journal*, *2*(4).

Alseddiqi, M. (2012). Performance Improvement of Technical and Vocational Education in the Kingdom of Bahrain [Doctoral thesis]. University of Huddersfield.

Alseddiqi, M., Mishra, R., & Pislaru, C. (2010). Design and Development of an On-Line Work-Based Learning (WBL) Module to Enhance the Technical and Vocational Education (TVE) System in Bahrain. In *Global Learn Asia Pacific 2010: Global Conference on Learning and Technology* (p. 1168).

Anderson, L., & Krathwohl, K. (2001). *A taxonomy for learning, teaching, and assessing: a revision of Bloom's taxonomy of educational objectives. Complete edition*. New York: Longman.

Brown, B. L. (2002). *Generic skills in career and technical education.* Retrieved from http://www.cete.org/acve/docgen.asp

TVE Directorate in Bahrain. (2006). *Private Sector Requirements in Kingdom of Bahrain*, Ministry of Education: Internal Report.

Ministry of Education (MoE). (2011). King Hamad's School of the Future Projects. Retrieved from http://www.moe.gov.bh/khsfp/

Quality Assurance Authority for Education and Training (QAA). (2011). The Vocational Unit Review. Retrieved from www.qaa.bh

Wang, R.Y., & Strong, D.M. (1996). Beyond accuracy: What data quality means to data consumers. *Journal of Management Information Systems*, *12*(4), 5–33. doi:10.1080/07421222.1996.11518099

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