Journal of Theoretical and Applied Information Technology
30th November 2016. Vol.93. No.2

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

A NOVEL APPROACH OF MULTIMEDIA INSTRUCTION APPLICATIONS IN ENGINEERING EDUCATION

[1]ATAOLLAH ZAREI ,[2] KHAIRIYAH MOHD. YUSOF, [3]MOHD FADZIL BIN DAUD, [4]HOSHANG KOLIVAND AND [5]TANZILA SABA

[1,2,3]Center for Engineering Education, Universiti Teknologi Malaysia, Skudai, Johor, Malaysia

[4]Department of Computer Science, Liverpool John Moores University, Liverpool, UK, L3 3AF

[5]College of Computer and Information Sciences Prince Sultan University Riyadh 11586 Saudi Arabia

Contact author E-mail: tanzilasaba@yahoo.com

ABSTRACT

Effective use of educational technology depends on knowledge of why and how to utilize technology to solve teaching and learning problems. The present study first conducts a systematic literature review of the limited studies undertaken on multimedia instruction applications for engineering education to critique the current status of knowledge in this area. The conventional qualitative content analysis method was employed for data analysis. The results highlighted the incompatibility of three basic educational elements i.e. engineering curriculum, educational resources and engineering students' learning characteristics all of which posed major challenges in teaching and learning engineering courses. Multimedia instruction enhances engineering students' understanding of engineering concepts, procedures, problems and solutions through direct visualization. Furthermore, it could indirectly assist students in achieving higher order learning levels and skills through enhancing or supporting educational resources and increasing students' motivation. Mobile multimedia instruction and a student-generated multimedia learning approach to improve engineering education are suggested for future research.

Keywords: *Educational Technology; Engineering Education; Multimedia Instruction; Teaching And Learning Problems; Systematic Literature Review*

1. INTRODUCTION

Multimedia instruction is one of the well-known teaching methods and using technology in the realm of education. Multimedia learning experts define multimedia as the combination of words and pictures. The words can be textual or verbal, and the pictures can be any graphics such as photos, illustrations, videos, and animations [1]. Multimedia instruction is based on the cognitive theory of multimedia learning (CTML). According to this theory, multimedia learning occurs when a learner builds mental representations from words and pictures connecting them to his or her previous knowledge [1]. This theory is grounded in three research-based principles: dual-channel theory, limited capacity theory, and active processing theory [2]. According to dual-channel theory, working memory has two different channels for auditory and visual representation which are processed differently, separately and concurrently [3]. In the limited capacity theory, however, each part of working memory has limited capacity. Thus, it is impossible to store or manipulate infinite amounts of information [4]. Finally, the active processing theory states that individuals construct their knowledge in meaningful ways by serving relevant materials, organizing them into a coherent mental structure, and integrating them with their prior knowledge [1].

Mayer [5], extracted twelve multimedia instruction principles to increasing learning effectively through reducing learners' cognitive load. Based on these principles, people learn better when: extraneous material is excluded, essential material is highlighted, graphics and narration are combined, words and pictures are presented at the same time and near each other, words are presented in conversational style, spoken by a friendly human voice, and material is segmented and presented in learners' pace. However, as Reeves (2006) argued, the mentioned principles are not enough for conducting effective multimedia instruction in practice. He stated that multimedia instruction should be considered as design rather than science.

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

Therefore, the designers should try to find effective solutions for practical problems in the context based on existing solutions and available facilities via an iterative cycle.

Regarding different problems facing students and instructors in learning and teaching subjects in each field, there is a need to consider each field separately. It means, for each field such as engineering, multimedia instruction designers should have enough knowledge about existing problems and multimedia instruction-based solutions in the field.

Regarding the lack of research studies which categorize teaching and learning problems and multimedia instruction-based solutions for learning and teaching engineering, this study is conducted to help the multimedia instruction designers for engineering education. Furthermore, it can help engineering education researchers to figure out current issues and challenges in multimedia instruction research for further research by addressing the current state of research in this area. Thus, the main objectives of this research are:

- To explore the current state of multimedia instruction research in engineering education
- To investigate the challenges in teaching and learning engineering courses that can be solved via multimedia instruction.
- To investigate the ways through which multimedia instruction improves teaching and learning in engineering courses.

Reviewing existing research studies related to the applications of multimedia instruction for teaching and learning engineering subjects can be considered as a way to achieve the mentioned objectives.

2. PROPOSED METHODOLOGY

2.1. Data Collection

The data collection method for this research was adopted from Kitchenham [6] procedure of collecting data in a systematic literature review to detect and collect as much appropriate literature as possible. The general steps consist of: identifying search resources or databases, defining the search term, and explaining inclusion and exclusion criteria. The elaboration of each step is as follows:

2.1.1. Databases

Three major online databases associated with the field of education were searched. These databases were Web of Science, ERIC (Education Resource Information Center), and Scopus.

2.1.2. Search term

The titles, abstracts, and keyword fields of the databases were searched to find all papers dealing with multimedia instruction applications for engineering education. The search term was:

"multimedia AND engineering AND (courseware OR instruction OR teaching OR education)"

2.1.3. Inclusion and exclusion criteria

This review studied journal articles from the last eleven years; i.e. 2004 until end of 2014. In addition, to further improve the quality of the research, only peer reviewed journal papers were reviewed. Applying these conditions, 101 papers from Web of science, 50 papers from ERIC, and 100 papers from Scopus were collected. After combining and excluding similar papers, 201 papers were studied.

In the first stage, the unrelated papers were excluded by skimming the titles, abstracts, and occasionally, the body of the papers. As this review focused on engineering education at the university level, papers [7] investigating engineering education at lower levels were excluded from the list of candidate papers. Another limitation was the interactivity level of learning materials. There are different approach to interactivity in multimedia learning [8], however, high interactive multimedia learning environments like simulation, virtual reality, and micro-world were excluded in this research because the fundamental learning theory for high interactive learning environments is essentially different from CTML as the fundamental theory of multimedia instruction. Besides, according to the Moreno, and Mayers'[9], definition of interactivity in multimedia instruction is limited to the four basic features of the learning material: start, stop, forward, and backward. Therefore, papers that looked into simulation like [10] and virtual labs like [11] were excluded from this study. Subsequent to the first phase of analysis, 45 papers remained.

2.2 Data analysis method

Considering the objectives of this study, i.e. investigating diverse challenges in teaching and learning and ways of overcoming these challenges through multimedia instruction, the papers were not categorized into smaller groups. Also, qualitative document analysis method was chosen to analyze papers with diverse and complex challenges and solutions. The general phases of this method are:

Journal of Theoretical and Applied Information Technology
30th November 2016. Vol.93. No.2

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

reading all the papers to obtain the whole picture, open coding, and finally, categorizing and organizing codes into meaningful hierarchical clusters and themes [12]. QSR Nvivo 10 software was used for performing qualitative data analysis. The constructed themes were checked and confirmed by two experts to increase the validity of the results.

3. FINDINGS

3.1. The current state of multimedia instruction research in engineering education

The selected papers are listed in Appendix 1. For each paper, the authors, publishing year, course, field, multimedia presentation technique, and delivery platform are mentioned. Several multimedia presentation techniques were identified from the selected papers: a) standard multimedia (M), which is the combination of texts, sounds, and graphics, b) animation (A), in which animated graphics, sounds, and texts are combined, and c) video (V), whereby real videos were used. In addition, three different delivery platforms were recognized: C was used to identify computer-based instruction, W for web-based instruction, and M for mobile-based instruction.

The following figures and tables show the quantitative analysis of the results. Fig. 1 depicts the number of research papers for each year in the last decade. Although the data reveals fluctuations in the last ten years, multimedia instruction for engineering education research was found to be an attractive path demonstrating a large potential for research and innovation whose claim is supported by the diversity of engineering fields and courses depicted in Table 1. Nevertheless, the variety of papers in engineering fields does not imply any significance of multimedia instruction in different engineering fields. Other factors, such as field expansion around the world, might provide better explanations for this phenomenon. For instance, mechanical engineering is taught in most engineering universities, and as such, it could not be compared with other fields like graphic engineering or geotechnical engineering.

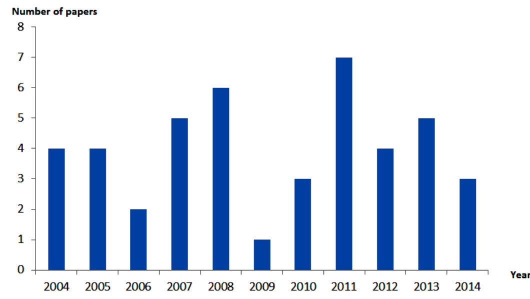

Fig. 1. The Number Of Research Papers That Studied Multimedia Instruction For Engineering Education From 2004 Until 2014

Table 1. The List Of Fields And The Number Of Papers For Each One

Row	Engineering Field	Num
1	Mechanical	10
2	Electrical	6
3	Computer	5
4	Chemical	4
5	Industrial	5
6	Materials	3
7	Civil	3
8	Biosystems	1
9	Building services	1
10	Energy	1
11	Geotechnical	1
12	System	1
13	Graphics	1
14	Mechatronics	1
15	General	4

Fig. 2 reveals the different delivery platforms employed for multimedia instructions from 2004 to 2013. It can be seen that the number of papers studying computer-based multimedia instruction gradually decreased, while the number of web-based multimedia instruction research papers gradually increased with only three out of thirty eight papers using both platforms. Thus, there is a platform shift from computer to web for multimedia instruction for engineering education research. Furthermore, mobile-based multimedia instruction was found to be of limited use in the period as there were only two papers investigating mobile-based multimedia instruction for engineering education.

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

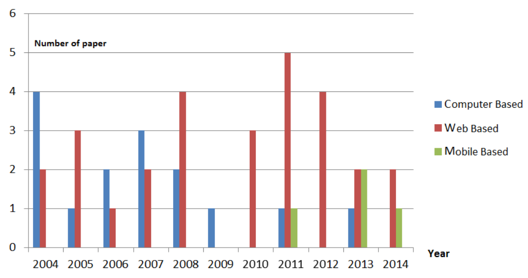

Fig. 2. The Number Of Multimedia Instruction Delivery Platforms From 2004 Until 2014

Fig. 3 shows the multimedia presentation techniques and the number of papers using these techniques. Seventy nine percent of the papers used standard multimedia, fifty percent used real video, and forty two percent used animation to illustrate the intended concept or procedure. Nevertheless, the combination of standard multimedia and video was the most frequently used method followed by the combination of standard multimedia and animation which showed that the use of only one multimedia presentation technique had not been a favorable method for teaching engineering courses and that instructors and designers utilized different presentation techniques based on students' needs.

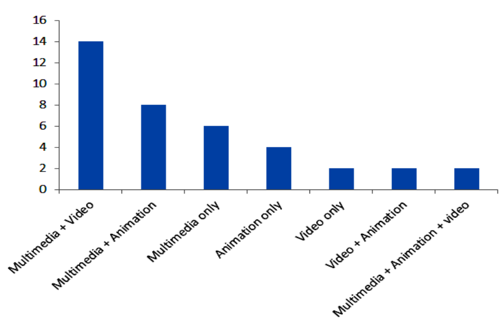

Fig. 3. Multimedia Presentation Techniques And The Number Of Papers That Used Those Techniques

3.2.Engineering Education Challenges

The main challenges in teaching and learning engineering courses at universities, which could be solved by multimedia instruction, are synthesized in Fig. 4. The challenges had been due to the incompatibility of three basic educational elements: engineering curriculums, educational resources, and engineering students' learning styles.

The first element, i.e. engineering curriculums involves engineering programs, curriculum design and development some of whose characteristics cause teaching and learning difficulty. First, engineering courses and subjects are difficult to be understood by students [13-19]. Second, some engineering disciplines, such as industrial engineering, represent a combination of different branches of knowledge and skills, including physical science, social science, and engineering principles and methods [20, 21]. Finally, there is a gap between theory and practice. In fact, even though a considerable part of engineering subjects and courses are realistic and practical, existing theories are unable to cope with some problems and challenges in real situations [22]. For example, handling hands-on exercise and understanding practical measurement instances without relevant work experience in applying standard rules to non-standard building design services can be very difficult [22].

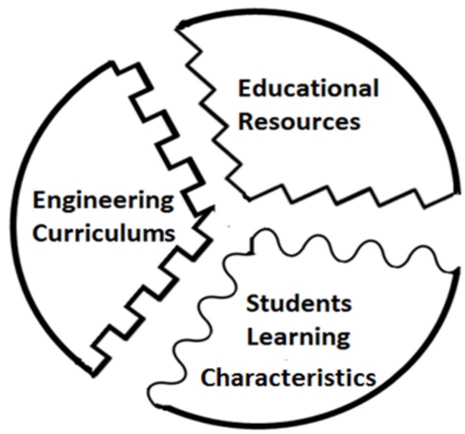

Fig. 4. Incompatibility Of Students' Learning Styles, Educational Resources, And Engineering Curriculum

The second element, i.e. educational resources, incorporates teachers, teaching time, course books, and practical experiences the main characteristic of which is limitation. Educational resources are associated with different sets of limitations. The first limitation, i.e. limitation in quality, means that the quality of resources is insufficient. Some educational resources, such as course books, are incapable of explaining difficult concepts due to printing limitations. In some cases, authors include extra educational materials in the form of CDs or DVDs to the book to remedy the situation [19]. The second limitation is concerned with quantity. In other words, the quantity of the resources is inadequate. For example, the number of existing lab facilities or the amount of lab materials is not enough to cater to the needs of students. This is because, executing experimental tests for and with civil engineering students can be very expensive as the cost of conducting a bending test on a 9-meter

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

long reinforced concrete beam can amount to USD15,000 [23]. The last limitation is concerned with accessibility or the lack of educational resources accessible for students. Generally, students have limited access to some educational resources like course books and instructors. Furthermore, on occasions, it is impossible to provide real experience for students to understand concepts, procedures, and challenges in real situations which are required in the achievement of course objectives. For example, it is highly unlikely to provide geotechnical engineering students with real deep excavation experience (Yuen & Naidu, 2007).

Finally, the last element is the learner or the engineering students whose main characteristic is diversity. There are two types of student diversity as related to effective learning. First, diversity in students' learning styles or students' different preferences to receive and process information which have been growing due to expansion of educational technology (Patterson, 2011). It is noteworthy to mention that despite the variety in engineering students' learning styles, most are visual, sequential, sensing, reflective [24], and active [25]. Second, it has been discovered that students' learning speed differs and they learn in their own speed due to varying backgrounds [13]. Among other learning characteristics considered by the researchers one can refer to two salient learning characteristics; students' intention to have immediate access to educational resources [26] and their consequentialism approach to learn subjects directly related to their future jobs (Fraile-Ardanuy, Garcia-Gutierrez [27].

The teaching and learning challenges and the impact of the associated characteristics are elaborated in the following subsections.

3.2.1. Incompatibility of educational resources' characteristics and engineering students' learning characteristics

The incompatibility of educational resources' characteristics and students' learning characteristics reduces learning quality. There are several types of incompatibilities: incompatibility of traditional teaching styles and engineering students' learning styles, incompatibility of teaching speed and learning speed, incompatibility of course books style with students' learning styles, and poor accessibility of educational resources.

Firstly, incompatibility of traditional teaching styles and engineering students' learning styles means that engineering students are mostly visual and sensing learners [24]. However, the teaching method employed in engineering classes is usually traditional or predominantly verbal [13, 17]. Therefore, traditional lectures are not in harmony with the learning styles of engineering students. This incompatibility decreases teaching and learning quality and students' motivation [24]

Incompatibility of teaching speed with learning speed in traditional classes means that the teaching pace is too fast, and hence, students are unable to follow the lecturer and fail to learn correctly. The students' learning speed differs mainly due to their previous knowledge, but the teaching speed is identical for all [13].

Incompatibility of course book style with students' learning styles, the third incompatibility, is indicative of the fact that engineering course books, being the main educational material, are text-based, and so, difficult concepts and procedures are not enough comprehensible for the visually-oriented students. For instance, according to Ozcelik and Acarturk [19], the computer network course book does not provide sufficient comprehension for computer engineering students.

The forth incompatibility, i.e. poor accessibility of educational resources is suggestive of engineering students' need of immediate access to learning materials while doing learning activities. However, student access to lectures may be limited to the class schedule in traditional systems. Besides, they may not have immediate access to other learning materials such as course books [26].

3.2.2. Incompatibility of engineering curriculums' characteristics and students' learning characteristics

Some teaching and learning problems are caused by incompatibility of engineering curriculums with characteristics of students' learning styles. In this regard, unfavorable courses in the engineering programs and inflexibility of class schedules are two salient issues, which are explained below.

The first problem is related to existing unfavorable courses in engineering programs. Engineering students feel some courses do not have a bearing on their future jobs. So, they may not be strongly motivated to pursue such courses. As a consequence, teaching and learning such courses are difficult for both instructors and students. Fraile-Ardanuy, Garcia-Gutierrez [27] reported the existence of this problem in the course of teaching and learning electrical machinery for civil engineering students. The second problem, class schedule inflexibility signifies that students' low class attendance is a salient issue which should be

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

remedied by a plan to support students based on their time and place [14, 16].

3.2.3. Incompatibility of engineering curriculums and educational resources

The limitations of educational resources in quality, quantity, and accessibility to cover educational needs have led to many challenges faced by lecturers involved in teaching engineering courses which include teaching difficult concepts and procedures, teaching amalgamated courses, and teaching within a limited class time.

The first problem is that the engineering concepts and procedures are usually too difficult to be explained by instructors via the traditional chalk and talk teaching method [13-17]. For example, Junaidu [17] asserted that some data structure algorithms, such as Dijkstra's single-source shortest paths algorithm, are very difficult to be explained on the board.

The second problem is difficulties in teaching amalgamated fields and courses by only one lecturer via traditional teaching methods. In fact, students need to learn via different approaches and resources to be able to have a holistic view and a bigger picture of the issue [20, 21].

The third problem concerns teaching time limitations which cause numerous problems in covering the syllabus and achieving course objectives. For instance, Peñín, Morales [28] reported this problem for teaching the technical drawing course.

3.3. Multimedia Instruction Applications

Multimedia instruction solves or reduces the above mentioned challenges in different ways. This improves engineering students' learning directly by increasing students' understanding and students' learning in different levels indirectly via enhancing or supporting educational resources and increasing students' motivation. The applications, shown in Fig. 5, are elaborated in the following subsections.

3.3.1. Increasing students' understanding

Multimedia instruction increases engineering students' understanding of difficult concepts and procedures directly. There are two different ways to achieve this objective: visualization and interactivity.

In visualization, multimedia materials are employed to visualize difficult abstract concepts and procedures to support visually-oriented engineering students [24, 29] . Junaidu [17], for instance, used web-based animation to explain difficult data structure algorithms such as Dijkstra's single-source shortest paths algorithm. The results of his study showed that students' learning achievement improved when they used these animations along five years of exploration. The power of different illustration techniques to explain difficult concepts and procedures are not identical. For example, Sidhu [13] submitted that it is impossible to show curvilinear motion of a robotic arm while moving from one point to another, necessary for explaining motion path algorithm via static graphics or 2D animation, and so, used 3D animation to explain this algorithm. Therefore, using the proper presentation technique is of paramount importance, but there are challenges in choosing the appropriate presentation technique, which are further elaborated in the discussion section.

Another aspect of visualization is using real photos and videos to support engineering students who are predominantly sensing learners [24, 29]. This is likely to assist them in sensing and realizing engineering concepts, procedures, and artifacts in real situations [16, 23, 24, 30-33]. For example, Yuen and Naidu [33] used a video file, filmed in one year period, recording whole construction sequence to explain construction sequence of deep basement excavation. The researchers suggested this method to bridge the gap between theory and practice.

Visual materials not only help engineering students to understand concepts and procedures, but also enable them to understand engineering problems. Research suggests that real videos can be employed to explain real engineering problems and to describe the real situation of a problem as part of multimedia case study approach for teaching engineering courses such as Introduction to Engineering [34-38]. In doing so, understanding problem definition and the real situation is crucial for solving problems especially in engineering fields.

Interactivity, as the second way, forms an important capability of multimedia instruction which can increase students' learning and understanding as students can use interactive multimedia material based on their learning speed [13, 16, 31, 39] choosing, stopping, starting, rewinding, forwarding, and repeating while using it. These facilities enable the students to control the content and information flow further stimulating students into action [31].

Journal of Theoretical and Applied Information Technology
30th November 2016. Vol.93. No.2

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

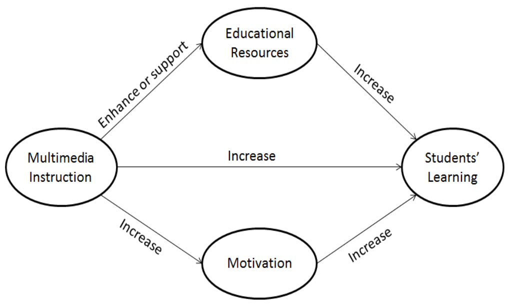

Fig.5. Ways Of Improving Learning Through Multimedia Instruction

3.3.2. Supporting educational resources

Multimedia instruction is capable of supporting educational resources such as course book, instructors, teaching time, and lab facilities via different ways. Multimedia instruction can support instructors through different ways enabling engineering teachers to explain difficult concepts and procedures effortlessly [13, 17, 40]. For example, Technology Assisted Problem Solving (TAPS) package helps instructors to explain motion path algorithm by showing curvilinear motion whose task is too difficult to explain via the traditional method [13]. Furthermore, multimedia instruction can support instructors to conduct other teaching methods. For example, it can be combined with problem based learning and case based learning methods to assist students in achieving higher order cognitive skills and soft skills such as critical thinking and communication skills [31]; [33, 34, 36-38, 41-45].

Through the second way, the reduction of lecturing time, multimedia instruction enables instructors to teach difficult concepts and procedures in less time [13, 17, 76-78]. Therefore, the instructors have more time to conduct other teaching methods and encourage students to do more learning activities in class.

The third way, i.e. replacing or supporting practical experiences, providing virtual experience through presenting engineering procedures via real videos or other multimedia presentation techniques, the gap between theory and practice and the difficulties in providing real experience for students can be covered [20, 23]. Furthermore, multimedia instruction can support students in doing practical learning activities. For instance, Patterson [24] used diagrams, color photos, lab equipment videos and video-based instruction of experiments as a multimedia lab manual for preparing students to do lab activities. The results showed that students' learning and satisfaction in the group that used multimedia lab manual were more enhanced compared to the other group that used the text-based manual.

In the fourth way, i.e. increasing the accessibility of educational resources, involved heterogeneity of students in terms of intellectual aptitude, availability throughout the day, and lodgings which means that there is an ever-increasing need for asynchronous teaching methods in which students impose their own study pace, at the time and place they themselves decide. Increasing students' access to a course material through multimedia instruction assists them in learning out-of-class according to their pleasure [31, 42, 43]. Nevertheless, students need immediate access to learning materials which is not possible through PC-based multimedia instruction. Mobile multimedia instruction is an effective solution to support students' learning activities [26].

The fifth way is to support course books. Taking into account the limitation of course books to explain difficult concepts or procedures, some authors developed multimedia materials to remedy the situation. Furthermore, by adding QR code to the course book, students are empowered to watch related multimedia materials while reading books via smart phones. For example, by adding QR codes to computer networks course book and using smart phone to watch related animations while reading the book, students' retention improved using the book and watching multimedia animation by laptop or PC [19]. The researcher also noted that this method increased students' motivation to spend more time on course materials.

3.3.3. Increasing students' motivation

As Benkrid and Clayton [44] claimed, the biggest enemy of students' learning is apathy. Multimedia instruction can increase engineering students' interest, satisfaction, self-efficacy, self-confident, and motivation because it enhances students' achievement, it is more appealing, and creates a linkage between theory and real-world applications [15, 24, 31, 44, 45]. For instance, the majority of students participating in the survey found that multimedia laboratory manual had been more interesting than text-based manual [24]. In addition, increasing students' motivation enhances the quantity and quality of their learning because it encourages students to study more [44] increasing students' cognitive engagement [1].

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

4. DISCUSSION

In this section, both the challenges and the solutions in the realm of multimedia instruction for engineering education are elaborated to suggest future research thus achieving the third objective of this study.

4.1. Challenges related to the why question

As mentioned earlier, a major issue in engineering education research is investigating effective solutions for engineering education problems. Thus, an in-depth study of the educational challenges seems to be in order at this juncture. Numerous challenges exist in engineering education. Although Figure 4 does not show an exhaustible list of the existing challenges, it can be used to describe some major challenges in teaching and learning engineering courses at the university level. Although multimedia instruction can relatively cover the mentioned challenges, it cannot solve these problems alone. Furthermore, lack of instructors' intention to change their teaching methods and use innovative teaching methods akin to multimedia instruction still remains as a big issue.

Much research has to be conducted to remedy the incompatibility of engineering curriculums and engineering students' learning characteristics as an engineering education challenge. The new generation of students are usually goal-oriented and wish to engage in learning activities that suit their needs [46, 47]. Not surprisingly, they do not wish to be involved in courses that are thought to be irrelevant to their future jobs. Although using multimedia instruction increases their motivation to learn such courses, the curriculum development experts should undertake more research to deal with this issue [79-81].

Besides, engineering academics, as an educational resource, have a crucial role in using other educational resources to eradicate or lessen the incompatibility of the existing resources, students' learning characteristics and engineering curriculums. This means that they should not only enhance their teaching effectiveness, but also make or follow effective strategies to use other educational resources effectively. In doing so, the main challenge is lack of rewards or incentives for teaching and low digital fluency among faculty members. According to the NMC Horizon Report, "There is an overarching sense in the academic world that research is first, while teaching is an obligation that must be performed." Furthermore, "training in the supporting skills and techniques are rare in teacher education and non-existent in the preparation of faculty." [48]. Therefore, there is a need to conduct more extensive research to explore the proper ways for supporting the lecturers. Student-generated multimedia learning, which is elaborated in the section 4.2.3, can be considered as an alternative to face this issue [82,83,84].

4.2. Challenges Related to the How Question

There are several challenges in the existing multimedia instruction solutions which have been discussed in section 3.3. Selecting proper material presentation techniques and delivery methods, and the role of students are the main challenges that need more deliberation and research to improve the multimedia instruction capabilities and effectiveness [85,86].

4.2.1. Selecting proper infrastructure

The First challenge concerns the change in the global trend of web access and watching multimedia materials from desktop to mobile. For example, according to ComScore reports, in the U.S., the time spent on mobile apps exceeded desktop web access in Jan 2014 [49] and in Germany, mobile video users grew by 215%, whilst online video via desktop PC or laptop users grew only 1.5% [50]. Also, according to YouTube statistics, 40% of its global watch time comes from mobile devices like smart phones and tablets [51]. Furthermore, engineering students, as members of the new generation of learners, should be supported by mobile multimedia instruction because they are not only visual and sensing learners, but also mobile, impatient, always on-line and need immediate support [46]. In addition to providing ubiquitous access to the learning materials, smart phones can support students through innovative ways like location aware multimedia instruction [52]. Despite the need for instructional designers to migrate to mobile multimedia instruction, this was studied in only two out of thirty eight papers. Thus, there is a need to conduct more research on mobile multimedia learning and instruction.

4.2.2. Selecting proper techniques

The second challenge is making decisions as to the appropriate techniques for presenting educational multimedia materials such as simple multimedia, videos or animations, especially 3D animations. In fact, forty two percent of the papers on educational animations have used a successful method of teaching and learning procedural knowledge. From the lecturers' viewpoint, static graphics or even 2D animations cannot adequately and accurately explain the concept or procedure in some subjects, but there is no comparative study between effectiveness of animation and static

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

graphics on students' learning achievement [13]. However, using animations instead of standard multimedia materials for teaching and learning is not advocated by all multimedia instruction experts. According to Mayer [5], people do not necessarily learn better from animation than from static diagrams. Dwyer and Dwyer [53] stated that animation is not a useful instructional tool for learning hierarchically structured contents or factual and conceptual types of information, while Wong, Marcus [54] submitted that educational animations are more effective for learners possessing higher levels of prior knowledge and certain knowledge domains like human motor skills [55]. Regarding the cost of developing educational animations, especially 3D animations, more research has to be undertaken to investigate the effective use of different multimedia presentation technics for teaching and learning engineering subjects [87].

4.2.3. The material producer issue

The third challenge involves lack of research on student-generated multimedia material as a multimedia learning approach. The lecturer-generated multimedia material is the predominant strategy of multimedia instruction for engineering education. In fact, in all the reviewed papers, the multimedia learning materials were developed by researchers and students watching them as consumers whose strategy has some limitations. For example, most lecturers have insufficient time to develop multimedia learning materials. Some may not possess adequate skills to produce high quality multimedia learning materials. However, according to the NMC Horizon Report, one of the key trends to speed up higher education technology acceptance is the shift from students as consumers to students as creators [48]. This strategy is supported by the constructivism and the social constructivism learning approaches. Moreover, this can increase students' creativity and skills in digital material creation. Regarding the unique capabilities of mobile phones in capturing a situation and producing multimedia materials, mobile learning experts suggest that the multimedia materials should be produced by learners [56-58]. Therefore, further research needs to be conducted on this strategy, its strong and weak points, and other relevant issues [88.

5. CONCLUSION

Multimedia instruction has proved its effectiveness in teaching and learning engineering courses solving some major educational challenges. One major challenge is the incompatibility of the three basic educational elements, which are engineering curriculums, educational resources, and learners' characteristics. Although multimedia instruction can reduce these challenges, one important issue is lecturers' resistance to change and to improve their teaching methods. Therefore, much more research needs to be conducted to deal with this issue.

The principal benefit of multimedia instruction for engineering education is increasing students' understanding of engineering concepts, procedures, problems, and solutions via visual materials which can be delivered through interactive ways. Enhancing students' motivation, as another benefit of multimedia instruction, can also increase the quality and the frequency of students' engagement with learning materials. In addition, this can improve students' learning by replacing, supporting or promoting educational resources like class time, instructors, course books and real experiences. By reducing needed time for teaching difficult concepts and procedures, multimedia instruction enables teachers to use teaching time more efficiently and to have sufficient time to use on other time-consuming teaching methods like group discussions. Furthermore, it can be used in combination with other teaching methods such as problem based learning and case based learning to assist students in achieving higher order cognitive skills and soft skills.

Finally, further research needs to be undertaken on the exploration of the huge potential of mobile multimedia instruction and student-generated multimedia learning strategies to improve engineering competencies among students and the gaps thereof.

REFRENCES:

[1] Sorden, S.D., *The Cognitive Theory of Multimedia Learning*, in *The Handbook of Educational Theories*, B.J. Irby, G. Brown, and S. Jackson, Editors. 2012, Information Age Publishing, Incorporated.
[2] Mayer, R.E., *Elements of a Science of E-Learning.* Journal of Educational Computing Research, 2003. **29**(3): p. 297-313.
[3] Paivio, A., *Mental representations*. 1990: Oxford University Press, Incorporated.

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

[4] Sweller, J., *Cognitive load theory, learning difficulty, and instructional design.* Learning and Instruction, 1994. **4**(4): p. 295-312.
[5] Mayer, R.E., *Multimedia Learning*. 2009: Cambridge University Press.
[6] Kitchenham, B., *Procedures for performing systematic reviews.* Keele, UK, Keele University, 2004. **33**: p. 2004.
[7] Frey, C.A., M.L. Mikasen, and M.A. Griep, *Put Some Movie Wow! in Your Chemistry Teaching.* Journal of Chemical Education, 2012. **89**(9): p. 1138-1143.
[8] Domagk, S., R.N. Schwartz, and J.L. Plass, *Interactivity in multimedia learning: An integrated model.* Computers in Human Behavior, 2010. **26**(5): p. 1024-1033.
[9] Moreno, R. and R. Mayer, *Interactive multimodal learning environments.* Educational Psychology Review, 2007. **19**(3): p. 309-326.
[10] Ong, S.K. and M.A. Mannan, *Virtual reality simulations and animations in a web-based interactive manufacturing engineering module.* Computers & Education, 2004. **43**(4): p. 361-382.
[11] Orquin, I., et al., *Introductory quantum physics courses using a LabVIEW multimedia module.* Computer Applications in Engineering Education, 2007. **15**(2): p. 124-133.
[12] Hsieh, H.-F. and S.E. Shannon, *Three approaches to qualitative content analysis.* Qualitative health research, 2005. **15**(9): p. 1277-1288.
[13] Sidhu, S.M., *Design approaches and comparison of TAPS packages for engineering.* Interactive Technology and Smart Education, 2007. **4**(3): p. 127-137.
[14] Laoui, T. and J. O'Donoghue, *Development of a support environment for first year students taking materials science/engineering.* Research in Science & Technological Education, 2008. **26**(1): p. 93-110.
[15] Hernandez-Abad, F., et al., *Educational Software to Learn the Essentials of Engineering Graphics.* Computer Applications in Engineering Education, 2012. **20**(1): p. 1-18.
[16] Munoz-Abella, B., C. Alvarez-Caldas, and L. Rubio, *Computer-Aided Tool for Teaching Mechanical Clutch Systems Design.* Computer Applications in Engineering Education, 2011. **19**(3): p. 493-500.
[17] Kolivand, H. and Sunar, M. S. *Covering photo-realistic properties of outdoor components with the effects of sky color in mixed reality*. Multimedia Tools and Applications, 2014, **72**(3):p. 2143-2162.
[18] Mulop, N., *The Effectiveness of Learning Thermodynamics through Multimedia Courseware Based on Visualization and Constructivism*, in *Center of engineering education*. 2012, Universiti Teknologi Malaysia.
[19] Ozcelik, E. and C. Acarturk, *Reducing the spatial distance between printed and online information sources by means of mobile technology enhances learning: Using 2D barcodes.* Computers and Education, 2011. **57**(3): p. 2077-2085.
[20] Lau, H.Y.K., K.L. Mak, and H. Ma, *IMELS: An e-learning platform for industrial engineering.* Computer Applications in Engineering Education, 2006. **14**(1): p. 53-63.
[21] Yueh, H.P., et al., *Effect of student engagement on multimedia-assisted instruction.* Knowledge Management and E-Learning, 2012. **4**(3): p. 346-358.
[22] Cheung, S.O., et al., *A user-oriented web-based multimedia programme for measuring building services engineering works.* International Journal of Engineering Education, 2007. **23**(5): p. 1038-1049.
[23] Cadoni, E., L. Botturi, and D. Forni, *The TEMAS Multimedia Learning Objects for Civil Engineers.* TechTrends, 2008. **52**(5): p. 17.
[24] Patterson, D.A., *Impact of a multimedia laboratory manual: Investigating the influence of student learning styles on laboratory preparation and performance over one semester.* Education for Chemical Engineers, 2011. **6**(1): p. e10-e30.
[25] Masters, J., T.M. Madhyastha, and A. Shakouri, *Educational applets for active learning in properties of electronic materials.* IEEE Transactions on Education, 2005. **48**(1): p. 29-36.
[26] Hassan, H., et al., *Smartphone-Based Industrial Informatics Projects and Laboratories.* Ieee Transactions on Industrial Informatics, 2013. **9**(1): p. 557-566.
[27] Fraile-Ardanuy, J., et al., *Improving understanding of single phase transformer behaviour through a multimedia tool.* International Journal of Electrical Engineering Education, 2009. **46**(1): p. 74-89.
[28] Peñín, P.I.Á., et al., *Multimedia-integrated application for computer-assisted teaching of technical drawing (AIMEC-DT).* Computer Applications in Engineering Education, 2004. **12**(2): p. 136-144.

Journal of Theoretical and Applied Information Technology
30th November 2016. Vol.93. No.2

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

[29] Felder, R.M. and L.K. Silverman, *Learning and teaching styles in engineering education.* Engineering education, 1988. **78**(7): p. 674-681.
[30] Butz, B.P., M. Duarte, and S.M. Miller, *An intelligent tutoring system for circuit analysis.* IEEE Transactions on Education, 2006. **49**(2): p. 216-223.
[31] Lau, H.Y.K. and K.L. Mak, *The virtual company: A re-configurable open shell for problem-based learning in industrial engineering.* Computers and Industrial Engineering, 2004. **47**(2-3): p. 289-312.
[32] Abuhashish, F. A. M., Kolivand, H., Sunar, M. S., & Mohamad, D. (2015). *Framework Of Controlling 3d Virtual Human Emotional Walking Using Bci*. Jurnal Teknologi, 2015, **75**(4):p. 17-25.
[33] Yuen, S.T.S. and S. Naidu, *Using multimedia to close the gap between theory and practice in engineering education.* International Journal of Engineering Education, 2007. **23**(3): p. 536-544.
[34] Sankar, C.S., et al., *Developing Leadership Skills in" Introduction to Engineering Courses" through Multi-Media Case Studies.* Journal of STEM Education: Innovations and Research, 2010. **11**(3): p. 34-60.
[35] Le, Q., *Implementation of Case Studies in an Introduction to Engineering Course for" LITEE National Dissemination Grant Competition".* Journal of STEM Education: Innovations and Research, 2012. **13**(4): p. 12-17.
[36] Clayson, A., *Effectiveness of LITEE Case Studies in Engineering Education: A Perspective from Genre Studies.* Journal of STEM Education: Innovations and Research, 2011. **12**(7): p. 15-31.
[37] Elrod, C.C., et al., *Utilizing Multimedia Case Studies to Teach the Professional Side of Project Management.* Journal of STEM Education: Innovations and Research, 2010. **7**: p. 17.
[38] Halyo, N. and Q. Le, *Results of Using Multimedia Case Studies and Open-Ended Hands-On Design Projects in an" Introduction to Engineering" Course at Hampton University.* Journal of STEM Education: Innovations and Research, 2011. **12**(7): p. 32-35.
[39] Klemes, J.J., et al., *Advanced multimedia engineering education in energy, process integration and optimisation.* Applied Energy, 2013. **101**: p. 33-40.
[40] Álvarez Peñín, P.I., et al., *Multimedia-integrated application for computer-assisted teaching of technical drawing (AIMEC-DT).* Computer Applications in Engineering Education, 2004. **12**(2): p. 136-144.
[41] Sankar, C.S. and P. Raju, *Use of Presage-Pedagogy-Process-Product Model to Assess the Effectiveness of Case Study Methodology in Achieving Learning Outcomes.* Journal of STEM Education: Innovations and Research, 2011. **12**(7): p. 45-56.
[42] Ramos Barbero, B., et al., *Effectiveness of a hypermedia tool in the innovative teaching of pneumatic engineering design drawing.* Computer Applications in Engineering Education, 2008. **15**(4): p. 289-307.
[43] Muńoz-Abella, B., C. Álvarez-Caldas, and L. Rubio, *Computer-aided tool for teaching mechanical clutch systems design.* Computer Applications in Engineering Education, 2011. **19**(3): p. 493-500.
[44] Benkrid, K. and T. Clayton, *Digital hardware design teaching: an alternative approach.* ACM Transactions on Computing Education (TOCE), 2012. **12**(4): p. 13.
[45] Debevc, M., R. Safaric, and M. Golob, *Hypervideo application on an experimental control system as an approach to education.* Computer Applications in Engineering Education, 2008. **16**(1): p. 31-44.
[46] Redecker, C., et al., *Learning 2.0: The impact of Web 2.0 innovations on education and training in Europe.* Final Report. European Commission-Joint Research Center-Institute for Porspective Technological Studies, Seville, 2009.
[47] Oblinger, D., J.L. Oblinger, and J.K. Lippincott, *Educating the net generation*. 2005: < p> Boulder, Colo.: EDUCAUSE, c2005.</p>< p> 1 v.(various pagings): illustrations.</p>.
[48] Johnson, L., et al., *NMC Horizon Report: 2014 Higher Education Edition.* Austin, Texas: The New Media Consortium, 2014.
[49] comScore. *Major Mobile Milestones in May: Apps Now Drive Half of All Time Spent on Digital*. 2014 02/02/2015]; Available from: http://www.comscore.com/Insights/Blog/Major-Mobile-Milestones-in-May-Apps-Now-Drive-Half-of-All-Time-Spent-on-Digital#imageview/0/.
[50] comScore. *Growth of Video in Germany: PC and Mobile*. 2013 02/02/2015]; Available from: http://www.comscore.com/Insights/Data-

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

Mine/Growth-of-Video-in-Germany-PC-and-Mobile.

[51] YouTube Statistics. *Mobile and Devices*. 2015 02/02/2015]; Available from: https://www.youtube.com/yt/press/en-GB/statistics.html.

[52] Ryokai, K., A.M. Agogino, and L. Oehlberg, *Mobile Learning with the Engineering Pathway Digital Library.* International Journal of Engineering Education, 2012. **28**(5): p. 1119-1126.

[53] Dwyer, F. and C. Dwyer, *Effect of Cognitive Load and Animation on Student Achievement.* International Journal of Instructional Media, 2006. **33**(4): p. 379-388.

[54] Wong, A., N. Marcus, and J. Sweller, *Instructional Animations: More Complex to Learn from Than at First Sight?*, in *Human-Computer Interaction – INTERACT 2011*, P. Campos, et al., Editors. 2011, Springer Berlin Heidelberg. p. 552-555.

[55] Wong, A., et al., *Instructional animations can be superior to statics when learning human motor skills.* Computers in Human Behavior, 2009. **25**(2): p. 339-347.

[56] Elias, T., *Universal instructional design principles for mobile learning*. Vol. 12. 2011.

[57] Herrington, A., J. Herrington, and J. Mantei, *Design principles for mobile learning.* 2009.

[58] ADL, *Mobile Learning Handbook.* Retrived from adlnet.gov: http://sites.google.com/a/adlnet.gov/mobile-learning-guide/basics, n.d. .

[59] Hohne, G. and V. Henkel, *Application of Multimedia in Engineering Design Education.* European Journal of Engineering Education, 2004. **29**(1): p. 87-96.

[60] McCarthy, M., R. Seidel, and D. Tedford, *Developments in project and multimedia-based learning in manufacturing systems engineering.* International Journal of Engineering Education, 2004. **20**(4): p. 536-542.

[61] Toral Marín, S.L., et al., *Implementation of a web-based educational tool for digital signal processing teaching using the technological acceptance model.* IEEE Transactions on Education, 2005. **48**(4): p. 632-641.

[62] Sidhu, S.M. and N. Selvanathan, *A TAPS Interactive Multimedia Package to Solve Engineering Dynamics Problem.* Campus-Wide Information Systems, 2005. **22**(5): p. 275-289.

[63] Bhowmick, A., et al., *Evaluation of alternate multimedia for web-based asynchronous learning.* International Journal of Industrial Ergonomics, 2007. **37**(7): p. 615-629.

[64] Jenkins, H. and J. Burtner, *An approach to develop and measure engineering visualization in an introductory mechanics course using computer-aided learning modules.* International Journal of Engineering Education, 2007. **23**(1): p. 150-161.

[65] Su, K.D., *The effects of a chemistry course with integrated information communication technologies on university students' learning and attitudes.* International Journal of Science and Mathematics Education, 2008. **6**(2): p. 225-249.

[66] Ramos Barbero, B., et al., *Effectiveness of a hypermedia tool in the innovative teaching of pneumatic engineering design drawing.* Computer Applications in Engineering Education, 2008. **15**(4): p. 289-307.

[67] Assael, M.J. and K.E. Kakosimos, *Can a course on the calculation of the effects of fires, explosions and toxic gas dispersions, be topical, enjoyable and meaningful?* Education for Chemical Engineers, 2010. **5**(3): p. e45-e53.

[68] Djenic, S., R. Krneta, and J. Mitic, *Blended Learning of Programming in the Internet Age.* Ieee Transactions on Education, 2011. **54**(2): p. 247-254.

[69] Garner, J.K. and M.P. Alley, *How the Design of Presentation Slides Affects Audience Comprehension: A Case for the Assertion-Evidence Approach.* International Journal of Engineering Education, 2013. **29**(6): p. 1564-1579.

[70] Guzman, J.L., S. Dormido, and M. Berenguel, *Interactivity in education: An experience in the automatic control field.* Computer Applications in Engineering Education, 2013. **21**(2): p. 360-371.

[71] Maiti, A. and B. Tripathy, *Remote Laboratories: Design of Experiments and Their Web Implementation.* Educational Technology & Society, 2013. **16**(3): p. 220-233.

[72] Ruikar, K. and P. Demian, *Podcasting to Engage Industry in Project-Based Learning.* International Journal of Engineering Education, 2013. **29**(6): p. 1410-1419.

[73] Anton, R., et al., *Power Plant Optimisation Simulator Using Catalogues: A Case Study with Student Assessment.* International Journal of Engineering Education, 2014. **30**(2): p. 495-504.

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

[74] Martin-Dorta, N., et al., *Virtual Blocks: a serious game for spatial ability improvement on mobile devices.* Multimedia Tools and Applications, 2014. **73**(3): p. 1575-1595.

[75] Torres-Ramírez, M., et al., *Video-sharing educational tool applied to the teaching in renewable energy subjects.* Computers & Education, 2014. 73: p. 160-177.

[76] Ahmad, AM et al., *Data Hiding Based on Improved Exploiting Modification Direction Method and Huffman Coding*, Journal of Intelligent Systems, 2014, 23 (4), p. 451-459, doi. 10.1515/jisys-2014-0007

[77] Harouni, M. et al., *Online Persian/Arabic script classification without contextual information,* The Imaging Science Journal, 2014, vo. 62(8), p. 437-448, doi. 10.1179/1743131X14Y.0000000083

[78] Rehman, A., and Saba, T. *An intelligent model for visual scene analysis and compression*, International Arab Journal of Information Technology, 2013, 10(13), p. 126-136.

[79] Fadhil, MS. et al., *Writers identification based on multiple windows features mining*, 3D Research, 2016, 7 (1), p. 1-6

[80] Waheed, SR., et al., (2016). *Multifocus watermarking approach based on discrete cosine transform,* Microscopy Research and Technique, 2016, 79 (5), p. 431-437

[81] Jadooki, S. et al., *Fused features mining for depth-based hand gesture recognition to classify blind human communication*, Neural Computing and Applications, 2016, p. 1-10, doi. 10.1007/s00521-016-2244-5

[82] Saba,T., et al., *Evaluation of current documents image denoising techniques: a comparative study* , Applied Artificial Intelligence, 2014, 28 (9), p. 879-887, doi. 10.1080/08839514.2014.954344

[83] Rehman, A. and Saba, T. *Evaluation of artificial intelligent techniques to secure information in enterprises*, Artificial Intelligence Review, 2014, 42(4), p. 1029-1044, doi. 10.1007/s10462-012-9372-9.

[84] Saba, T. and Rehman, A.*Machine Learning and Script Recognition*, Lambert Academic publisher, 2012, pp:65-70.

[85] Neamah, K. et al., Discriminative features mining for offline handwritten signature verification, *3D Research* vol. 5(3), 2014, doi.10.1007/s13319-013-0002-3.

[86] Rehman, A. and Saba, T. "Off-line cursive script recognition: current advances, comparisons and remaining problems". *Artificial Intelligence Review*, vol. 37(4), 2012, pp.261-268. doi. 10.1007/s10462-011-9229-7.

[87] Saba,T. et al., "Improved statistical features for cursive character recognition" International *Journal of Innovative Computing, Information and Control (IJICIC)* vol. 7(9), 2011, pp. 5211-5224.

[88] Saba T. et al., Language independent rule based classification of printed & handwritten text, *IEEE International Conference on Evolving and Adaptive Intelligent Systems (EAIS),* 2015, pp. 1-4, doi. 10.1109/EAIS.2015.7368806

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

Appendix 1:

The List Of Research Papers That Studied Multimedia Instruction For Engineering Education From 2004 Until 2014

	Reference	Course/ Subject	Field (Engineering)	Technics	Platform
1	[40]	Technical Drawing	Graphic	M, A	C
2	[59]	Engineering Design	Mechanical, Mechatronics, Materials	M	C, W
3	[31]	Engineering Project Management, Engineering System Analysis	Industrial	M	C, W
4	[60]	Manufacturing Systems	Mechanical	M, V	C
5	[25]	Properties of Material	Electrical, Materials	M	W
6	[61]	Digital Signal Processing	Electrical, Computer	M,A	W
7	[62]	Engineering Dynamics	Mechanical	M, A	C
8	[32]	Unit Operations	Chemistry and Food	A,V	W
9	[30]	Introductory Circuits	Electrical	M	C
10	[20]	Engineering System Analysis	Industrial	M,A,V	C, W
11	[63]	Production, Planning and Control	Industrial	M	W
12	[13]	Mechanics dynamics	Mechanical	A	C
13	[22]	Building Services measurement	Building Services	M, A	W
14	[64]	Introductory Mechanics	Mechanical	M	C
15	[33]	geotechnical applications	Geotechnical	V	C
16	[17]	Data structure	Computer	A	W
17	[65]	Chemistry	Mechanical, Civil	M, A	C
18	[23]	Structural Mechanics and Static	Civil	M, V	W
19	[14]	Materials Technology	Materials	V, A	W
20	[45]	Control System	Electrical	V	W
21	[66]	Pneumatic Engineering Design	Industrial	M, A	C
22	[27]	Electrical Electric single Phase Transformer	Civil	M, V	C
23	[67]	Risk Assessment	Chemical	M,V	W
24	[37]	Introduction to Project Management	System	M, V	W
25	[34]	Introduction to engineering	Chemical, Mechanical	M, V	W
26	[24]	Lab course: (Introduction to Process Engineering)	Chemical, Materials	M,V	W
27	[36]	Introduction to Biosystems Engineering	Biosystems	M,V	W
28	[38]	Introduction to Engineering (engineering ethics)	General	M,V	W
29	[41]	Introduction to engineering, Introduction to Mechanical Engineering	General, Mechanical	M,V	W
30	[68]	Programming Fundamentals (1,2)	Electrical, Computer	M, A	W
31	[16]	Mechanical Clutch Systems Design	Mechanical	M, V	C
32	[19]	Computer Networks	Computer	A	M
33	[21]	General Engineering and Technology	General	M, V	W
34	[44]	Digital Hardware Design	Computer, Electrical	M, V	W

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

	Reference	Course/ Subject	Field (Engineering)	Technics	Platform
35	[35]	Introduction to engineering	General	M, V	W
36	[15]	Engineering graphics	Mechanical	M, A	W
37	[39]	Process Integration	Energy	M, A, V	W
38	[26]	Industrial Informatics (2)	Industrial Electronics	A	M
39	[69]	Communications	General	M	C
40	[70]	Process control	Control	M	C
41	[71]	Virtual Lab	Electrical	M, A	W
42	[72]	Industry Management	Civil	V	M
43	[73]	Thermodynamics	Mechanical	M, A	W
44	[74]	Spatial ability	Civil, Electronics, Mechanical	M, A	M
45	[75]	Renewable energy	Industrial Electronics	V	W