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DESIGN AND DELIVERY OF A FULLY ONLINE CAD-CAM COURSE FOR ENGINEERING STUDENTS

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ABSTRACT

Computer Aided Design and Computer Aided Manufacturing (CAD-CAM) course consider as an essential demand for engineering students to be achieved. Real life of design and manufacturing processes should be provided in a clear and coherent structure to support student for understanding well the provided materials. E-Learning Deanship at King Khalid University (KKU) offers a world-class technology platform to support E-Learning and EKnowledge processes. E-Learning tools have been utilized and well employed according to the Quality Matter rubric (QM) to fulfill a master CAD-CAM course, which has been chosen as the best E-Learning course on the whole university and got the QM recognition. The course elements transfer the real life of industry to the students through virtual classes and various resources. Interactions between student to student and students to instructor are available along the semester. Essential activities to measure how well the students understand the course materials have been created.

Keywords: CNC, CAD-CAM, Elearning, LMS, QM.

1. INTRODUCTION

The vast majority of the universities around the world consider CAD_CAM course as essential demand for mechanical, manufacturing and industrial engineering student at undergraduate level since Manufacturing is a wealth generating activity for a nation. CAD/CAM are needed for the economic growth of a nation. CAD-CAM process is needed to produce very complicated shapes in a very short time and high quality while it achieves high productivity in manufacturing (Than et al 2006; Fusaomi et al. 2013).

Elearning is the use of technology to extend, enhance, and enrich the learning and competence-building experience through enhanced collaboration and access to Eknowledge resources. Elearning can be the instrument for enhancing innovation and entrepreneurship skills of learners, enhancing their employability.

The role of Elearning in educational development has been world-wide recognized as a priority in order to reinforce academic development, to widen access, to attain universal scope and to extend knowledge, as well as to facilitate education throughout life (Virginio et al. 2004; Council of Ministers of Education, Canada1.998; Kirsh.2002).

The Elearning deanship at KKU has four services goals associated with its mission. It is to provide a level of services that enables: 1) all users to engage in successful learning practice,2) KKU to embed Elearning in all learning processes and engage users, 3) KKU staff to create and update courses that use Elearning, and 4) KKU staff to use Elearning to assure quality in learning. (Elearning Deanship at KKU).

The first aim of this paper is utilizing the well-established E-learning infrastructure for introducing enhanced online CAD-CAM course in a high level of Bloom's Taxonomy(Adam 2006; Ferris 2005) for improving the quality and effectiveness of education for the engineering students. The second one is facilitating the access of all learning sources for the students anywhere and anytime while they are getting online support in all the access time.

The design and structure of the online CAD-CAM course has been developed on the following bases:1) Instructor of the course to teach the students how the information of part geometry, tool path, cutting tool, cutting plan, manufacturing knowledge should be integrated using the Elearning facilities. 2) The students should not only appreciate the existing CAD/CAM systems but they should also utilize the provided Elearning tools to come up with alternative solutions for developing more CAD/CAM systems.

2. E-LEARNING INFRASTRUCTURE AT KING KHALID UNIVERSITY (KKU)

The E-Learning Deanship has designed and deployed a world-class technology platform to support E-Learning and EKnowledge processes at KKU. Students, faculty, and administrators achieve authorized/authenticated access through the center portal to a robust, fully integrated Learning Management System (LMS) and supporting applications and knowledge resources. This LMS extracts data from the Student Information Systems (SIS), and in the future the KKU library, and Blackboard's e-Portfolio.

It is also supported by the Classroom Capture Application, Authoring Tools, e-Assessments, Virtual Classroom Tools, and a highly capable Learning Object Repository (LOR) that can share learning objects drawn from a variety of international open learning resources and content providers. Table 1 summarize the available electronic systems and tools in KKU (Elearning Deanship at KKU).

2.1 The Learning Management System

The LMS is used to offer the courses and facilitate administering the educational process with the different features that make the process and the experience simple and rich. Blackboard was chosen for its high efficiency and simplified user experience in addition to proven success with a huge user base of tens of millions. The Learning Management System in KKU is simply a website that is accessible anytime and from anywhere in the world. The courses offered to the students in three levels; a-Supportive level, b-Blended level and c-Full E-learning level.

Table 1: Available electronic systems and tools (Elearning Deanship at KKU)

System	Description
Learning Management System (Blackboard) Http://lms.kku.edu.sa	The central component in the E-Learning platform of KKU. Used to offer courses, and manage content and users.
Electronic Testing (Questionmark) http://qm.kku.edu.sa Class Recording	Questionmark is an electronic testing application with great features.
(Tegrity) http://tegrity.kku.edu.sa	This application enables faculty members to record their classes in video and offer them on the course site. Tegrity is integrated with Bb.
Virtual Classroom (Elluminate) http://vc.kku.edu.sa Learning objects Repository (Hive) http://lor.kku.edu.sa	Enables video communication between participants in realtime. Sessions can be recorded for future review.
Students Mail http://mail.ekku.edu.sa	Mail and collaboration tools for all KKU students.
ePortfolios (Bb ePortfolio) http://lms.kku.edu.sa	An ePortfolio (special web space designed to hold information, experience, and work documentation) for all faculty members and students.
Learning objects Repository (Hive) http://lor.kku.edu.sa	Offers a modern mechanism for storing and sharing digital content. The system will be connected to the national LOR and other international repositories.

3. CAD-CAM CURRICULUM

Cad Cam Curriculum at faculty of engineering, Mechanical engineering department must follow general guidelines set by the Accreditation Committee within the King Khalid University (KKU) and the Ministry of Higher Education. These guidelines include the number of credit hours needed to obtain the program, three credit hours has been allocated to achieve the CAD CAM program. A specialized committee from mechanical engineering department was given the task of developing CAD CAM curriculum similar to regional and international universities (Curriculum plan, Ain Shams University, Egypt.2008; Curriculum plan, 10th of Ramadan university, Egypt.2009; Curriculum plan, California state university.2009) based on the following factors:

3.1 E-Learning capabilities

One of the concrete future strategic objectives of education and training systems in the EU is improving the quality and effectiveness of education and training systems through applying the E-Learning tools (Sahin et al.2007; Yadong et al 2007). The curriculum has adapted the KKU

E-Learning tool and strategies (previous sectionl) which improving education and training for instructor and students, making the best use of resources, and making learning more attractive.

3.2 Industrial needs

As regional industry developed through automated production and computerized manufacturing, requirements for multi-disciplinary engineers with in-depth knowledge of mechanics, and computers and programming skills increased. The demand for such system engineers was fast developing.

3.3 Educational motivation

As interaction among different engineering disciplines increased, students were encouraged to study system functionality. This developed the need for a curriculum that offers integrated engineering courses.

3.4 Mechanical engineering development

As technology advanced, computers and automated manufacturing started to play bigger roles in mechanical systems and therefore more and more mechanical engineers started to take computer and automated courses in order to strengthen their grasp on mechanical system technology.

The approach for developing the appropriate CAD CAM curriculum was based on the following key concepts:

- Know your machine (from a programmer's viewpoint)
- Understand the engineering drawing of a part to be machined.
- Prepare to write programs
- Understand the motion types
- Know the compensation types
- Format your programs in a safe, convenient, and efficient manner
- Know the special features of programming
- Recognize your machine (from an operator's viewpoint)
- Understand the three modes of operation
- Know the procedures related to operation

4. E-COURSE STRUCTURE AND DESIGN

The course has been established on the basis of quality matter rubric (QM Rubric 2013).The author has achieved all the quality training courses and now is a peer reviewer of the QM programs. The course is delivered fully online and prepared from the students' perspective; the latest technologies have been used to structure and design the learning materials in the course. Course

components; Learning Objectives, Learning material, Learning activities, Assessment, External resources are worked together to ensure that students have achieved the desired learning outcomes. The course has been created and delivered to the students based on the following criteria:

4.1 The overall design of the course is made clear to the student at the beginning of the course

The course introduction sets the tone for the course, lets students know what to expect, and provides guidance to ensure they get off to a good start. Instructions make clear how to get started and where to find various course components.

An initial Announcement has been used to direct the student to the Start Here menu item. The directions provided in the Start Here page as shown in Figure 1 are explaining in detail all the major components of the course, what they are for, how to navigate to them, and guiding the student through the course.

The Calendar and Start Here page syllabus as shown in Figure 2 do a very good job of introducing the student to the purpose and structure of the course, including course schedule, modes of communication, types of learning activities, and how learning will be assessed.

Course and institutional policies with which the student is expected to comply are clearly stated, and link to current policies is provided. The syllabus section Course Policy does a good job of explaining the requirements for compliance on assignments, attendance, and discussions.

The first paragraph in the Start Here page clearly states pre-requisite courses and required computer skills as it can be seen from Figure 1.

The syllabus Instructor Contact Information section does a great job of introducing the instructor and providing necessary contact information. The photo of the instructor which has been provided in the first page of the syllabus helps forge a human connection.

Students are asked to introduce themselves in the first virtual class of the course under Week 1 mission.

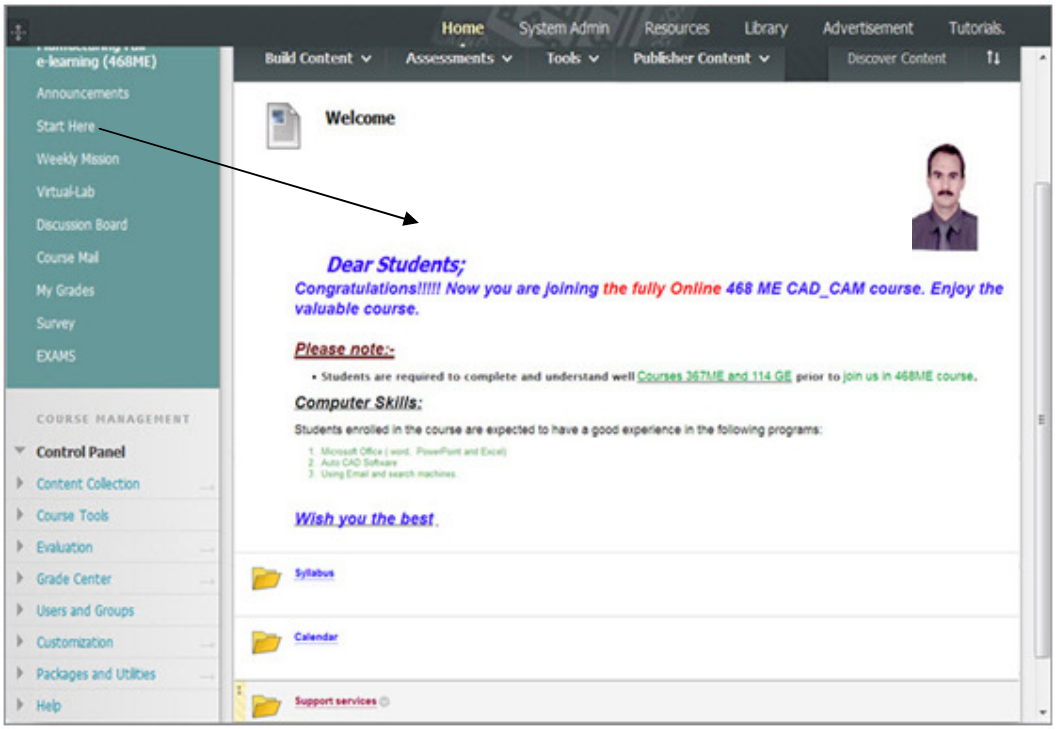

Fig 1: Start Here elements, pre-requisite courses, required computer skills and welcome note

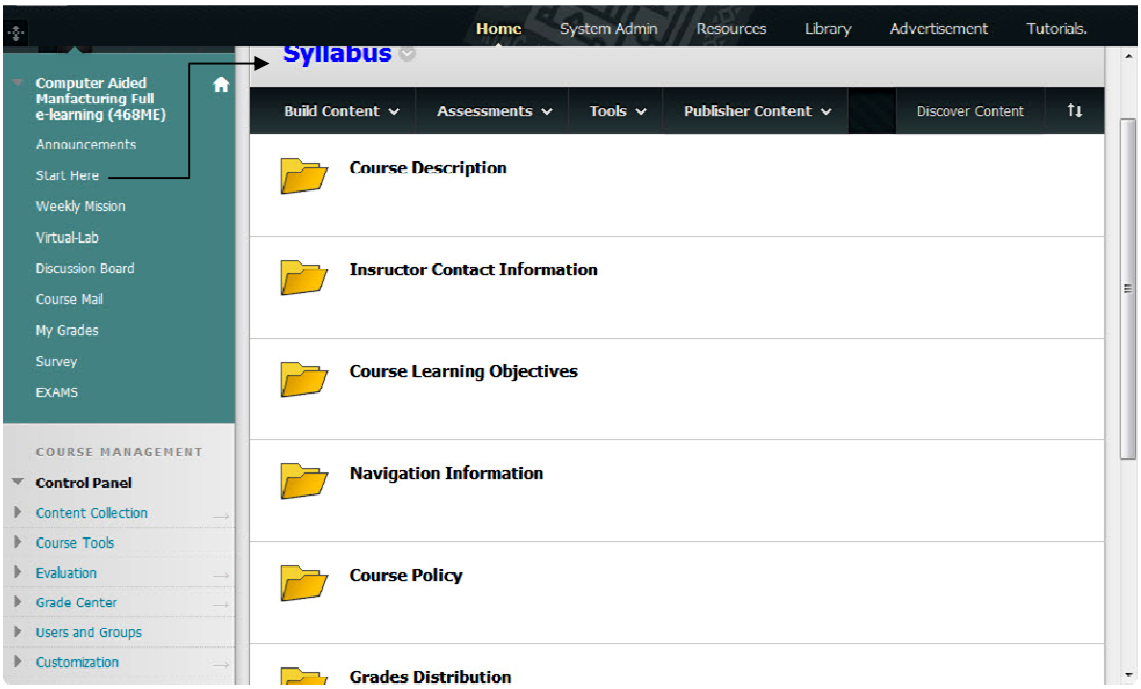

Fig 2: Syllabus contents

4.2 The learning objectives establish a foundation upon which the rest of the course is based

Course learning objectives is one of the most important elements which are clearly stated and explained under START HERE Syllabus section Figure 3. They have been created to be measurable and describe what students are to gain from the course materials. The course learning objectives aligned with the module learning objectives and that was very helpful to achieve the desired outcomes of the course. Glossary of learning objectives terms has been stated and analyzed in Table 2.

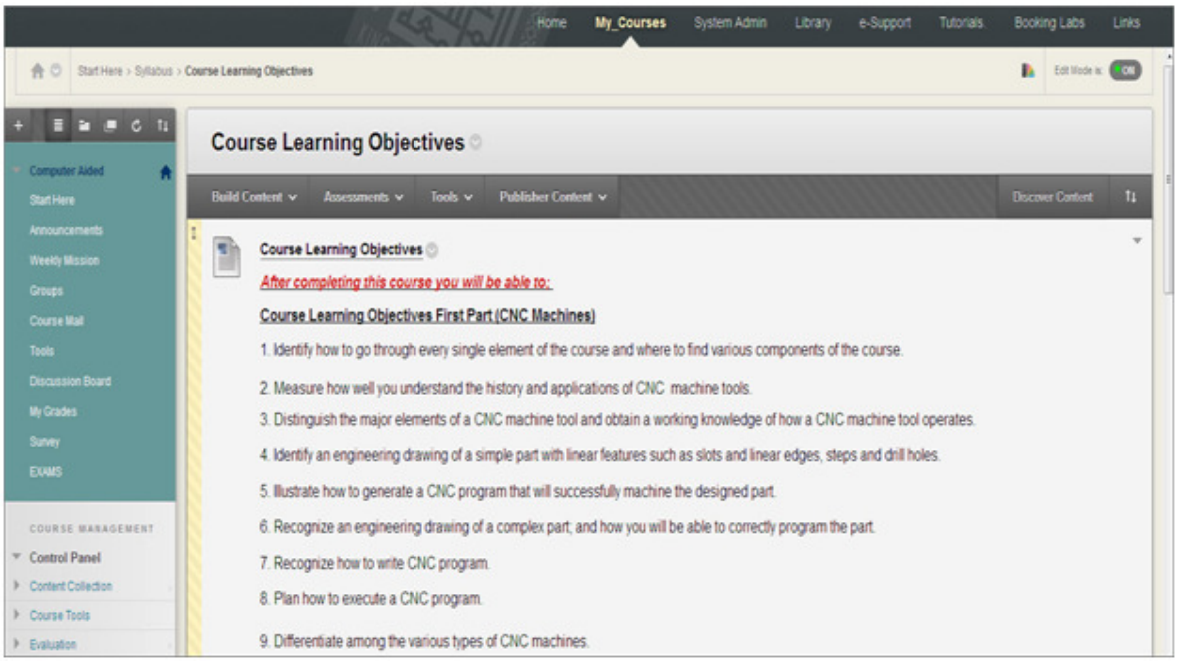

Fig 3: Course learning Objectives

4.2.1 The course learning objectives describe outcomes that are measurable

Syllabus section Learning Objectives Figure 3 does a good job of listing all the course outcomes and they are measurable. Student performance is described in each outcome in specific, observable terms such as identify, distinguish, measure, and illustrate. A glossary of terms has been included as there are many terms used in the outcomes that may not be known to the student at the beginning of the course.

At the completion of this course, the student should be able to:

1. Identify how to go through every single element of the course and where to find various components of the course.
2. Measure how well you understand the history and applications of CNC machine tools.
3. Distinguish the major elements of a CNC machine tool and obtain a working knowledge of how a CNC machine tool operates.
4. Identify an engineering drawing of a simple part with linear features such as slots and linear edges, steps and drill holes.
5. Illustrate how to generate a CNC program that will successfully machine the designed part.
6. Recognize an engineering drawing of a complex part; and how you will be able to correctly program the part.
7. Recognize how to write CNC program.
8. Plan how to execute a CNC program.
9. Differentiate among the various types of CNC machines.

4.2.2 The module learning objectives describe outcomes that are measurable and consistent with the course-level objectives

The Weekly Missions (Figure 4-a) contain Learning Objectives (Figure 4-b) that describe the specific competencies, skills, knowledge that students should be able to master and demonstrate. The learning objectives make clear to students learning expectations and outcomes on a weekly basis and are stated prominently at the beginning of each weekly mission. Instructions to students on how to meet the learning objectives stated clearly in every weekly module.

4.2.3 The learning objectives are appropriately designed for the level of the course in a higher scale of Bloom's Taxonomy

The learning objectives are appropriately designed for the level of the course, which is a 400-level course and according to Bloom's taxonomy should require activities that address content mastery, critical thinking skills, and core learning skills. This would include proficiency in written communication (covered via multiple discussions and groups) as well as distinguish between fact and opinion and identifying bias and stereotypes, which are covered through numerous readings, discussions, and quizzes.

4.3 Assessment strategies are designed to evaluate student progress

Assessment is implemented in a manner that not only allows the instructor a broad perspective on the students' mastery of the content, but also allows students to measure their own learning throughout the course.

4.3.1 The types of assessments selected measure the stated learning objectives and are consistent with course activities and resources.

By reference to stated learning objectives; Assessment designed to measure the effectiveness of student learning; and to be integral to the learning process. There are several quizzes writing assignments that measure the stated learning goals. All are based on the learning materials provided.

These assessments (ways of confirming student mastery) are consistent with the course and module objectives of the course. It would be helpful to map each quiz and writing assignment to the appropriate course outcome, either in the syllabus or in the actual assignment.

Table 2: Glossary of learning objectives terms

Classify Example	Arrange or include in classes or categories. Classify the various types of robot geometry available
Distinguish or Differentiate Example	Recognize or note/ indicate as being distinct or different from; to note differences between. Milling and turning CNC M/C both of them are CNC M/C to make a distinguish; milling has got three axes X,yand Z while Turning M/C has got only two axes X and Z, etc….
Evaluate Example	Make a judgment based on criteria. The important of the various methods of workpiece gripping based on the nature of the workpiece, force required to grasp it, etc…
Illustrate Example	If you are asked to illustrate a topic your answer should consist mainly of examples to clarify or explain your understanding of the topic. Illustrate how to generate a CNC program. Here you should write a CNC program to explain the different phases of a CNC program.
Investigate Example	Plan, inquire into and draw conclusions about the task you will do. Investigate the design and selection of the correct gripper type
Justify Example	Support an argument or conclusion. Justify the use of robot. Here use your evidences and formulas that you studied to support your answer.
Measure Example	Ascertained especially by comparison with a standard: to take the measure of a thing. Measure how well you understand the history and applications of CNC machine tools.
Recognize Example	To identify from knowledge or characteristics. Recognize how to write CNC program. To write CNC you should have all the knowledge about the M/C and the characteristics of the product.

Fig 4a: Weekly mission menu

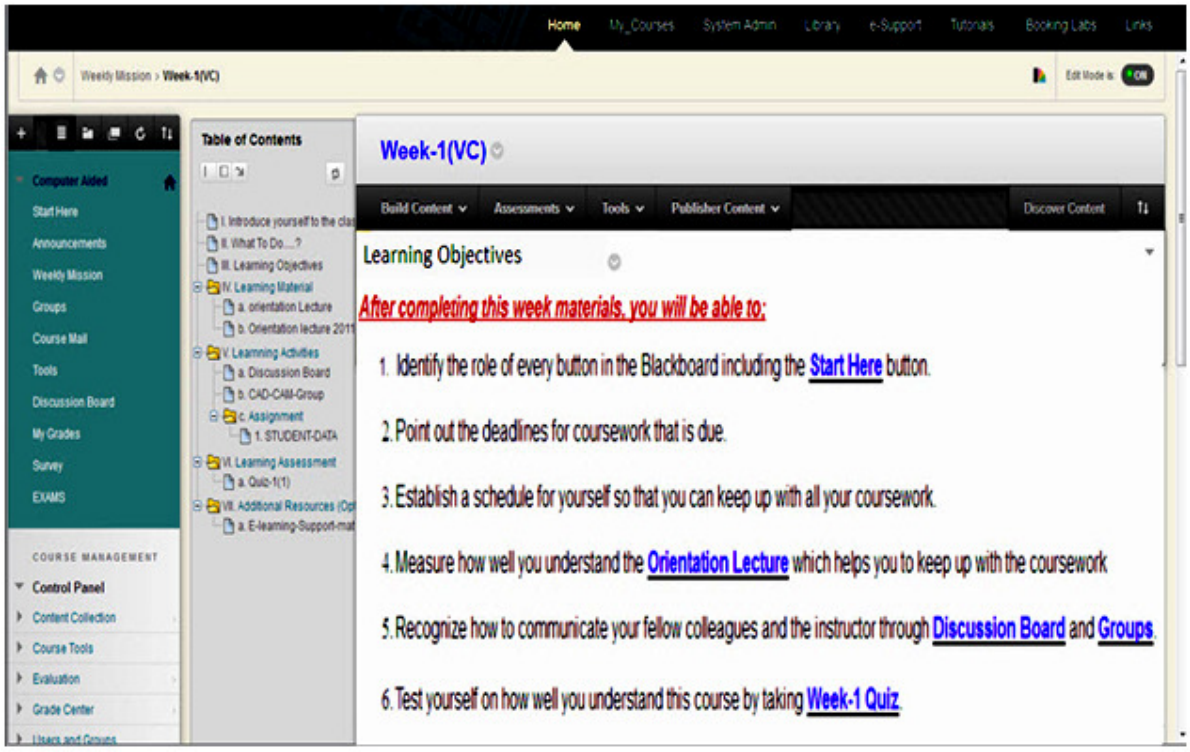

Fig 4b: Module Learning Objectives

4.3.2 The course grading policy is stated clearly

Syllabus section Grades Distribution clearly states the course grading policy. It does a good job of listing each gradable activity and associated points, as well as the grade awarding based on accumulated points. Also Syllabus section Course Policy clearly states that late work is not accepted. Specific and descriptive criteria are provided for the evaluation of students' work and participation and are tied to the course grading policy.

4.4 Instructional materials are sufficiently comprehensive to achieve stated course objectives and learning outcomes.

The instructional materials form the core of the course. It consist of chapters from the required textbook, Virtual classes as shown in Figure 5, recorded lectures, PowerPoint and Word documents, virtual labs as it can be seen from Figure 6 a & b and links to external resources. This is a rich set of instructional materials that align with the course and module objectives. The purpose of instructional materials and how the materials are to be used for learning activities are clearly explained in what to do as shown in Figure 7. The course materials are robust and create a rich learning environment for students. The course presents meaningful instructional materials from a variety of sources, including the textbooks, websites, recorded lectures, and other documents. Instructional materials are varied, and different perspectives are presented by a large number of external sources. All the instructional materials that has been used in the course are current.

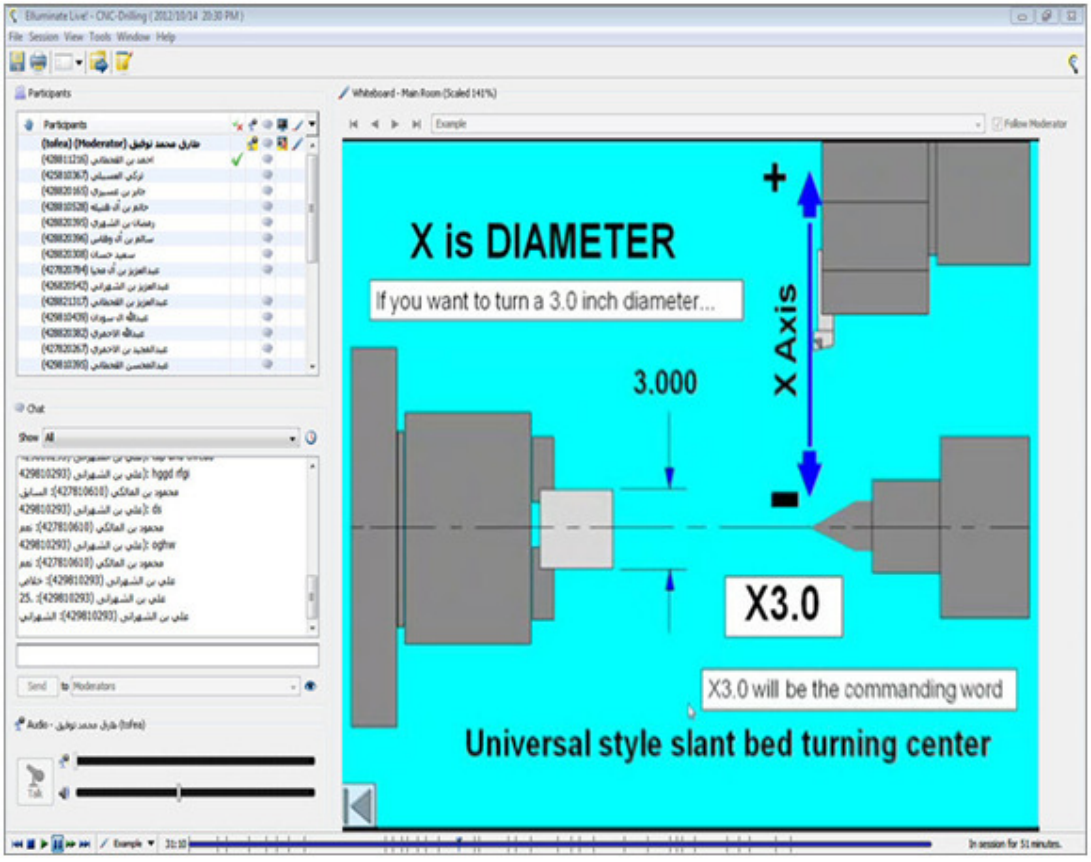

Fig 5: Virtual Class on CNC turning center

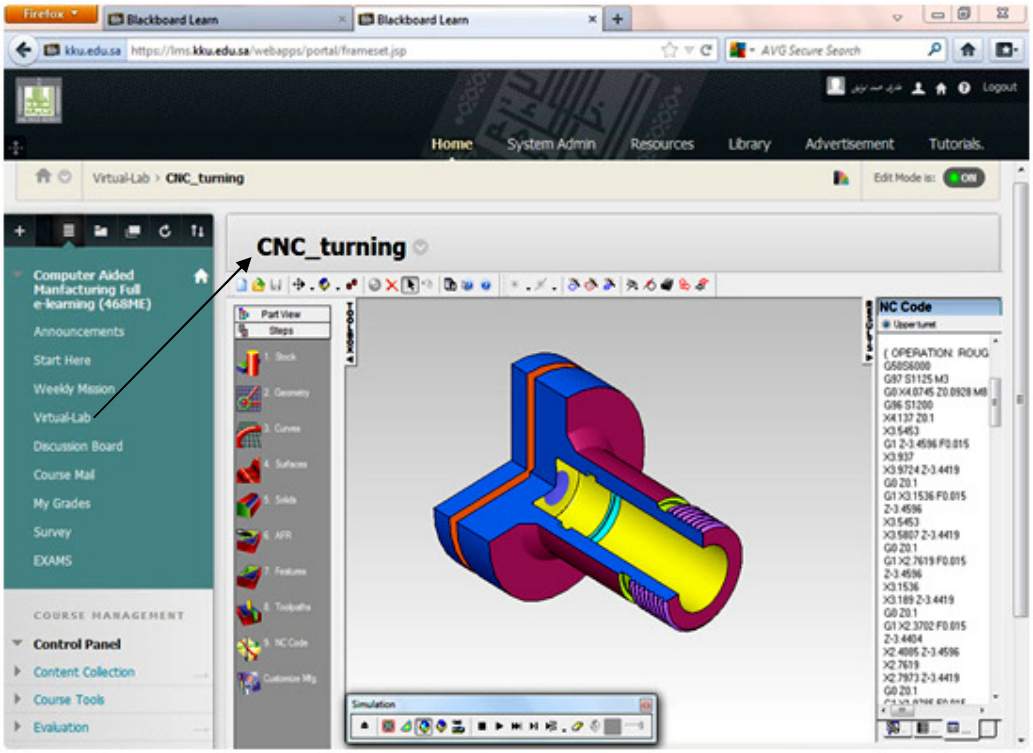

Fig 6a: Virtual lab of CNC Turning Operation

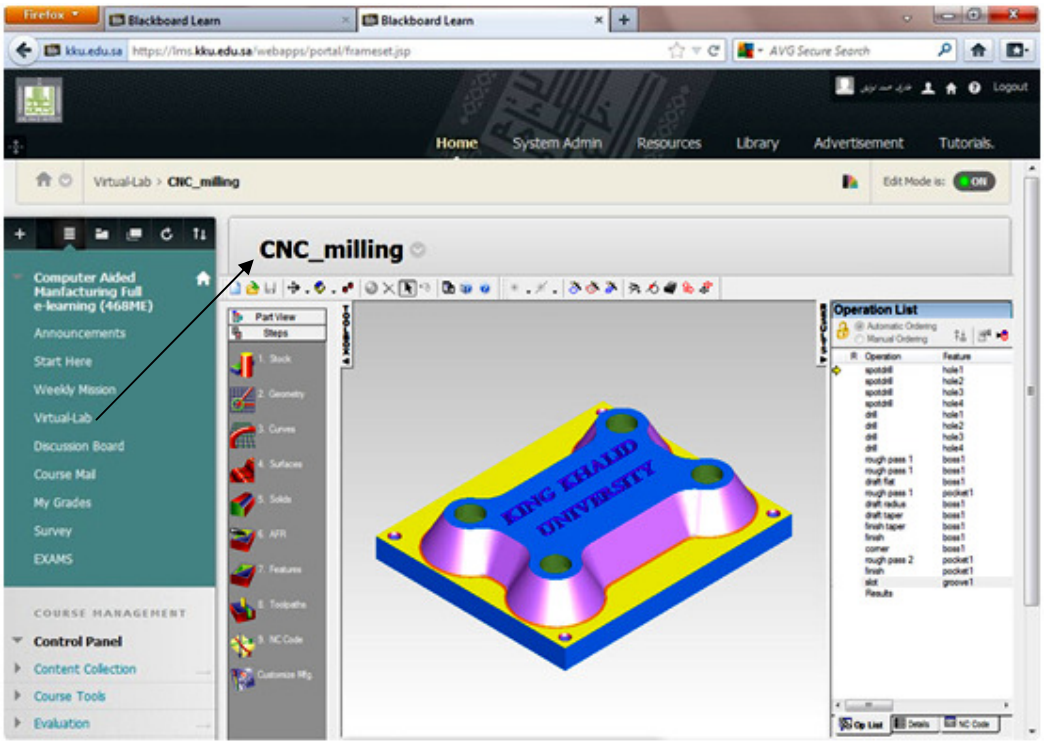

Fig 6b: Virtual lab of CNC Milling Operation

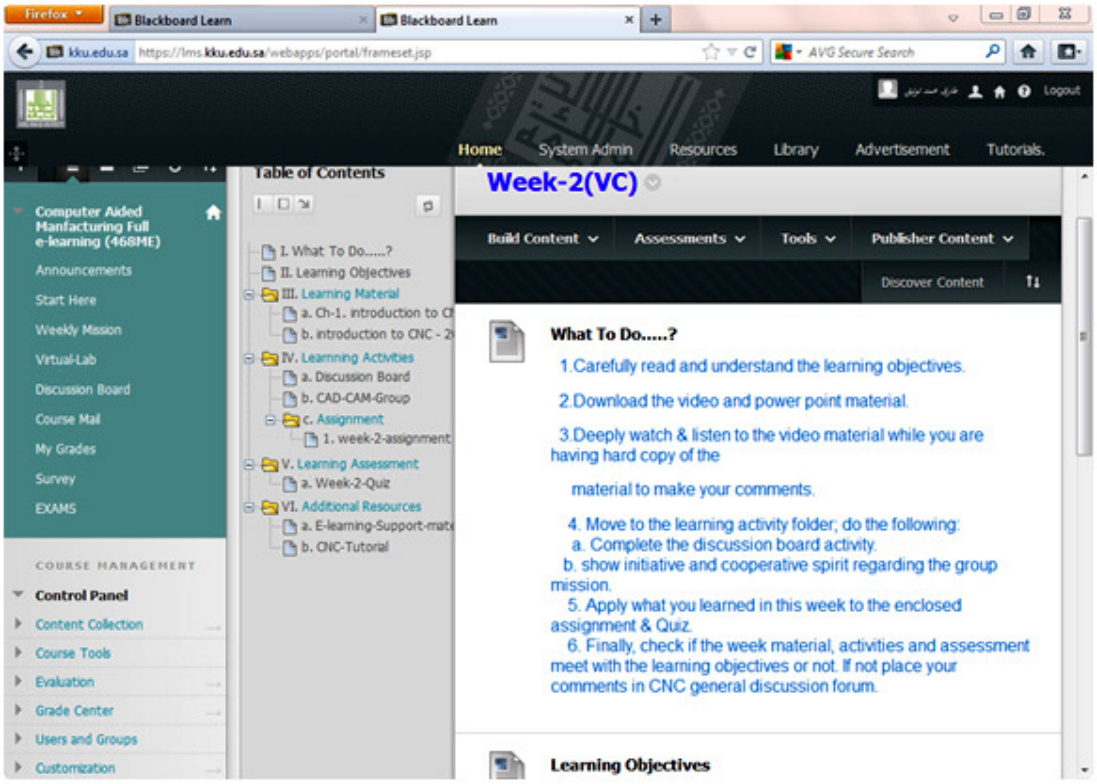

Fig 7: Week-2 table of contents and What To Do instructions

4.5 Forms of interaction incorporated in the course motivate students and promote learning.

Learning activities are varied in order to provide reinforcement and mastery in multiple ways and to accommodate multiple learning styles. Activities include reading or watching recordings from multiple sources, class discussions, writing assignments, and quizzes.

The course discussion provide many opportunities for student-student and student-instructor interactions. Additional student-instructor interaction takes place though feedback from graded assignments. In particular, the virtual classroom provides real-time instructor-student and student-student feedback.

The requirements for student interaction are clearly explained. The syllabus explains clearly that students who miss 25% of the course will be prevented from taking the final exam.

4.6 Course navigation and technology support student engagement and ensure access to course components

The technology enabling the various course components facilitates the student's learning experience and is easy to use, rather than impeding the student's progress.

The use of discussion boards, groups, virtual classroom, and recorded lectures were good ways to support the course learning objectives. All the course tools and media support student engagement and guide the student to become an active learner.

4.6.1 Navigation throughout the online components of the course is logical, consistent, and efficient

The process of controlling the movement of the student from one place to another in the course is logical, consistent, and efficient. From the initial Start Here announcement, to the Start Here page, to the syllabus, the student is easily guided, encouraged, and reminded on where to click. The weekly missions are all organized in the same format, providing consistency.

4.6.2 Students can readily access the technologies required in the course

All required technologies are easily obtainable, either through download, purchase at the bookstore, or another means. There are several hyperlinks within the course, so the Internet is a technology being utilized. Since the student would not even be in the course without having access to a browser, this condition is satisfied. The students are told at the beginning what software skills are required. The course uses the latest version 9.1 of Blackboard.

4.7 Student's evaluation of the course

A survey has been conducted to measure the students satisfaction of the course elements and the way the instructor introducing the course. The survey analysis showed that the students are very satisfied with course as shown in figure 8. The survey questions was as follow:

Q1- For the course you are studying ... Does it include all of the information that can help you navigate and interact with it without any explanations from faculty member?
Q2- Electronic communication is available between student and Instructor and student and his colleagues. Have you found your course supports this and the communication has already happened?
Q3- Electronic content is characterized by the use of multimedia, coordination, arrangement, the ease of use and must facilitate student understanding of scientific material, does your course contents have played the same role?
Q4- The purpose of the learning materials is to overcome and facilitate new information and to make it easy to understand. Does your course contain this kind of activities?
Q5- E-Learning evaluation is characterized by diversity (tests, quizzes, discussions and activities), whether evaluation method in your course includes these benefits?
Q6- E-Learning makes student the center of educational process so student changes from idle recipient to an interactive learner. Do you find your teaching method support this procedure?
Q7- If ignored some technical problems that may occur to the learning management system sometimes, do you find E-Learning more useful and interesting than traditional learning?

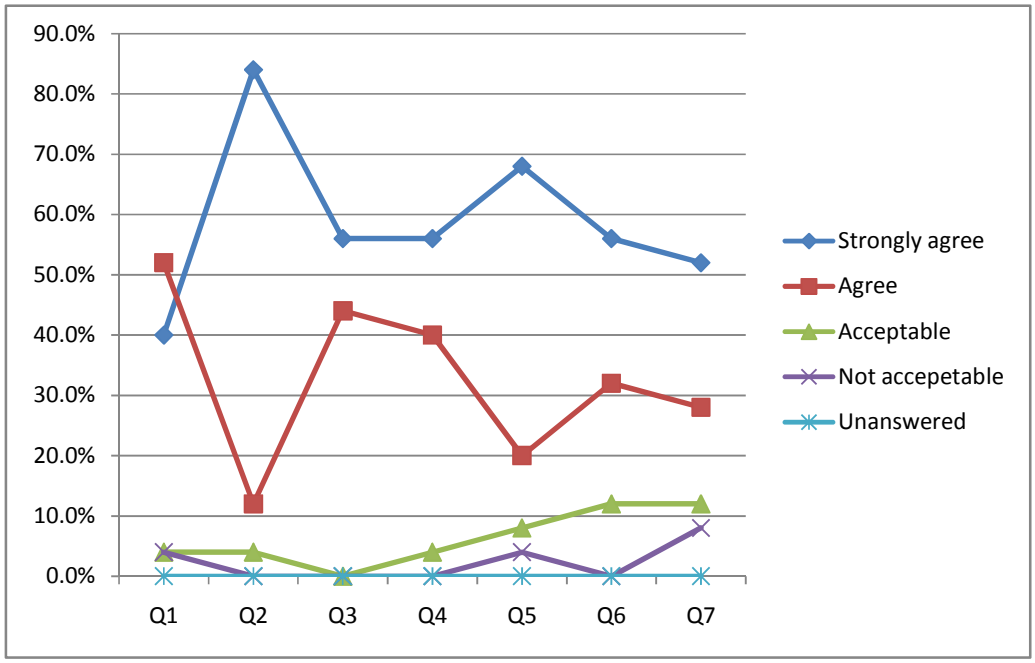

Fig 8: Survey analysis of the students satisfaction of the course elements

5. BENEFITS AND DRAWBACKS OF E-LEARNING

Among the several benefits of applying full E-Learning CAD-CAM course, it can be stated the following:

A. Benefits for instructor

- E-Learning allowed the instructor to record his lecture during class and provides the students with video lecture to be available along with class notes so students can access it anytime.
- The integrated test tool (E-assessment) allows the instructors to randomize exam questions and make a unique exam for each group of student. This reduces the chance of students cheating of each other.
- E-assessment saves the instructor from having to manually grade exams and deal with students' grade complaints.
- E-assessment efficiently and accurately grade tests, preventing the instructor from miscalculating a grade.
- E-assessment allows the instructor to provide students with a wide range of questions from all the course topics and not only focuses in specific subjects.
- Making a bank of test questions are available and allows the instructor to make and run various exams simultaneously.
- E-Learning library are available for instructor and students which provide them with up to date knowledge.
- Communications among students themselves and instructor have been enhanced through the available interaction tools (discussion board, groups, blogs and virtual classes) and are available 24/7.

B. Benefits for students

- Learning materials are available 24/7 which makes scheduling easy and allows a greater number of students to attend classes.
- Students can have the lecture anywhere anytime. Student can have the lecture while he is having a cup of tea.
- The technologies used in E-Learning provide students with powerful and interesting electronic tools which they may never see in a traditional classroom.
- E-Learning Enhances computer and Internet skills since you give the students indirect training courses in all applications used in E-Learning classes
- E-Learning accommodates student's preferences and needs - it's student-centered.
- Flexibility of learning which allows student to skip over material he already know and focus on topics he would like to learn.
- Interaction among the students and instructor are available 24/7 so student can get answer for any question very easy.
- The number of the students passed has been increased comparing with face to face classes.
- Wide range of resource materials is available in different format.
- E-Learning is self-paced and gives students a chance to speed up or slow down as necessary.

- For students who have trouble learning in traditional learning environments, like shyness to ask any question in front of his colleagues. E-Learning is ideal. It is offering a solution for anyone.
- Student benefit from taking E-assessments because they get to see their results as soon as they submit their test.
- E-Learning provide students with various types of learning activities (discussion board, group, quizzes and tests) which allow students to measure how well they understand the learning materials.
- E-Learning increased the number of students passed compared with traditional learning.
- Student costs are frequently less (parking, fuel, vehicle maintenance, residence, food)

Drawbacks of E-Learning

- One disadvantage of E-Learning is that learners need to have access to a computer as well as the Internet. They also need to have computer skills with programs such as word processing, Internet browsers, and e-mail. Without these skills and software it is not possible for the learner to succeed in E-Learning.
- E-Learners need to be very comfortable using a computer. Slow Internet connections or older computers may make accessing course materials difficult. This may cause the learners to get frustrated and give up.
- Another disadvantage of e-learning is managing computer files, software comfortability and learning new software, including E-Learning. For learners with beginner-level computer skills it can sometimes seem complex to keep their computer files organized. The lesson points you to download a file which the learner does and later cannot find the file. The file is downloaded to the folder the computer automatically opens to rather than a folder chosen by the learner. This file may be lost or misplaced to the learner without good computer organizational skills.
- E-Learning also requires time to complete especially those with assignments and interactive collaborations. This means that students have to be highly motivated and responsible because all the work they do is on their own. Learners with low motivation may not complete modules.
- Another disadvantage of e-learning is that students may feel isolated and unsupported while learning. Instructions are not always available to help the learner so learners need to have discipline to work independently without assistance. E-Learners may also become bored with no interaction.

6. CONCLUSION

E-Learning has been employed to design and implement a full E-Learning course at faculty of engineering in King Khalid University. Course components are worked together to ensure that students will be able to achieve the desired learning outcomes which clearly stated and explained to students.

Interaction between the instructor and students, among students, and between students and course materials has been achieved and evaluation of students has been assessed and measured.

Full E-Learning is a powerful tool, virtual classes is one of the most important tools of full E-Learning to communicate with students, some features should be developed, availability of hand writing and free hand sketch make it more interactive.

Advantages of applying Full E-Learning and measures of success for students and faculty have been stated and presented the major benefits of e-learning in flexibility and develop knowledge of both the faculty and student in various areas.

Hence, it can be concluded that applying the full E-Learning based on QM standards will be very helpful to enhance the teaching processes for both the instructor and students. And there are many significant evidences of success for student and instructor who involved in this course. Few of them can be concluded in the following:

- The number of the students passed increased compared with face to face classes.
- The faculty of engineering won the university cup of the E-Learning.
- The quality of education has been improved.
- The number of the students enrolled E-Learning classes increased.
- Students are very impressed and interested in E-Learning as it can be seen in the survey Figure 8.

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