

# Learning and Teaching Mechanical Engineering Courses with Blended Learning Environment - Higher Order Application of Bloom's Taxonomy.

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## Abstract

Mechanical Engineering students who learn how to design and analyse usually experience complex and /or abstract aspects that they may not be able to fully understand without additional tutorial lessons or further explanations. For example, to learn construction of manufacturing, at Higher Order of Cognitive Skills (HOCS) of Bloom's Taxonomy, students need to visualize materials and sequences of construction process. This paper presents the development and implementation of a computer tutoring software, this method of teaching, named 'learning with blended environment', is designed to assist students in thoroughly understanding and effectively mastering teaching material. The tutoring software was used to teach mechanical engineering course at Sheikh Khalifa Institute of Technology in Bahrain. The evaluation of the effectiveness of the tutoring tool is also discussed.

**Keywords:** Lower Order of Cognitive Skills(LOCS), Higher Order of Cognitive Skills (HOCS).

## 1. INTRODUCTION

In engineering disciplines, students learning about engineering analysis and design typically experience such complex or abstract concepts that they usually need additional tutorials with illustrative animations, simulations, or further explanations with visualizations (*Anderson & Krathohl; 2001* and *Sousa, D.A. 2006*). For example, (i) In order to learn the concept of clutch in automotive technology, students need to visualize materials and sequences of the clutch operation, i.e., how all components of a facility are assembled; (ii) through Blended Learning, automotive engineering students can visually observe the performance of different types of clutch; thus enabling them to understand in depth the characteristics of the clutch components; (iii) in automotive engineering, intuitive understanding may be developed when students observe and interact with animations/visualizations of clutch function.

Indeed, visual simulations or visualizations (Blended Learning) cannot be achieved using just a textbook and within a traditional lecturing environment (*Gall, James, 2001-2002*). The need of integrating advanced education technology tools into the curriculum is essential. It has been recognized by accrediting bodies that these tools enhance student to learn and improve quality of Mechanical Engineering Education (*Atkins, et al., 2003; Bouchlaghem & Beacham, 2000; Messner & Horman, 2003*). In effect, studies on the benefits of technology-based education demonstrate that interactive multimedia units provide motivation, increase learning rate, contribute to retention and even helps in effectively managing large classes while supporting the teacher as facilitator (*Atkins, et al., 2003; Iskander, 2002; Kurtis, 2003*). This paper provides development and implementation of a computer tutoring software. This method of teaching is presented, named 'Learning with tutoring software', the method is designed to assist students in Higher Order of Cognitive skills (HOCS) to

enable deep understanding and effective mastering of teaching material (Anderson, Krathwohl; 2001). More specifically, the visualization-based features of the proposed tutoring framework help increase classroom interaction and students' personalized learning experience.

Sample problems and assignments can be integrated into the framework so students can directly participate in class discussion and exercises as well as study these concepts more thoroughly at their own pace independently.

## 2. BACKGROUND

In investigating effective and engaging ways to teach mechanical engineering courses, a literature review of pertinent research and best practice reveals principles that support the use of blended learning and offer ways to optimize their use through co-constructed meaning and application. These principles will be used as guidelines for developing the proposed blended-based learning and teaching framework.

Findings are summarized as follows.

**Use of Blended Learning:** When teachers incorporate visual simulations of real-life scenarios into their classroom and laboratories activities, students participate more and have a more satisfying learning experience (Duran, et al., 2007). Visual simulations are particularly effective at deepening understanding of abstract and highly mathematical subjects such as engineering manufacturing (Abdulrasool and Mishra; 2008). Likewise, 3D animation and walkthrough computer models demonstrate construction processes, and complementary text describes the various steps for dual coding of information (Haque & Saherwala, 2004). Additionally, studies have shown that today's students are more attuned to computer and video technologies and are likely to learn better if they are provided with computer-based modules (Kurtis, 2003).

**Different Visual Tools:** At different stages in the students' learning, different types of visual tools should be considered.

For example, at the instructional stage, simulations can be more structured in order to check for student's understanding throughout the module. When students progress to the analysis and application stage, they welcome more unstructured environments where they can script their own engineering experiments, and control their own learning (Uran & Jezernik, 2008).

**Drill and practice:** In education, drill and practice displays several characteristics that foster deep learning: active and manipulative environment, authentic complex and contextualized content and tasks, ability to reach a goal using a variety of routes and strategies, peer interaction, combination of cooperation and competition, increased sense of control and investment of effort (DeKanter, 2005).

**Core Learning:** Because engineering is often couched in terms of its applications, developing curriculum with core concepts across engineering disciplines can be difficult. Nevertheless, when students work with faculty and community experts to learn core engineering concepts through visual simulation drill and practice, test those concepts in the real world, and then apply their academic and field experience to develop their own engineering practice, they can learn deeply and contextually (Boardman & Clegg, 2001).

### 3.The Proposed Visualization-Based Tutoring Framework

In the proposed tutoring framework (refer to Figure 1), the content of materials are covered and organized in three main sections: Learn, Practice and Assess. These three separate sections enable students to achieve deeper understanding as they undergo a three-stage learning process:

**Learning:** first, students are going through the tutoring software to enhance their knowledge and understanding. Links between relevant documents are provided within the materials, these links will allow students to review the materials of interest themselves, thus resulting in better memory of what was learned.

**Practicing:** Students are prompted to solve practical problems using their acquired knowledge, and apply what was learned to unfamiliar problems.

**Assessing:** Students learning are assessed by means of questions. Their answers to these questions are scored and used to assess their resulting learning against objectives of the course. To satisfy each chapter, based on the assessment outcomes, the tool provides the students their results and recommendations based among what topics in the chapter to be reviewed before going for further subsequent chapters in case of any failure or weaknesses presented by the student.

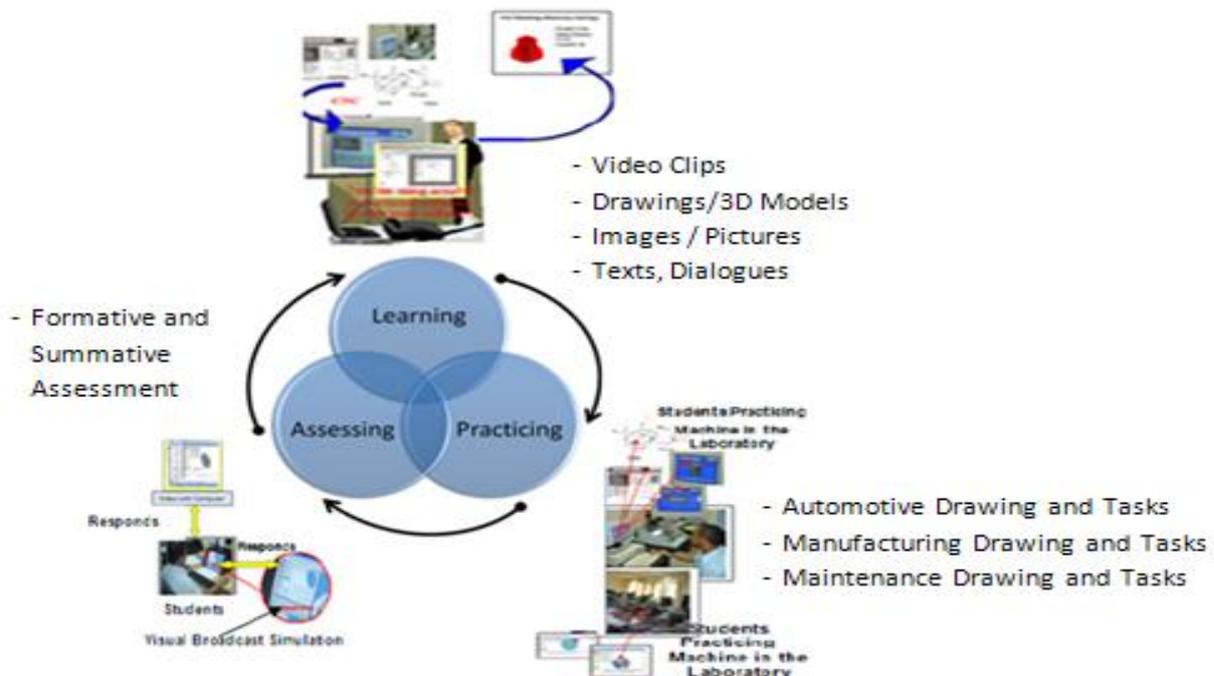


Figure 1 the Proposed Tutoring Framework Abdulrasool, S. Mishra, R. (2008)

The proposed tutoring framework described above was implemented into a computer platform through three steps. First, the learning materials were prepared and organized in chapters, sections and subsections including texts, dialogues and illustrative visualisations (e.g. video clips, drawings, 3D models, images, and photos). At the end of each chapter, questions were given as multiple-choice

quizzes or tests, which will be scored to assess the student's knowledge. Second, the user interface for the proposed tutoring tool was designed such that the student will be able to interact with the learning tool through illustrative blended learning and dialogues rather than just reading or watching. The students are processed to answer questions in the shape of quiz to test the capability of student's learning. If the students are incapable of achieving passing grades of Laboratories Work, in order to move the upcoming chapters, he/she will be recommended to undergo the chapter material again. Finally, the proposed tutoring software and the user Manual are implemented into a computer platform to obtain a visualization based on the tutoring tool, named e-learning Package. Toolbook, Video Clips and Photoshop software are adopted through visual learning for the implementation of combined chapter (automotive clutch lessons), since it offers the broadest range of creative tools to design interactive dialogues and visualizations using advanced graphics, text, animation, video and audio tools. (Abdulrasool, S. Mishra, R. 2008).

#### 4. IMPLEMENTATION AND RESULTS

Teaching at higher order of cognitive skills with e-learning is clearly likely to help our students made better progress. Editing learning materials with e-learning to embrace course learning outcomes is essential to prior submitting students with teaching subjects, such outcomes are:

- 1- The construction of the clutch assembly.
- 2- The operation of the clutch assembly and its components.
- 3- Analyze the common faults that may occur in the clutch assembly.

Figure 2 and 3 shows typical screen shots of the tutoring software (e.g. video clips, drawings, 3D models, images, photos and drawing) to cover mechanical engineering course (Automotive Clutch).



**Chuck the condition of the clutch cable adjusting nuts and remove the propeller shaft**

**Figure 2** Video clips and 3D images for adjusting nuts and propeller shaft



**Remove the gearbox with proper tools and dismantle the clutch components**

**Figure 3** Video clips and 3D images for gearbox and clutch components

After going over the learning materials for a particular subject (e.g. clutch tie rod), students are prompted to answer questions in a quiz that tests student's ability to seek answers and solutions upon their previous learnt knowledge. These quizzes are scored to make sure students understand the materials before going further in the subsequent chapters.

Figure 4 is an example of the quiz for Chapter (Automotive Clutch). The quiz scores and assessment results are reported to provide students with recommendations on what materials should be reviewed for deeper understanding. Figure 5 shows a typical assessment report.



**Check the condition of the dismantled components (Pressure plate and clutch plate) and replace**

**Figure 4** Students Assessment and the Results (clutch components)



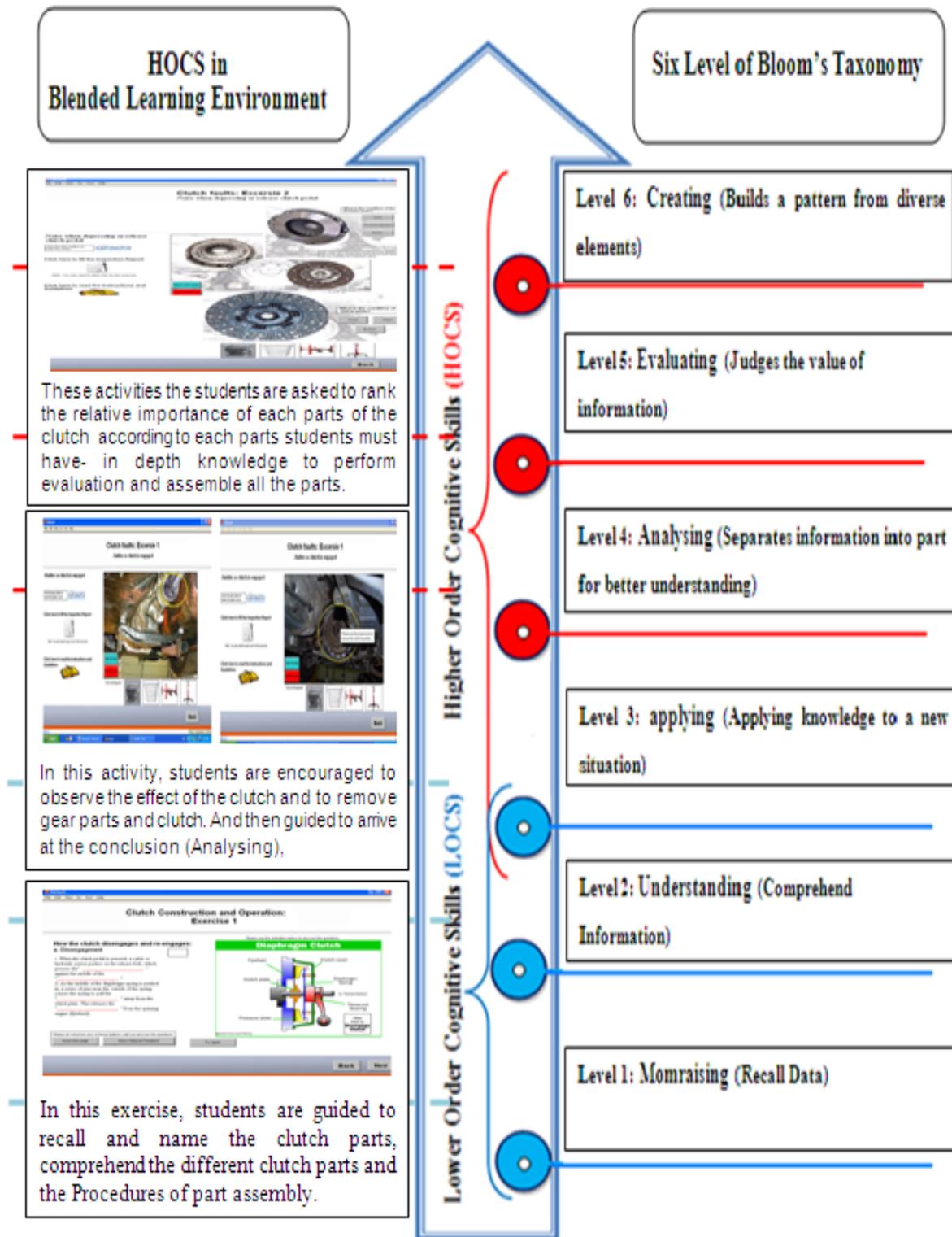
**Inspection report or fault finding Report**

**Figure 5** assessment report

### 5. Applying High Order of Cognitive skills in Blended Learning Environment

The assessment of an engineering course with respect to student expectations or learning objectives is a necessary activity for enhancing the course quality. The assessment tools such as homework, quizzes, tests, exams, lab reports, oral presentations and projects were used as evidence of the overall student achievements with respect to the learning objectives of the mechanical engineering course (Automotive clutch) where the proposed visualization-based tutoring framework at HOCS was implemented.

Figure 6 shows the hierarchy named Bloom's Taxonomy consists of the 6 levels of cognitive processes. Level one to three represents the Lower Order of cognitive skills, Level four to six represents High Order of cognitive Skills (Whittington, M.S., Stup, R.E., Bish, L., & Allen, E. (1997).



**Figure 6** Lower and Higher Order of Cognitive Skills (LOCS &HOCS)  
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**Table 1** high order of cognitive skills (Blooms Taxonomy)

<b>Blooms Taxonomy Level</b>	<b>Blended learning</b> that focus on scaffolding thinking which contributes in:
<b>Applying:</b> the student can use the information in a new way by Choosing, demonstrating, dramatizing, employing, illustrating, interpreting, operating, scheduling, sketching, solving, using and writing.	This level includes student guidelines to arrive at a certain concept, rule, principle or method and use them in a new situation.
<b>Analysing:</b> the student can distinguish between the different parts by Appraising, comparing, contrasting, criticising, differentiating, discriminating, distinguishing, examining, experimenting, questioning, and testing.	This level includes requirements that students need to critic or review materials or ideas.
<b>Evaluating:</b> the student can justify a stand or decision by Appraising, arguing, defending, judging, selecting, supporting, valuing and evaluating	This level includes student guidelines to study different components of a particular object, in ways to appreciate the relationships between different parts and the whole aspects of a process to embrace the working principle behind the process.
<b>Creating:</b> the student can create new product or point of view by Assembling, constructing, creating, designing, developing and formulating.	This level includes student requirements that help in constructing a new product from the components given or applying different aspects of their prior learning to put a product together.

## 6. CONCLUSION

According to recent research projects on education, the use of interactive blended learning helps students in deeply understand abstract and highly abstract engineering subjects in engineering courses. A computer tutoring framework was developed and implemented into automotive of engineering courses at Sheikh Khalifa Institute of Technology in Bahrain. The proposed tutoring framework was incorporated with blended learning objects including graphics, animation, video, and illustrative images/photos, which were found to be very effective in learning and teaching engineering courses at High Order of Cognitive skills (HOCS).

These learning objects consist of modules that will help students achieve deeper understanding (learn), apply learning to unfamiliar problems (practice) and optimize achievement of predefined learning outcomes through a diagnostic feedback loop (assess). Learning objects were designed to address basic, intermediate and advanced knowledge to provide spiralled learning. The blended learning provides dynamic representations of knowledge and improves accessibility of instructional materials because the learning objects provide an alternative to normal text. The interactive approach enables students with different learning styles to comprehend theoretical constructs and apply them in grounded practice. The constructivist paradigm is further enhanced with the technology's built-in diagnostic feedback loop, which optimizes individualized learning. The proposed tutoring tool was also evaluated for its effectiveness in learning and teaching of engineering courses. It was reported that the tutoring tool overall helped students to effectively learn materials.

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