



DEVELOPMENT OF KNOWLEDGE BASED TUTORING SYSTEM ON BASIC CONCEPTS OF ENGINEERING DRAWING

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ABSTRACT

Learning is a continuously evolving process with a constant search for newer and more suitable strategies and tools for enhancing its effectiveness along with more student centric approaches. Heterogenous nature of the classes demands individualisation of teaching coupled with more adaptive teaching strategies. Knowledge Based Tutoring System (KBTS) is one such approach of customising instruction to the needs of individual learners. Domain Knowledge Component, Student component, Pedagogy component and Control component are used in KBTS to model different entities involved in teaching learning process. Planning, Discussion, Evaluation and Remediation modules cater to the communication requirements of the system. Engineering Drawing, a course in the Engineering Curriculum of different universities, require high level of abstract visualisation skills on the part of the learners to imagine various objects in different positions and orientations in order to draw their views. This paper discusses the steps followed in developing a Knowledge Based Tutoring System for teaching the basic concepts of Engineering Drawing to the engineering students.

Keywords: Knowledge Based Tutoring System, Engineering Drawing

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1. INTRODUCTION

Education, being a process which depends on a complex mix of dynamic interactions between students, facilitators, media and infrastructural facilities, is affected by the new avenues of communication thrown open by the advancements in the educational technology. These technologies enable the teachers to adapt the instructional strategies to fit the individual abilities of the learners in addition to cutting across the barriers of space, time, material and media. Effective use of ICT tools will result in better management of teaching learning process leading to a more comprehensive achievement of the leaning objectives.

2. EVOLUTION OF KBTS

With the increased accessibility of computers, use of computers became more widespread in teaching resulting in the development of a variety of learning resources based on the capabilities of the computers. Computer Assisted Learning (CAL) packages were developed for various types of contents. These packages typically presented instructional content in a particular area followed by assessment of learning through questions. The different types of computer assisted instructional packages were reviewed by Sleeman (Sleeman and Brown, 1982), and he proposed a more adaptive system of computer based instruction and used the word Intelligent Tutoring System to describe the new system. Martha (1988) proposed a Knowledge Based Tutoring System (KBTS) which consisted of different modules which try to model the entities involved in teaching learning activities such as student, teacher and content. Wenger (1989) viewed KBTS in terms of issues relate to Artificial Intelligence.

3. COMPONENTS OF KBTS

According to Burger and Desoai (1992), KBTS is a powerful instructional tool identified by the following components

1. Domain Knowledge component: This component consists of the content matter which KBTS intends to teach. Martha (1988) refers to this component as “expert module” of the KBTS.
2. Student component: This module, also known as “student diagnostic module” (Martha, 1988), represents the student with respect to initial behaviour, terminal behaviour and the transformative behaviour as the student progresses through the course.
3. Pedagogy components: Teaching involves the use of pedagogical principles which are represented by this module. Martha (1988) refers to this component as “curriculum and instructional module”.
4. Control component: Providing a convenient interface, updating the databases and taking decisions about further delivery of content is implemented through this component. According to Martha (1988), this component represents “instructional environment”

For implementing KBTS as per the content matter and tutoring strategy, KBTS also has a communication cycle. These set of procedures are organized into four modules viz., Planning, Discussion, Evaluation and Remediation to constitute the communication module. This model is represented in Figure 1.

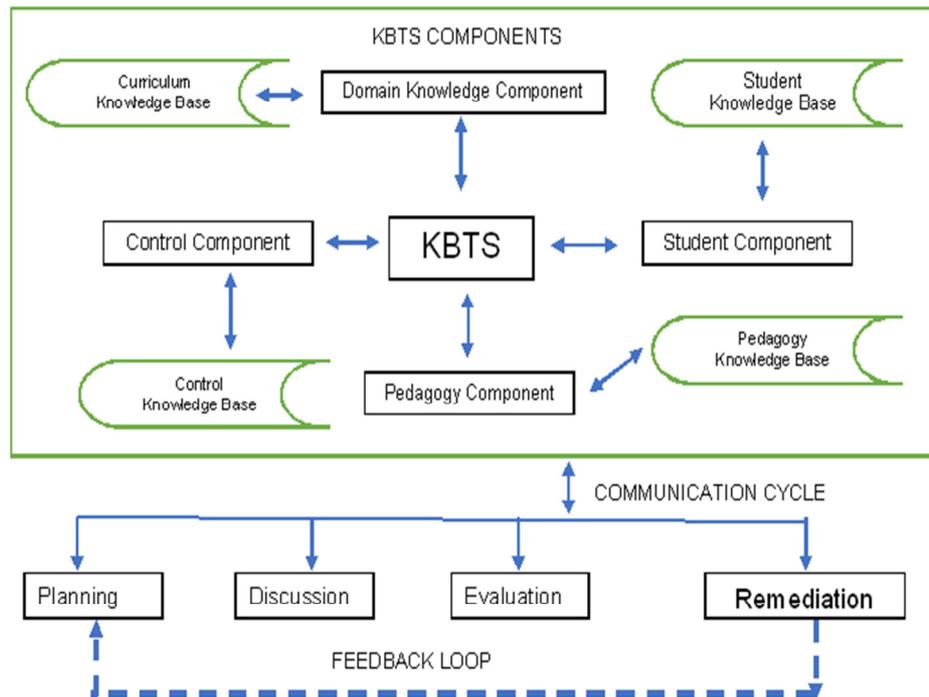


Figure 1 Block diagram representing Framework for Developing KBTS on Engineering Drawing

3.1. Planning module

In KBTS, Curriculum Knowledge Base (CKB) is the repository of Content Knowledge. This knowledge is used to provide learning experiences to the students as per predefined rules contained in the KBTS. The aim is to generate a learning path for each student which has to bridge the gap between the current entry behavior and desired terminal behavior for that particular learner. The student model is accessed for understanding the current student behaviour and Pedagogy Knowledge Base provides appropriate teaching strategies to develop a topic hierarchy.

3.2. Discussion Module

At certain stages of learning, the learner may need personal guidance and certain tutors are assigned to meet this need as “experts” for providing necessary learning support. These experts can log into the system with necessary access right to view the progress of the learner with respect to the content and learning activities. There is also a discussion forum through which learners can interact with other learners as well as experts.

The discussion module is included to accomplish the twin objectives of

- Providing an opportunity to each learner to interact with an expert with respect to his queries and doubts on the content
- Providing an opportunity for a learner to interact other learners to benefit from sharing information and learning experiences

3.3. Evaluation Module

Feedback from the learner is an essential aspect for developing further learning path for the learner. It is done both at the formative and summative level. Formative evaluation helps in reforming the instructional strategies whereas the summative evaluation points to the level of effectiveness of the KBTS used.

4. METHODOLOGY

The methodology adopted for developing KBTS involves the following two phases.

Phase 1: Identifying the concepts for developing KBTS in Engineering drawing.

Phase 2: Developing the KBTS for the identified concepts

Phase 1: This phase involves the identification of topics in Engineering drawing for developing KBTS

Engineering drawing, which is a common course for different engineering programs in the first year study, was selected for developing the KBTS. Engineering Drawing is a course requiring special visualization skills on the part of the learners (Gordana M., Vladimir G. 2012). The topics are selected based on their difficulty level as perceived by the subject experts based on their experience in teaching the subject. For this purpose, certain teachers who are currently teaching the subject are identified. Data from these subject experts is collected through a questionnaire and analyzed to arrive at the relatively difficult topics which are appropriate for developing KBTS.

4.1 Profile of respondents and outcome of the survey

For conducting the survey to identify the relatively difficult topics in Engineering Drawing Curriculum, a total of 14 faculty members were selected from 7 engineering colleges. All the topics were listed and the respondents were asked to rate each chapter with respect to the difficult level of the topic in comparison with other topics in the curriculum. The rating scale quantified the responses using 1 for “very easy” to 4 for very difficult. Table 1 shows the analysis of the of the data collected through survey using a questionnaire

Average difficulty level for each topic was calculated and the result is shown in table 1

Table 1 Table showing ranking of chapters based on difficulty level

S. No	Topic	Average difficulty Level	Remark	Remark
1	Introduction to Computer Aided Sketching	1.429	8	
2	Principles of Orthographic projections	2.929	3	Selected
3	Orthographic Projection of Points	3.5	1	Selected
4	Orthographic Projection of straight lines	3.143	2	Selected
5	Orthographic Projection of Plane surfaces	2.214	7	
6	Projection of Solids	2.143	5	
7	Sections and development of lateral surfaces	2.857	4	
8	Isometric Projections	2.214	6	

As per the table above, the following three topics were identified for developing KBTS

Module 1: Orthographic Projections

Module 2: Projection of Points

Module 3: Projection of lines.

Depending on the curriculum content in each of the modules, the specific objectives were framed.

Phase 2: Development of KBTS for the identified concepts

The next step was the development KBTS for the identified topics. As the subject of engineering drawing is highly graphic intensive, proper care was taken to include graphics and animations along with audio and text. As the material is deployed online, bandwidth considerations are important for quick loading of the content. The content was broken into

smaller units and each content was loaded only when it is required during the delivery of course. The user is also given a visual indication on the screen of the status of loading of the content.

The next step in this phase involved validation of the KBTS. Alpha testing was done by expert teachers who are teaching the course of engineering drawing. The expert teachers went through all aspects of the KBTS and their feedback was collected and analyzed. Based on the analysis of the expert feedback, necessary changes were incorporated into the KBTS

4.2 Description and organization of content in the KBTS

Basic requirement of a KBTS is its ability to be independently used by the learners to study the three identified concepts namely i) Orthographic projections ii) Projection of points and iii) Projection of lines. Engineering drawing, being a graphic intensive subject, require apt use appropriate graphics and animations as the core of the content matter used for learning. The three identified topics are built into the KBTs as three separate modules. Specific objectives and teaching points were identified for each of the modules according to a logical sequence. Embedded self tests were included at appropriate places as part of formative evaluation

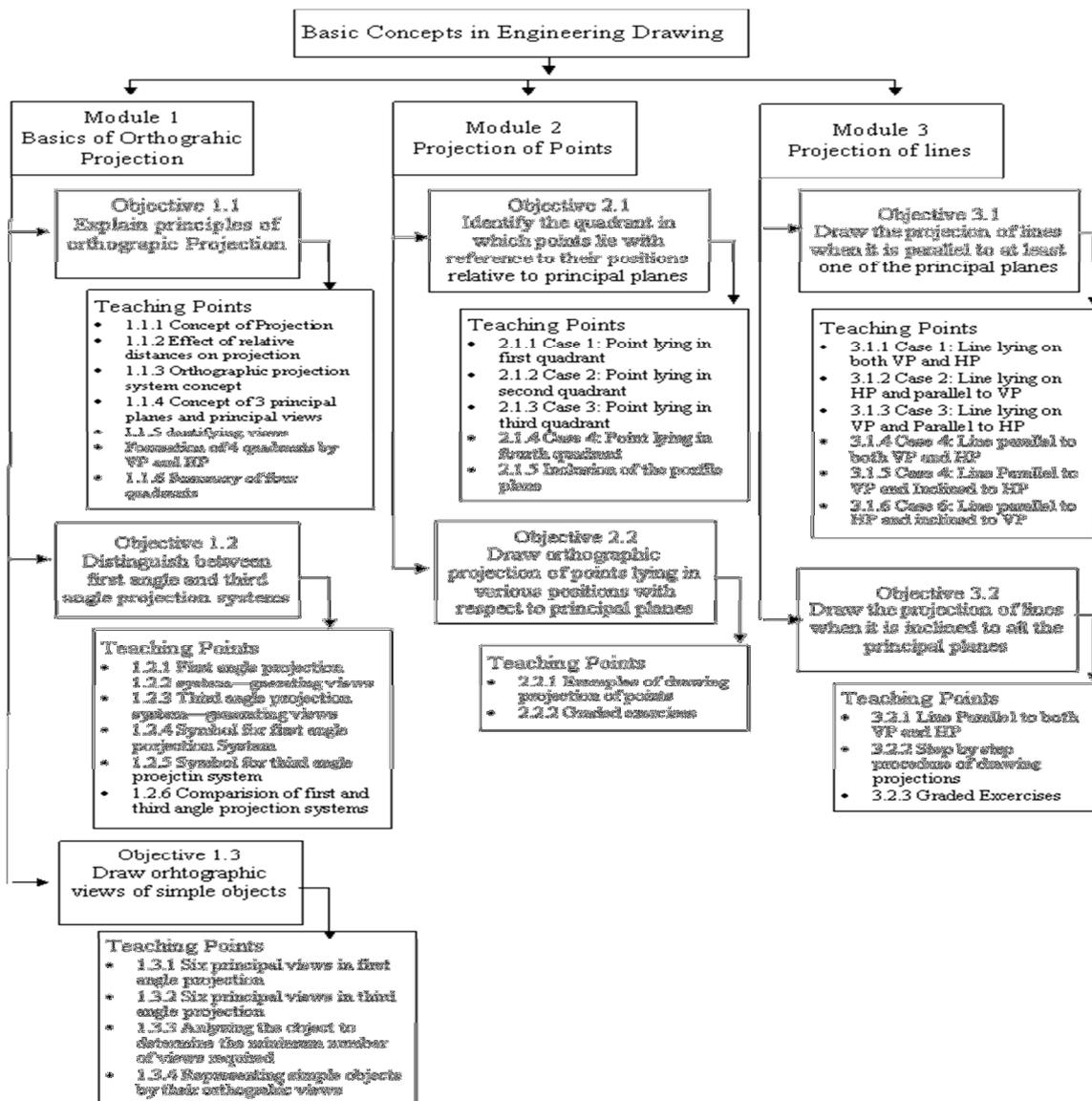


Figure 2 Organization of the KBTS in terms modules, objectives and teaching points

The content was arranged at three levels. At the top level, there are three modules and under each module, there are specific objectives and under each specific objective, there are teaching points. The figure 2 shows the organization of the KBTS in terms modules, objectives and teaching points.

4.3 Development of KBTS

Based on the content and teaching points, a model was formulated for developing the KBTS consisting of the following steps.

Step 1: Developing hierarchy modules, objectives and teaching points to be covered by the KBTS

Step 2: Development of the appropriate Content

Step 3: To make an instructional design to logically connect the content matter

Step 4: To develop a presentation plan and design based on pedagogical principles.

Step 5: Incorporation and organization of Multimedia elements

Step 6: Using suitable authoring tools to integrate all the resources

Step 7: Alpha Testing of KBTS

Step 8: User Manual preparation

Step 9: Pilot Study

Step 1: Developing hierarchy modules, the Objectives and teaching points to be covered by the KBTS

At the top level, KBTS consists of the three identified modules. Under each module, appropriate specific objectives corresponding the modules were identified and listed. For each of the specified objectives, the underlying teaching points were selected. The teaching points deal with the specified chunk of content. Learning a set of teaching points will lead to the achievement of the relevant specific objective and the achievement a set of specific objectives will cover the respective instructional module. This hierarchy is represented in Figure 2.

Step 2: Development of the appropriate Content

The teaching points were used as the basic instructional element and for each teaching appropriate learning resources were developed by review of relevant book and other media. The multimedia elements of graphics, audio, video and animations were used in such a way as to make a seamless integration of different types of contents

Step 3: To make an instructional design to logically connect the content matter

A logical and systematic sequencing of the content is an essential requirement for effective learning (Bloom 1956). At the beginning of each module, overviews of the content covered in the module were specified for proper orientation of the learner towards the content. The ever relevant learning principles of “simple to complex”, “known to unknown” and “concrete to abstract” were kept in mind for sequencing the content matter. A well-integrated combination text, graphics, animation and audio were incorporated in the KBTS. Embedded self-test were included at suitable places.

Step 4: To make a presentation plan and design based on pedagogical principles

The content was developed using multimedia contents which includes text, graphics, animation and audio components for promoting effective learning (Cynthia, K L. 2008). A modular approach was adopted for content development. In this approach, each teaching point

is converted into a separate elemental unit which includes all the multimedia elements necessary for learning the particular teaching point. Developing material in terms of discrete elemental units provides three distinct advantages.

1. The material can be rearranged in different sequences for different learners so as to match with the learning abilities and preferences of the specific learner.
2. Remedial material can be built using only the required elements based on the embedded formative evaluation tests
3. Bandwidth being a major consideration in online delivery of content, only the required elemental unit of instruction is loaded and then unloaded before loading the next selected elemental unit of instruction.

Step 5: To make a presentation plan and design based on pedagogical principles

Diverse resources are required to incorporate different multimedia elements into the KBTS (Zarko S., et. al. 2015). Digital video camera still camera were used for capturing videos and images. Graphics and pictures were scanned using scanners. The final versions of the multimedia elements were developed by editing the captured contents in appropriate Multimedia software tools like Adobe Photoshop, Snagit editor, Adobe Flash, Adobe Premiere Pro, Pinnacle Studio HD, flash converter. Narration and sound were recorded and processed using Super mp3 recorder and editing of sound was done using Sony Soundforge and Wavepad sound editor. Adobe Flash was used for developing animations with integration text, images and audio.

Step 6: Using suitable authoring tools to integrate all the resources

After developing individual multimedia elements, the next step is the integration of these elements using authoring tools. The integration was done mainly using adobe flash as the authoring tool because of its flexibility and strong scripting features. Macromedia Director, Swishmax-2 were also used as supporting authoring tools.

Following were the major considerations in selecting the multimedia authoring tools

1. Ease of use of tool with convenient user interface.
2. Support for a wide variety of media, flexibility in their selection and usage
3. Provision for interactivity using Scripting facilities.

Step 7: Alpha testing of KBTS

Testing the package before its use is the next logical step. Usually, Alpha testing is first carried out. Alpha testing is an internal testing by persons who have not been involved in the development of the System (Cunliffe, D. and Elliott, G. 2004). The purpose of Alpha testing is to determine the changes that are required to be carried out in the content, media elements and instructional design aspects of the KBTS for enriching its effectiveness.

It was necessary to test both content matter and appropriateness of multimedia elements used for the content in consideration. As subject experts are not necessarily experts in multimedia development, panels consisting of subject experts as well as multimedia specialists were included in the panel. Two such panels of three members each were identified for Alpha testing of the KBTS. The panel consisted of two experienced teachers who teach the subject and one person having knowledge in the development of multimedia. The KBTS package was modified based on the input from the two panels.

Step 8: Preparation of Help material

A need was felt for the providing accurate information to the user about how to use the KBTS to derive maximum benefit from it. This information enables the users to make a planned use of the package as well as to derive optimum benefits out of it. As the KBTS is used online, online support was also given in terms of links which any user can use to access different help information. The following links were used to provide information to the users about the correct usage of the KBTS

1. Providing information about the KBTS through an introduction
2. Defining important terms used in the KBTS through a Glossary
3. FAQ – This answers the frequently asked questions.
4. Contact US link which will allow the user to communicate with the KBTS team
5. Forum - This gives a platform for the users to post any relevant information which will be visible to all other uses and experts in the KBTS team. The experts an intervene and post answers and clarifications whenever required.

Step 9: Pilot study

A pilot study was conducted using a sample of 30 students of First semester Bachelor of Engineering (Mechanical) programme drawn from an Engineering colleges affiliated to Visheswarayya Technological University (VTU), Karnataka. The students were chosen randomly for the pilot study. Material was revised based on the input from the pilot study.

5. CONCLUSION

As each learner is unique with respect to various parameter affecting his/her learning, matching the instruction to the unique characteristics of the learner is a constant requirement for effective instructional strategies. Various such strategies have been tried and tested to meet this constant need with varying degrees of success. Knowledge Based Tutoring System is one such approach which tries to model a student in relation to the other entities in the teaching learning process such as Domain Knowledge, Pedagogical Principles and Control Element and tries to coordinate all these modules to enhance the effectiveness of the teaching learning process.

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