

E-learning of automated parts feeding

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Abstract

Purpose – This paper seeks to describe the development of an e-learning package in Automated Parts Feeding, by discussing the concept of e-learning, the development process and presenting the automated parts-feeding contents covered in the package.

Design/methodology/approach – Macromedia Flash MX has been used as the main development platform. Other authoring tools include ProEngineer Wildfire, Autodesk 3ds Max, Adobe Premiere Pro and Adobe Photoshop. These tools provide the important framework for organising and editing the elements of the e-learning courseware and ensure maximum effectiveness of the 2D/3D graphics and animation in the courseware.

Findings – The courseware has been fully tested. Evaluation of the software by users indicate that the majority of users are pleased with its effectiveness, quality, design, length of content and style of delivery.

Originality/value – It serves as a supplement teaching package for students, instructors, engineers and technologists who are interested in the specialised field of automated parts feeding.

Keywords Parts, Electronics industry, Education, Vibration, Feeding devices

Paper type Research paper

1. Introduction

The assembly operation is a very important aspect of the manufacturing process. This process is required when two or more component parts are to be brought together to provide the finished product. In automated assembly (Boothroyd, 1992), before parts can be put together, they often have to be loaded into a hopper, translated, singularised (each part separated from the bulk), appropriately oriented and discharged down a chute for the workhead to pick it up for assembly. The device performing this task is generally referred to as a parts feeder. The most commonly used automated parts feeder is the vibratory bowl feeder. For such a feeder, the path along which the parts travel is formed as a helix and is located around the inside wall of a cylindrical, bowl-shaped hopper which is secured to a heavy base by sets of inclined leaf springs. The bowl is vibrated by alternating the activation and deactivation at a certain frequency (e.g. 50 Hz) of an electromagnet mounted on the base, and a support system ensures that the resulting movement of the bowl is such a way that it provides torsional vibration about the vertical axis coupled with linear vertical vibration. All parts of the inclined track vibrate along a short, almost straight path, inclined to the horizontal at a greater angle than that of the track. The pushing action of the feeding parts at the bottom of the bowl and the vibratory motion cause feeding parts in the bowl to climb up the track to the outlet at the top of the bowl. Besides, the vibratory bowl feeder, many different types of non-vibratory feeders have also been developed

such feeder for tubular parts (Chua and Yeo, 1991), feeder for fragile parts (Chua, 2006), reciprocating tube hopper feeder, centreboard hopper feeder, rotary disk feeder, tumbling barrel hopper feeder, centrifugal hopper feeder (Boothroyd, 1992), etc.

Orientation is one of the most important tasks in automatic production (Riley, 1996). Every item possesses six degrees of freedom in space. After orientation, it is restricted to only one degree of freedom as it travels to the exit of the bowl and down the chute for the next operation. Parts feeders are usually placed some distance away from the workhead in order to provide free access to the workhead and the assembly machine itself. This requires that the parts be transferred and maintained in orientation between the feeder and the workhead through the use of a feed track. Since most parts feeders do not supply parts at the discrete intervals required by the work head, the parts feeder must be adjusted to overfeed slightly, and a metering device called an escapement is required to ensure that the parts arrive at the workhead at the desired intervals. After the parts leave the escapement, a part placing mechanism places the parts in the assembly.

In today's knowledge-based economy, acquiring and utilizing the latest information and skills quickly are key to gaining the edge over competitors, but with the wealth of information available, and the short time cycle of current information, coupled with busy travelling schedules of executives, conventional training methods can no longer satisfy the need of a business to train employees with the latest information. This is where e-learning comes in. From passive learning to active learning, "train as and when you need" can be realized through e-learning. E-learning provides the best mechanism for knowledge workers to become ongoing, active learners. Over the years, tertiary institutions and industries have been adopting e-learning since the last decade. In the business context, Education and Training (both on-the-job and off-the-job) are important for maintaining productivity, innovation, and competitiveness. Using a combination of internet technologies to deliver instant,

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up-to-date information and knowledge almost anywhere in the world, e-learning provides the following advantages over conventional classroom training methods (Sloman, 2002):

- instant, global distribution and updates;
- accessible and flexible learning anywhere, anytime;
- self-paced format accommodating all levels and schedules;
- more cost-effectiveness than large expensive corporate training facilities; and
- consistency of information: everyone receives the same information in the same way.

Today learners themselves are changing. They are becoming more demanding, increasingly looking for more flexible means of accessing Education and Training. They are also expecting more learner-centred approaches than the traditional teacher-driven approach and classroom-based model. Learners are now seeking an experience contextualized to their own situation and customized to their own learning style. In addition, there is also their increase expectation of the quality and richness of Education and Training resources due to their increasing familiarity with the highly interactive, immersive environments provided by computer games and the high quality of video and audio entertainment delivered by DVD, CD-ROM, broadband.

The rapid development of information and communication technologies, facilitate a transformation in the efficiency of teaching and learning (Steed, 1999). It is no longer necessary to aggregate students by asking them to attend a particular class at a particular time in a particular location. Technology can achieve this aggregation in real time if required. All learners, either individually or in groups, can be actively involved in the learning process. Technology can provide mechanisms to ensure that the teaching component is not just pitched at the middle level of student ability. It can provide a dynamic personalized experience based on upfront diagnosis of needs and individual preference. Technology can provide detailed monitoring/tracking/reporting and analysis of individual learning activity.

This e-learning package is developed for undergraduates and can also be used by technical personnel engaged in automatic assembly work. To the best of the authors' knowledge and experience, and after searching the internet, there is no known e-learning package in this specialised field of automatic parts feeding.

2. E-learning methodology

2.1 Approach

The first step in designing an e-product or e-learning solution is to understand the users' needs. This needs analysis usually comprises a variety of market research strategies including interviews, brainstorming sessions and forming focus groups with typical users. Analysis of the data also begins the process of documenting the scope of the solution design and functional requirements, in particular:

- user/learner requirements;
- content requirements;
- delivery and support requirements; and
- organizational and administrative requirements.

Once established, these requirements form the basis of the subsequent design and development processes.

The subject of automatic parts feeding has been taught as part of a manufacturing automation course at the authors' university for some years. Although several books on automatic parts

feeding were recommended for references to students, they still found it difficult to understand some concepts and visualise how the different types of parts feeders work. No laboratory classes were available that can be used to reinforce the lectures on parts feeding and make it lively. Through feedback from students, the authors felt strongly that there was a need for such an e-learning software to enhance their understanding of the subject. The feedback received included the four points stated in Section 2.1.

2.2 E-learning design

A number of critical elements need to be considered in the design of e-learning products (Asian Productivity Organization, 2003). Firstly, there must be a clear and agreed articulation of the strategic intent of the product, the rationale behind its development, and its purpose. Secondly, the learning design is applicable at a number of levels. At the highest level, it concerns the educational philosophies and paradigms that underpin the solution. Learning design also involves media selection and ensuring that the technology considerations do not override the educational and administrative efficiency requirements of the solution. At a more detailed level, it includes translation of the learner's needs into the particular teaching and learning approaches and strategies to be applied within the product (for example, building on existing knowledge, ensuring clear linkages between content and objectives, and building a community of learners where appropriate). Ultimately, learning design results in the storyboarding of the solution. Thirdly, content includes the breadth, depth, and authority of the subject matter. This element needs to be backed up by quality assurance processes including contribution and re-view by recognized (and accredited, where appropriate) subject matter experts. Fourthly, the interface design and usability must be considered because multimedia and e-learning products create an environment within which the user or learner operates. A number of factors contribute to the users' perception of that environment and the ease of working within it. These factors include concepts such as interaction design, navigation design, information design, screen design, graphic design, and usability. They are critical to the effectiveness of the product, particularly for products designed for markets that are only beginning to grow accustomed to the medium. Lastly, learner support ensures the provision of assistance to the users at all stages of interaction with the product. The support can range from simple tracking aids or help menus on a CD-ROM to the planning for intervention by teachers, mentors, or learning facilitators in an e-learning solution.

Communicating visual information through language is often quite laborious. It is much easier to explain an architectural form with a drawing than with mere words. By applying e-learning, the effectiveness of communication is greatly enhanced. The application of e-learning requires an appropriate mix of media. When learners are inexperienced and concepts involve movement, the use of animation and video will be more effective than simple text and graphs. However, heavy use of animation and video has associated cost problems and is time-consuming to develop.

In short, a good learning program can be enriched by the addition of multimedia. The advantages it provides allow learners to be fully immersed in a learning environment. For multimedia to enhance learning, it must have authenticity, that is, it must present the learning material in a relevant and appropriate manner. The key to successful e-learning is using multimedia to make the course display authentically while ensuring easy

accessibility. Multimedia-enhanced learning can be seen as the blending of technologies to achieve desired outcomes.

2.3 Courseware development

Macromedia Flash MX (Sanders, 2002) has been selected by the authors as the major development software in constructing the courseware. Macromedia Flash MX is recognized as the most effective and efficient tool for creating sound and animations for the world wide web, and a Flash movie can be run on the desktop or on a CD-ROM using a Flash player. The important feature of Flash is the ability to put together objects that normally have high bandwidth requirements and crunch them down into media that can quickly be transferred over the web inside a web page. This means that movies send out over the internet and viewers will not have to wait long for the movies to load and play.

Flash has become the tool of choice for creating lively and interactive media for the web. Flash MX does web animation with sound, including music, in a more compact fashion than any other soft-ware tools available. Flash is an application that brings together active elements that extend well beyond HTML, and it is far less complex and time-consuming to use than Java and related programming environments. Figure 1 shows the working environment of Macromedia Flash MX.

Flash is a moviemaking software application. The files created in Flash are animated movies; there are basically two methods for creating an animation sequence in Macromedia Flash MX namely, frame-by-frame animation and tweened animation.

In frame-by-frame animation it is made up of series of little pictures called frames. As each frame passes in front of the visual field, the illusion of motion is seen. Image in every frame has to be created by the courseware developer, whereas in tweened animation. Flash will fill in the blank frames between two key frames. Therefore, time and effort can be greatly reduced.

2.3.1 Frame-by-frame animation

Frame-by-frame animation is one way to create animation in Macromedia Flash. The main benefit of frame-by-frame animation is that it allows complete control over the animations, which means that both complex and subtle changes can be done. The downside to this method is that creating individual animations in each frame can be time consuming and tedious. It can also result in very large files if symbols are not used. Figure 2 shows the creation of animation using frame-by-frame method to animate the blade reciprocating action and the parts escapement down the delivery chute.

2.3.2 Motion tweening

Motion tweening is a great way to create animations without having to create a unique drawing for each frame. This is a tremendous time saver and generates much smaller documents. Instead of creating a unique drawing for each frame, by identify a starting frame and an ending frame using key frames, Macromedia Flash will fill in everything in between. Figure 3 shows the creation of animation using motion tweening method. It is used to animate the reciprocating action of the tube.

Figure 1 The working environment of Macromedia Flash MX

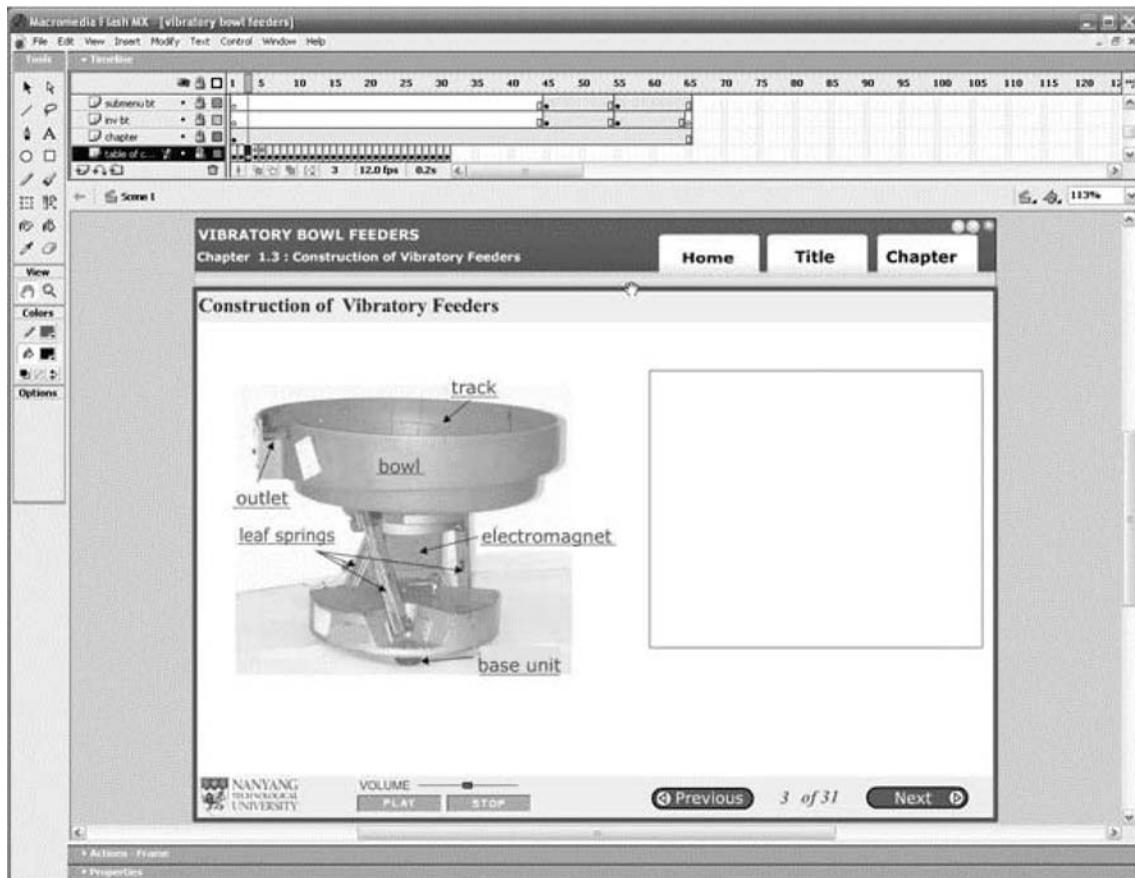


Figure 2 Creation of animation using frame-by-frame method

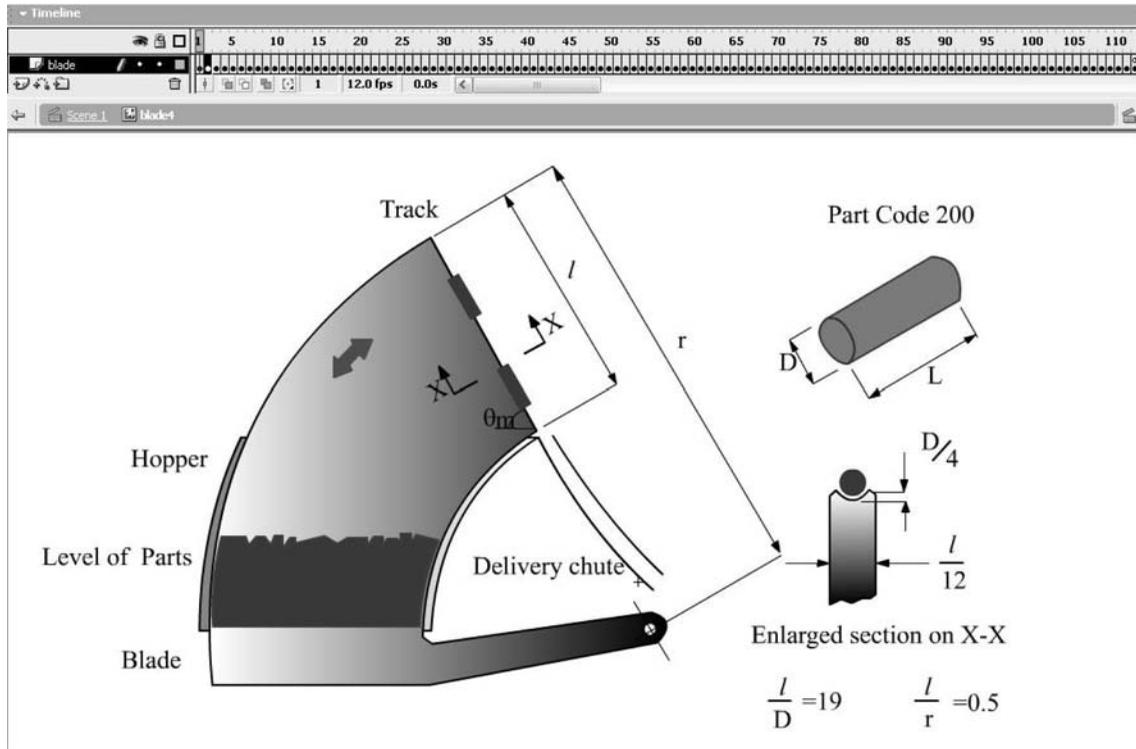
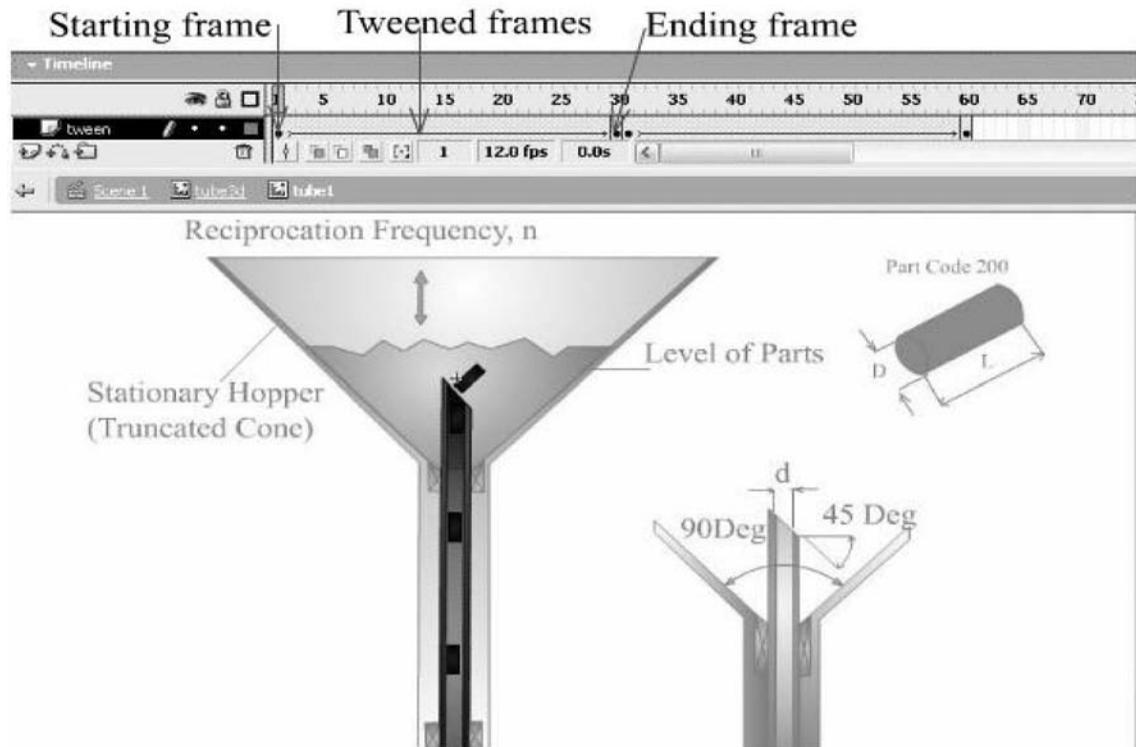


Figure 3 Creation of animation using motion tweening method



2.3.3 Creation of 3D animation

Besides, using Macromedia Flash MX as a primary tool in developing the animation, the software Pro Engineer Wildfire (Kelley, 2005) and 3ds Max (Kelly, 2005) are also used as a supplementary tool. Pro Engineer Wildfire is the best tool in drawing complex 3D (Figure 4). Objects created within Pro Engineer can be shared with other applications. The authors uses this tool to export Photo Render files (*.igs) to 3ds Max.

The software 3ds Max is industry standards for 3D modelling, rendering, and animation. 3ds max is an advanced software program for creating and rendering models. Models can be rendered as still images, or motion can be added to create a rendered animation. The final, rendered product can range from very realistic to fantastic. Figure 5 shows the working environment of 3ds Max.

When creating an animation in 3ds max, the same basic process used with traditional animation is employed. Objects have key frames specified for their movement. 3ds Max then calculates the tweens for the animation. When a key frame is specified, 3ds Max saves information about the related action as an animation key. This key can be edited, adjusted, or removed. The objects are auto-mated and the 3ds Max camera “films” the movement.

Rendering multiple frames for a complete animation is time consuming, even on fast machines. Each frame is individually processed. Realistic materials, shadow casting, and other factors can slow the process as well. Rendered product can render directly to a movie format such as AVI, or render a

sequence of still image files to file formats such as TGA and then use the RAM Player to save them into a movie. The latter method is the recommended choice. It is a few steps more than rendering directly into a movie, but it gives more control over file size and quality of output. In addition, if there are frames with errors, repair or removal can be done on it. Figure 6 shows the rendered product (tumbling barrel hopper) from 3ds Max.

2.3.4 Creation of video clips and slide show

Adobe Premiere Pro software revolutionizes nonlinear video editing. It enables videos to be edited, a small portion of the video to be extracted and adding of special effects into the video. It is used for this e-learning package as it allows the capturing and digitizing of video from any video source such as video camera and video cassette player, performs high- end precision editing and produces studio-quality soundtracks. With the use of video clips, the content of the courseware can be clearly illustrated and the teaching package will be more user-friendly. Users will be able to experience how the vibratory feeder bowls work and this approach is hardly found in any other teaching package nowadays. The video clips are then imported into Macromedia Flash MX and published as a Flash movie (SWF file). The video player allows the user to select four video clips. The interactive buttons allow pause, fast forward and rewind the clip. Figure 7 shows the video player. Image-editing programs Adobe Photoshop software enable images scanned in or obtained from other sources to be “touched up” or modified in any way that the designer

Figure 4 The working environment of ProEngineer Wildfire

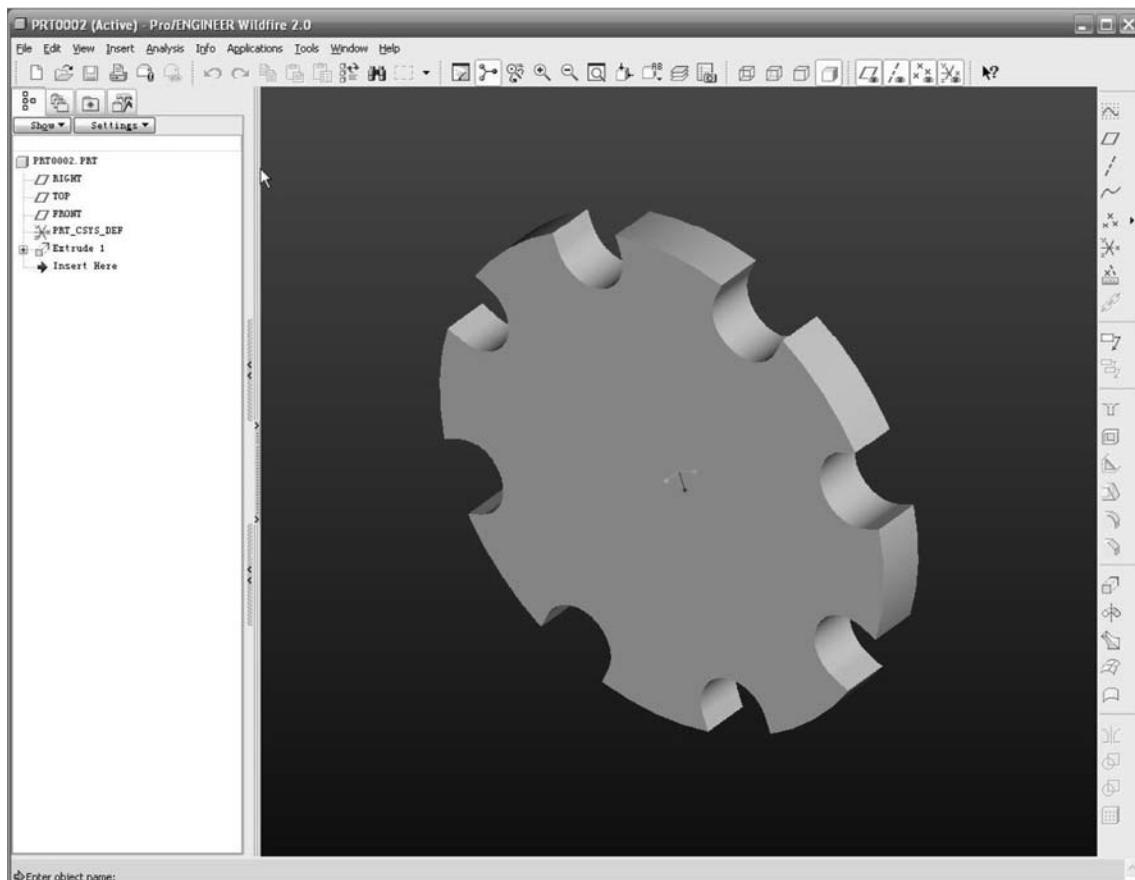
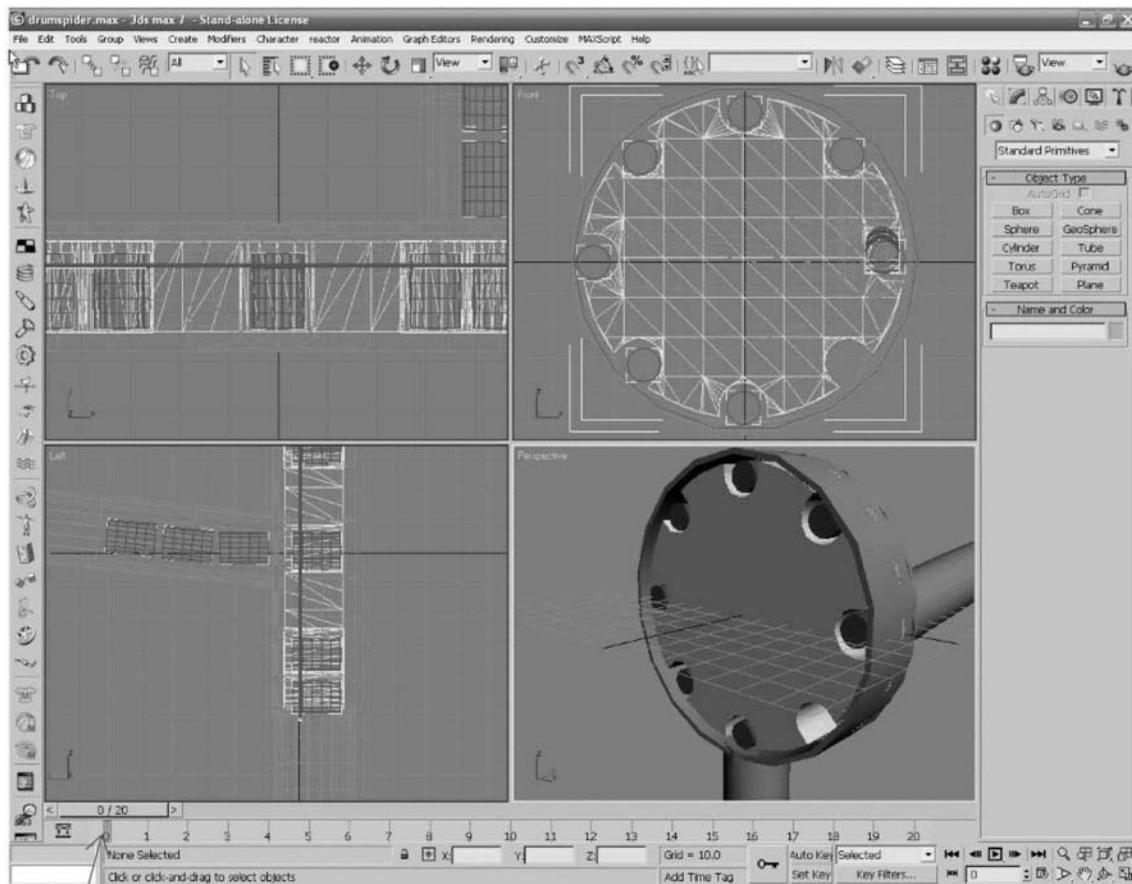


Figure 5 The working environment of Autodesk 3ds max



Animation key

wants. Figure 8 shows the slides show player. High quality picture of the vibratory bowls are displayed.

2.3.5 Creation of quiz using flash component

Flash components are actually a specific example of the more general Flash MX component architecture. A component in Flash MX is a reusable, packaged module that adds a particular capability to a Flash movie. Components can include graphics as well as code; they are neat little bundles of self-contained functionality that can easily drop into the projects. For example, a component can be a radio button, a dialog box, a preload bar.

From a Flash point of view, components are effectively ready-made movie clips that install and drag into the movies. Flash MX components provide visual programmers with a drag-and-drop development environment. Flash components can create a user interface visually in the Flash authoring tool and then easily hook that interface up to routines that perform some action. Figure 9 is a screenshot showing the creation of quiz components. Figure 10 shows a sample of vibratory bowl feeder review questions which can be presented in a random or sequential order. If the user answers the question wrongly, the correct answer will be shown in red. At the end of the quiz, the review page will display the user's scores.

3. E-courseware on automated parts feeding

Interactivity is the key to learning as it will improve the learning experience. This courseware developed comprises textual information with assorted explanatory graphics, such as diagrams, charts and animation icons. The way that this

Figure 6 The rendered product in Autodesk 3ds max

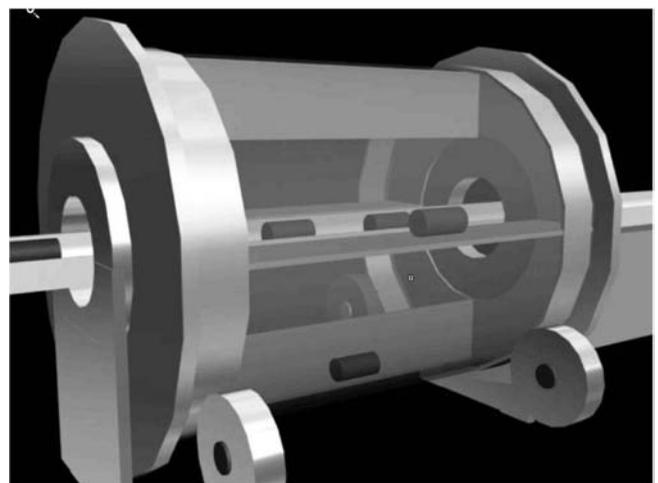


Figure 7 Incorporation of video player in the courseware

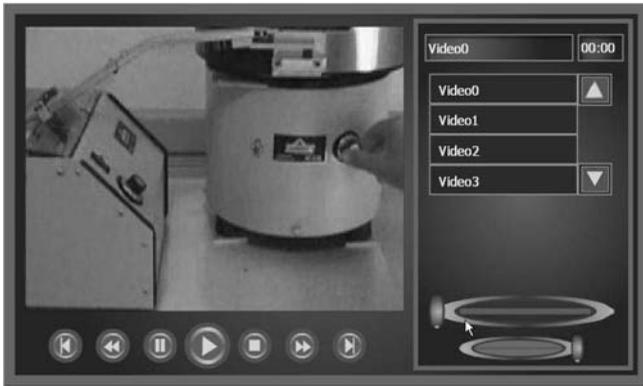


Figure 8 Incorporation of slides show player in the courseware



Figure 9 A screenshot showing the creation of quiz components

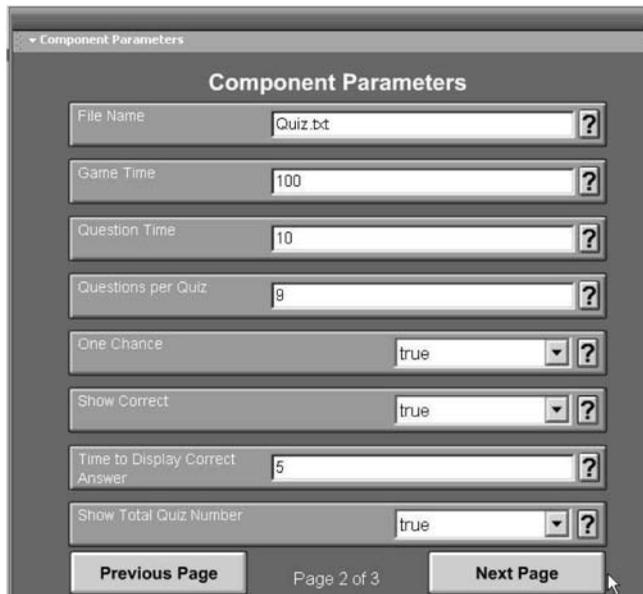
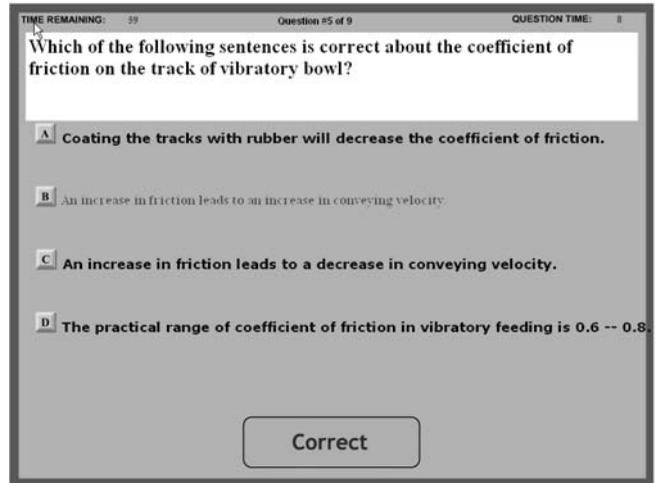


Figure 10 Sample review questions on vibratory bowl feeder



e-courseware scores over a traditional textbook is in its ability to jump from links in the text to other pages, video or animation. This improves the effectiveness for learning by encouraging the user to learn with more than just their visual sense.

There are four topics in the e-courseware namely, vibratory bowl feeders, orientation of parts, non-vibratory feeder, feed tracks, and escapement. Figure 11 shows the homepage for the automated parts feeding. The course objective is clearly shown to the user. Navigation to the topic is easily achieved by just clicking on the relevant button. Figure 12 shows the table of content for vibratory bowl feeder topic. Once the user starts the courseware, table of content will be displayed on the screen. This is the page where the courseware communicates with the user throughout the course and is also where the user controls the flow of the course and determines its overall status.

Figure 13 shows the sample page from vibratory bowl feeders. The gauge on the bottom right-hand corner of the screen shows the total number of text and audio pages that are available and the current page. The top-right section of the screen displays the current topic and the chapter. The back button takes the user back to the previous step and the forward button advances the page to the next.

Figure 11 Main page of courseware on automated parts feeding

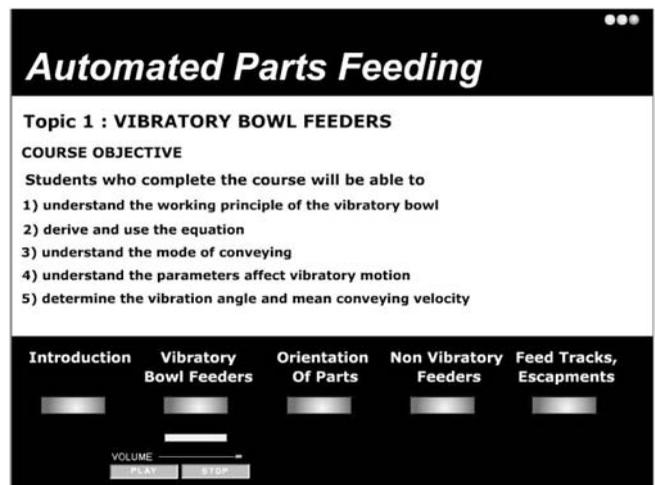
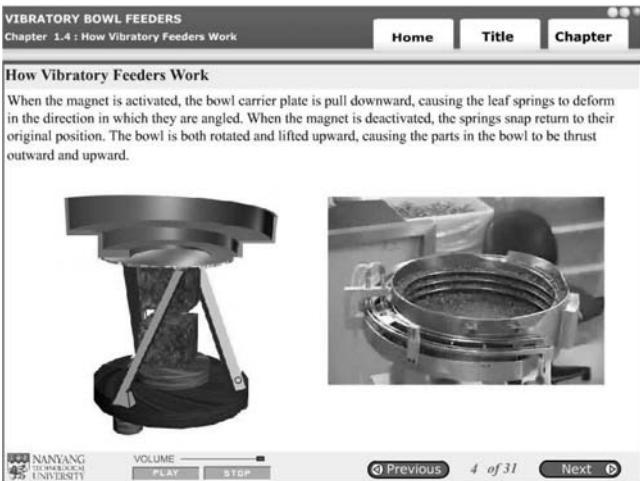


Figure 12 Content page showing topics covered in the courseware

VIBRATORY BOWL FEEDERS		
Chapter 1.1 : Table of Content		
	Pages	
1.1	Table of Content	
1.2	Vibratory Bowl Feeders	2
1.3	Construction of Vibratory Feeders	3
1.4	How Vibratory Feeders Work	4
1.5	Forces Acting On A Part	7
1.6	Dimensionless Analysis	9
1.7	Limiting Condition	10
1.8	Modes of Conveying	11
1.9	Graphically Illustrates of Equations	13
1.10	Work Example	14
1.11	Parameters That Affect Vibratory Motion	16
1.12	Determination of Vibration Angle	21
1.13	Determination of Mean Conveying Velocity	23
1.14	Load Sensitivity	27
1.15	Solution to Load Sensitivity	29
1.16	Summary	30
1.17	Quiz	31

Figure 13 Sample page on vibratory bowl feeders from the courseware



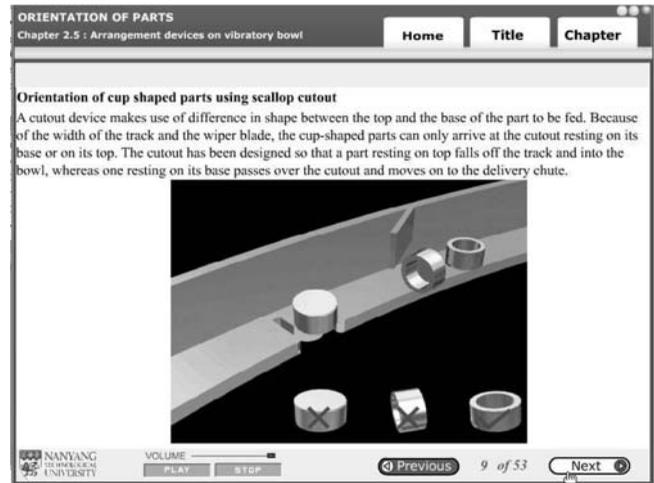
Clicking the chapter or title buttons will display a menu with additional user options, such as switching between chapter and topic modes. The media button turns the background music on/off and adjusts the volume. Clicking the quit button on the top right corner will allow immediate ending of the course prior at any stage.

Figure 14 shows a screen on the orientation of parts with 3D graphics animation. Only the desired orientation of the part passes through the cut-out. Figure 15 shows a screen on the animation of parts on feed tracks and escapement. Figure 16 (a) and (b) shows an example on orientation of parts. Interesting and sophisticated animations in this section help the user in understanding the questions.

4. Evaluation of courseware survey results

This survey was done for the evaluation of the overall effects of our automated parts feeding e-learning courseware and to show the important factors that were considered in designing and developing this e-courseware. The sample size was 40 and consisted mainly of undergraduate mechanical engineering students.

Figure 14 Sample page on orientating the parts in the courseware



The activities of this survey included:

- the courseware was uploaded onto the internet for access by the above users;
- a questionnaire was designed and distributed to the users;
- users were then interviewed;
- performing evaluation activities with the results obtained to investigate the effectiveness of this courseware;
- identifying factors for improving effective delivery of the courseware; and
- suggesting design strategies and policies for further improvement of courseware in the future.

The major results of the survey are shown in Figure 17 which shows that respondents generally agree that the courseware is effective towards their learning experience. The courseware was appropriate and effective for the respondents and has provided them with new knowledge and greater understanding of concepts taught. Figure 18 shows that after completing this course, the respondents generally agree that the objectives are made clear and unambiguous. They now understand better the working principle of the vibratory bowl feeder and how the

Figure 15 Sample page on feed tracks and escapement in the courseware

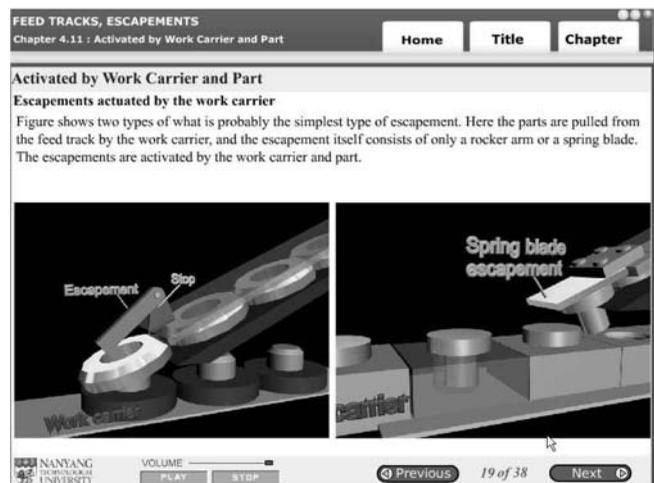
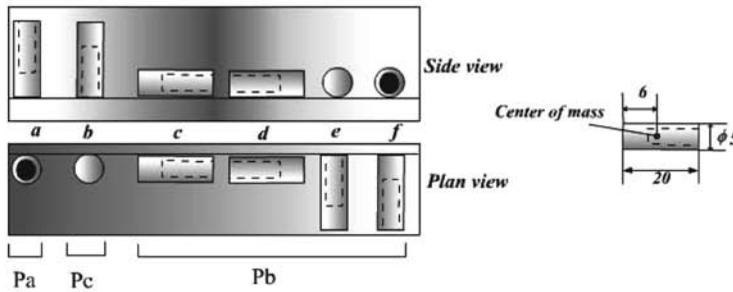


Figure 16 Examples on parts feeding incorporated into the courseware

Example 1

Figure 1 shows the six orientations of a cylindrical-shaped metal part that is to be fed by a vibratory-bowl feeder.

- (i) Sketch the orienting devices along the bowl track, which will finally accept parts with orientation a.
- (ii) What are the matrices for the orienting devices? The efficiency of the system?
- (iii) In your opinion, out of the six orientations shown, which orientation has the highest probability of occurrence when the parts are sliding up the track of the vibratory-bowl? Give reason(s) to support your answer.



More Examples

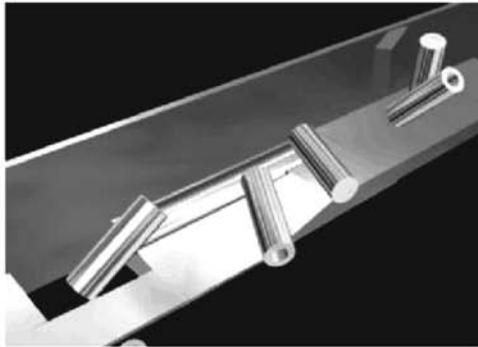
Example 1
1 of 3

Next ▶

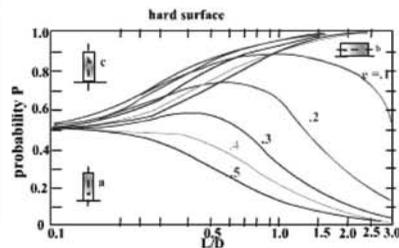
(a)

Example 1

(i)



Wiper blade reject orientations a and b
Narrowed track reject orientation c and f
Gap reorient c or d to a



(i) $C.G = 6/20 = 0.3$; $l/d = 20/5 = 4$;
From the graph $P_a = 0$, $P_b = 1$, $P_c = 0$

initial distribution matrix $[a \ b \ c \ d \ e \ f] = [0 \ 0 \ 0.25 \ 0.25 \ 0.25 \ 0.25]$
assume equal distribution

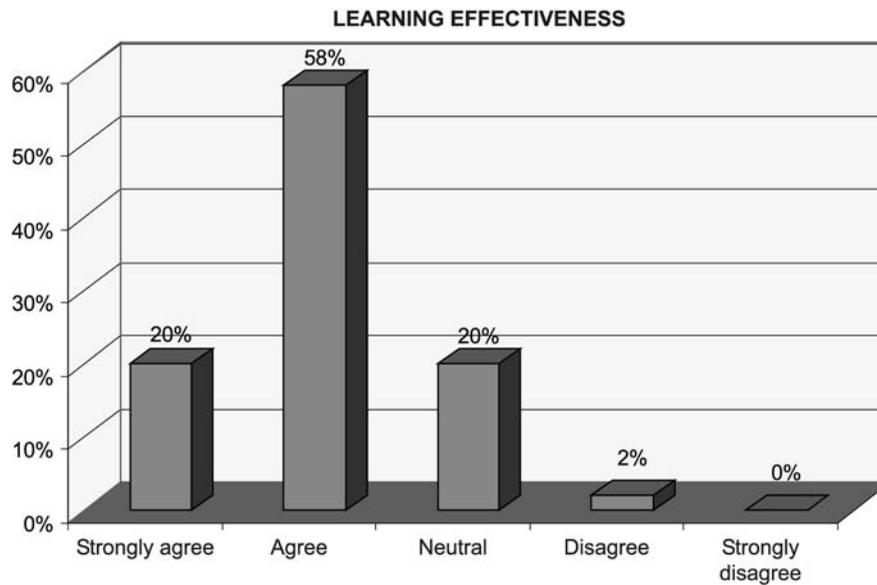
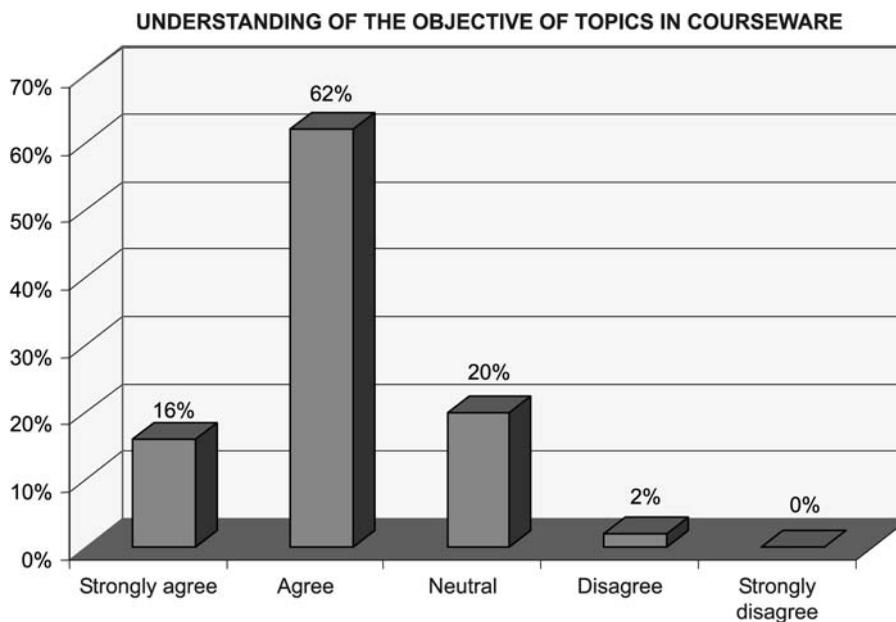
More Examples

◀ Previous

Example 1
2 of 3

Next ▶

(b)

Figure 17 Effectiveness of the courseware**Figure 18** Understanding the objectives of each topic

various equations were derived and used. Figure 19 shows that the respondents generally agree with our design strategy. They felt that the most important factor in our design is the use of videos and frequent animation to enhance the learning experience. The course content was clearly written and logically organized. The length of the course is felt to be just right as shown in Figure 20. The respondents generally agree that the course delivery is effective, and 20 per cent strongly agrees as shown by Figure 21. They are able to access the course whenever they needed and was able to navigate through the courseware easily. In general, ease of navigation and access to the software environment, content design strategies, video and

animation seemed to be the most important factors affecting the effectiveness of courseware.

There is a portion in the survey form asking users to provide general written comments as feedback.

The main encouraging opinions received on the package are:

- courseware design is user friendly – ease of navigation, reading and good content design;
- clear explanation of abstract and difficult concepts using animation;
- exciting to view 3D animation of feeder operation and parts motion;
- interactive;

Figure 19 Effectiveness of courseware design

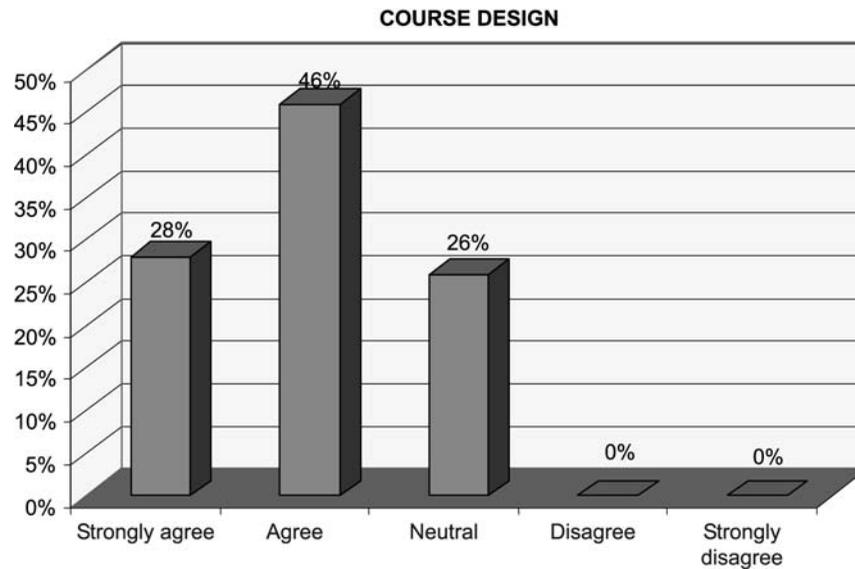
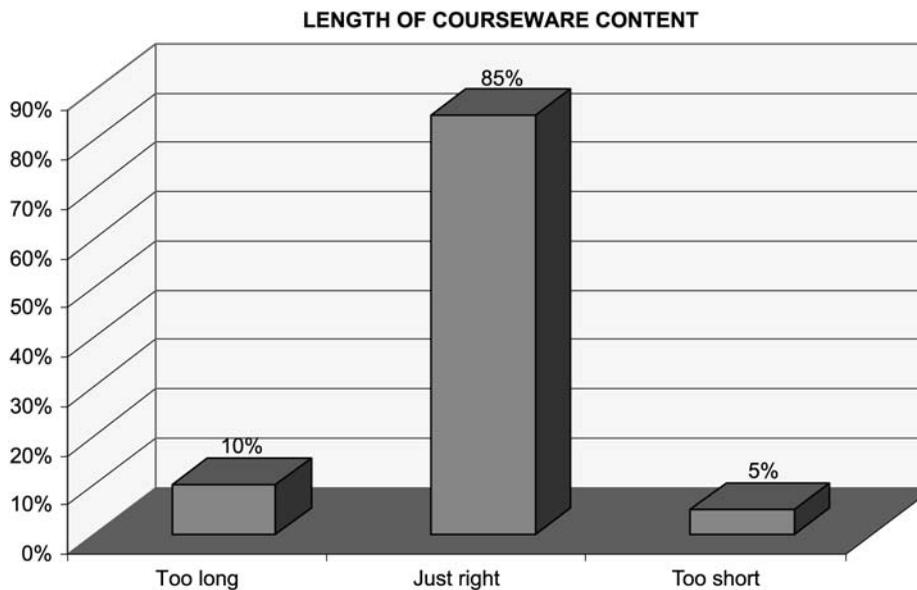


Figure 20 Length of courseware content



- has motivated their interest in the subject of automatic parts feeding;
- help them to learn faster and retain the knowledge better due to the animation, visuals and sound;
- interesting and lively graphic user interface (GUI);
- good colour mixing;
- straight-to-the-point delivery; and
- clear objectives

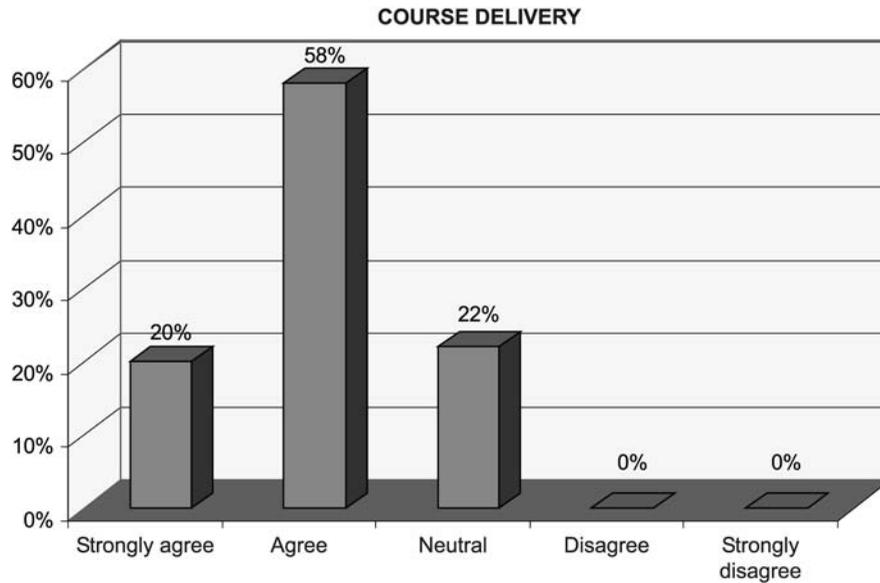
Students' suggestions of design strategies and policies for further improvement of the package are:

- Provide narration and choice of turning it on or off.
- Provide background music and choice of turning it on or off.
- More quiz questions.

- Track the user's performance on the quizzes and provide this data to him. Create an assessment system to provide a final grade for the user on his performance.
- More videos and animation of some concepts.
- Provide more examples of industrial applications.
- Incorporate search engine to locate words in the package so that users can go straight into that desired part of the package without having to go through the content and navigate through the pages, e.g. tumbling, barrel, hopper, coding, scallop, etc.

All the above feedback will form the basis for future work on the package.

Figure 21 Courseware delivery



5. Conclusion

This e-courseware has been fully developed with rich content and well-built functionality. It has been tested on aspects such as stability, downloading speed and performance of the courseware. The topics in the courseware are vibratory bowl feeders, orientation of parts, non-vibratory feeder, feed tracks, escapement, quizzes, and assessments. Sophisticated animations were incorporated in this e-learning package. These have made visualizing and understanding of difficult topics easier and faster as compared to reading textbooks alone. Furthermore, each learner can learn at his or her own pace.

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