Open Polytechnic
KURATINI TUWHERA

Enhancing learning for engineering trade learners: Augmented paper-based materials in course design

Proof of concept

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Contents

Acknowledgements

Note: A glossary of technical terms used in this report is attached as Appendix 1. Glossary items are italicised the first time they are used in this report.

Copyright

Executive summary

This project was funded by Ako Aotearoa and initiated by Open Polytechnic staff to test the feasibility of embedding *augmented reality targets*, which could be viewed on computers using a simple webcam, into print material for second-year apprentice engineering trade learners at the Open Polytechnic. This would enable them to see the *images* in 3-D form, thus improving their learning experience.

With augmented reality (AR) software the real-world image is augmented by virtual computer-generated imagery that is created when a webcam or camera-like device 'reads' the target embedded in a page.

The second-year apprentice engineering trade learners were chosen as a 'test' group because they are generally kinaesthetic learners who don't always have access to the real-life artefacts they are studying. If this project was successful, further developments could be undertaken to enable augmented targets to be viewed via cellphones.

Learners who view images of artefacts on a computer screen are able to rotate and enlarge them, as well as view them from different angles.

Objectives

The objectives for the project were:
1. Test the 'proof of concept' of using three-dimensional digital *graphics* for paper-based distance learning materials.
2. Collaborate with schools and support centres to develop materials.
3. Deliver the course materials to learners.
4. Seek feedback from learners.
5. Write a research report that includes recommendations for further use and an analysis of *scalability* and transferability.

Outcomes

The agreed outcomes were the development of:
- 'proof of concept'
- material for learners to trial – this included the development of targets in one unit of work
- a scalable and transferable process.

The process involved conversion of three-dimensional *AutoCAD* models so that they could be used by learners using AR software *triggered* from printed learning material using a web camera.

The AR software converted the models into three-dimensional images that could be viewed from all angles by manipulating the viewing angle of the web camera. We then inserted targets into course materials, put the AR software and image files on a DVD, developed instructions and sent the materials to learners to trial. As part of this process three staff from the Open Polytechnic user tested the course materials and software.

Issues related to computer compatibility caused difficulties for learners and meant that while the project team felt that the development of a process and associated learning had been successful, we were unable to trial the material fully with learners.

Conclusions and recommendations

Proof of concept was achieved from an instructional design perspective where the learning materials provided an additional dimension for the learner. The process of adding easily accessible 3-D graphics to augment the paper-based learning packages used for teaching trade engineering theory also was achieved with relative ease. The technological implications associated with the learners' study environment presented greater challenges which limited the full potential of the learning outcome.

The recommendations arising from this project are:
1. Use the process developed for this project to insert augmented reality targets in course material.
2. Establish learners' computer hardware and software configurations and their capability to meet the technical requirements to augment paper based learning packages
3. Establish a repository of high-quality images that can be rendered in 3-D.

Introduction

The project entailed developing a process to embed AR targets into course materials and trialling the materials developed with a group of learners to see whether or not having access to the images improved their learning experience and helped them engage with the material. The four staff members who collaborated on the project believed that kinaesthetic learners (those who learn by doing, moving and manipulating) would benefit from being able to manipulate virtual three-dimensional (3-D) images using a webcam and a computer.

Fig. 1 *An image of a roller bearing, viewed on a computer screen via a webcam focused on the augmented reality target*

It was expected that if learners engaged with the material, retention and completion rates on the course would improve, and learners would have a more satisfactory learning experience.

Augmented reality technology allows for interaction between the real environment and computer-generated virtual objects, making it useful for the development of educational applications that allow manipulation and visualisation. It is used in medicine, aviation, real estate and architecture, as well as in museums and other cultural institutions.

Targets that contain code are embedded into print material (in this instance) and a camera-like device 'reads' the code when aimed at the target. The 3-D images are then rendered on the computer screen using appropriate software.

Project team

The Open Polytechnic's cross-disciplinary project team was: Sandra Maathuis-Smith, academic staff member, School of Information and Social Sciences; Martin Glaeser, academic staff member, Applied Technology Centre, School of Workplace Learning and Development; Gary Mersham, academic staff member, School of Information and Social Sciences; and Cheryl Brown, instructional designer, e-Learning team. Open Polytechnic centre managers acted as project mentors.

The project was supported by Todd Cochrane, a Weltec academic staff member who researches and teaches in this area, and Mark Billinghurst and Julian Looser from HITLab NZ, a human interface technology lab. Staff within the Information Services department and the e-Learning team at the Open Polytechnic also provided advice. Ian Rowe from Ako Aotearoa's Central Hub provided financial support.

Project principles

The principles of the project were:

- Learner-centredness: The project aimed to improve the learning experience for learners at the Open Polytechnic.
- Partnership: The project was a partnership between four sectors of the Open Polytechnic.
- Sharing of results: All results would be shared with all interested parties.

The consultation principles were:

- Communication: Communication would be open at all times, and any issues would be discussed by appropriate members of the team.
- Openness: All documentation would be made available for team members on a Moodle course page.

Purpose

Many of the learners within the course US19873 *Demonstrate Knowledge of Bearings Used in Machines and Equipment*, an 8-credit Level 3 course offered at the Open Polytechnic, do not own computers and are not currently using e-learning methods for study. Most of the learners work as apprentices in engineering firms.

The project team hoped that the use of these embedded targets would engage the learners, but also provide a way to 'test the waters' for future research and development in the area of augmented course materials.

Thus, the project served several purposes:

- test the development of the process
- evaluate the learning experience for the learners
- provide a basis for further research and development.

The project team aimed to insert up to 20 AR targets for roller bearings into the printed course material and to supply software that would enable the learners to view the rendered images on their computer screens. While roller bearings are common artefacts, there are variations that are not commonly used and learners might not see all of them in workshops. Images were readily available in 3-D form, thus reducing the time needed to source suitable images.

It was expected that once this concept had been proved and a process developed, it could be used to render other, rarer, artefacts.

Background

One of the biggest problems facing distance education providers that offer engineering courses is the lack of contact learners have with physical artefacts such as tools and components, and the lack of experience they have of physical engineering processes. The assembly and disassembly of components in an engineering system can be better explained and demonstrated when the learner has access to a 3-D representation of the individual components and their positions in space.

Engineering learner profile

Learners enrolled in the trade engineering courses are usually contracted apprentices with the engineering industry trade organisation. They are mostly male and aged between 18 and 25, although there are some older apprentices (up to 50 years of age). Most have minimal school qualifications. Most have NCEA level 2 or below, with the majority being at level 1 or below. Many fit the description of a 'kinaesthetic learner'.

These learners are studying to complete apprenticeship training requirements. While there is a 95 per cent completion rate, completion is often achieved at the second attempt. The learners usually enrol in distance courses because they are working and based away from the main cities.

The project process

Fig. 2 *Project team members involved in the analysis part of the process*

The project team followed the ADDIE process:

Analyse	The learners' needs were considered and the pilot group chosen. We had agreed that we would try to embed the AR targets into the material, so we needed to decide on the images, and agree on the best process to use the software that was available.
Design	Once the process was decided, images were chosen and sourced, a way of embedding the images discussed, and terminology agreed. The pre-release user testing and evaluation processes were designed and applications made to the ethics committee.
Develop and implement	The two tutors trialled the agreed process to source, develop and embed the images. Surveys and a letter for the evaluation were developed and user testers recruited. The targets were developed and embedded into the materials, and users tested the software and applications. As a result, some changes were made to the instructions for users/participants. Pre-release user testing was carried out. Following the pre-release user testing evaluation, learners were contacted and DVDs containing the software as well as the printed materials were sent out.
Evaluate	Feedback from learners was collated, the project process evaluated, and recommendations made.

Budget

The budget of $9,128 (GST-exclusive) provided for tutor and project management, at a base average rate of $35 per hour. This low charge rate meant that the Open Polytechnic in effect donated resources and support to the project.

	Income ($)	Expenditure ($)
Ako Aotearoa	9,128	
Analysis: 40 hours		1,400
Design: 55 hours		1,925
Development: 25 hours		875
Implementation: 30 hours		1,050
Evaluation: 20 hours		700
Follow-up and reporting (including digital story): 85 hours		2,978
Webcams		200
Total		**9,128**

Communication and plan

A project plan that would carry the project through a 6-month period was developed. The team met once a week to report on progress. The project mentors were sent copies of updated reports.

Project progress was shared with staff from the School of Workplace Learning at the Open Polytechnic in order to keep them up to date with progress and allow feedback. Tutors involved in Real Estate and Pharmacy programmes were particularly interested in the developments. Other presentations were made to general and instructional design staff and there were regular informal meetings with Todd Cochrane at Weltec, who offered advice and support.

Two milestone reports were sent to staff at Ako Aotearoa's Central Hub as agreed.

Analysis

The analysis involved in-depth discussions with the course tutor regarding the learners' needs, the difficulties they were encountering and ways we believed the project could help solve those needs.

The two tutors who were developing the material needed to source the images and decide how many and which images to use.

The software used for creating AR scenes in this project was *BuildAR*, provided by HitLab NZ. At the time of the project this tool was available free of charge. According to Mark Billinghurst of HITLab NZ and ARtoolworks the free version of BuildAR will remain available, but the intention is to bring to market a low-cost professional version with more functionality. The BuildAR software is available for download from the HITLab NZ website (http://www.hitlabnz.org/wiki/BuildAR).

HITLab NZ also supplied us with a viewer – this software allows viewing of the AR images created. This will be available in the new version of the BuildAR software.

HITLab NZ supplied us with a conversion tool to convert the files into an 'open scene graphic' format. Depending on what program you are using to create the 3-D objects there will be an export option or a plugin for *.osg* or *.ive* formats, which are the optimised alternatives to *.obj* file types. The optimised file formats are smaller and load faster than the .obj file format.

The reason we used these tools for the AR development was primarily that it was free and that support and development was New Zealand based.

Design

This is the design process that was developed and implemented.

Start

Do you have an appropriate graphic to use as the target?

Do you have an appropriate 3-D image?

Source an image or create a .bmp file format

NO

YES

YES

NO

Source an image or have one created in .obj file format

Is the file in .bmp format?

Is the file in .obj file format?

NO

Use a program that can open the file to export it as a .bmp file

YES

NO

Use a program that can open the file to export it as a .obj file

YES

Convert files to .osg with a 3-D rendering environment

Run BuildAR software.

Produce tags associated to 3-D images

Produce 3-D graphics files and save to 'Scenes' folder

Compile all software and 3-D files

Develop exe file so that AR software runs from CD/DVD drive

Embed targets in course materials

Produce user DVD or CD

It is not actually necessary to have the original files in .obj format. If the 3-D images are created within a 3-D development program there will be an option or plugin to save these directly in .osg or .ive format, hence taking out any middle processing steps. We had to complete this extra conversion because we used existing 3-D files that were in a non-compatible file format for the AR software. These needed to be opened by a program which Open Polytechnic staff had access to and converted to an acceptable .obj format for the AR software. Although these files worked, they were found to be too large and took too long to load, so we optimised the files by conversion to the OpenSceneGraph .osg and

binary .ive formats. Both .osg and .ive formats were used, as there was no discernable difference in performance.

The team members then designed the evaluation process and applied for approval from the Open Polytechnic Ethics Committee.

Development and implementation

The process was as follows:

1. We converted 3-D models so that they could be viewed by learners using AR software, then added the targets that would trigger the software to the printed learning material. Discussions with HITLab NZ and staff in the Information Services department at the Open Polytechnic were crucial in ensuring that the AR software worked reliably with commonly available personal computer systems.

2. A range of bearings described in the existing learning material was identified from the SKF (a large roller bearing manufacturer) website. An AutoCAD (industry-standard design software used in engineering and architecture) design file for each bearing was downloaded.

3. AutoCAD was used to open each file and export the 3-D *CAD* model in a file format that could be further converted into an .obj format. This .obj format was then converted into an .osg format compatible with HITLab NZ's AR software.

    The .obj format files were very large and although they did open and run in the BuildAR software, they were very slow to load. The .obj files were optimised by converting them to .ive or .osg formats using a conversion tool (*osgconv*) supplied by HITLab NZ.

    Blender, free open-source 3-D content-creation software, is an alternative program for converting the files into an OpenSceneGraph (.ive or .osg) file format that is compatible with the AR software. It was not necessary for this project to use this program, as the conversion tool supplied by HITLab NZ worked.

4. The files were then exported to BuildAR software. BuildAR is a tool for creating AR scenes or images. A folder containing the set of images was created.

    It was important for learners to be able to run the software with a minimum of effort. Julian Looser from HITLab NZ provided advice and developed a version of the development software that enabled learners to view the 3-D content without having to install the development software.

5. The AR software and graphics files were burnt onto DVD for pre-release evaluation and learner trials.

    BuildAR software was also used to generate an image that was used as the target, which triggered the software from the printed page. The team decided to use a target in the form of words and a heavy black border so that the webcam could easily distinguish between the target and the other artefacts on the page, such as figures and images.

6. We purchased basic Microsoft VX-500 webcams that could be posted to learners who did not already have webcams, and incorporated the pages with the embedded targets into the course material. We also developed instructions for loading the webcam and running the viewing software.

Pre-release user testing

Once the process had been developed the material was tested by three users recruited from Open Polytechnic staff, as according to Neilson (2000) the best results for pre-release user testing are obtained when there are five or fewer users. Each user had different levels of computer confidence, ranging from low to high.

Fig. 3 *One of the users loading the webcam*

Each user was given:
- a set of instructions
- a set of course materials with integrated graphics
- a Microsoft VX-500 webcam
- a DVD with the AR viewing software.

The users were in the Open Polytechnic's multimedia lab. Two used Dell laptops with separate Hewlett Packard monitors, while the other (the highly confident user) viewed the material using only the Dell laptop. All computers were loaded with Windows XP.

Over a 1-hour period the users were asked to load the camera, following the instructions, then insert the DVD with the AR viewing software and run it. Once that was done they were asked to focus the camera on the AR targets embedded in the loose-leaved printed materials. They were **not** given all of the course materials.

Three project team members observed the users, focusing on the ease with which users:
- understood the instructions
- loaded the camera
- identified the AR targets
- loaded the DVD.

The observers were instructed to intervene with the users as little as possible. Towards the end of the hour the users completed a survey and were free to discuss the session with the observers.

Trialling with learners

We decided that a qualitative methodology would be appropriate for the 'proof of concept' aspect of the project. The learners would, we believed, wish to participate in the project and to use these images, as it would enable them to see 3-D images that they could manipulate, and the ability to do this would increase their understanding of course materials.

No inducement was offered, but those who participated were sent webcams, which they kept.

Once they had agreed to participate the learners were sent:
- course materials with the AR targets embedded – these pages were stapled into the course materials as if they were a normal part of the material
- a Microsoft VX-500 webcam – these webcams were chosen because they were cheap and because they had 'plug and play' capability
- instructions on how to load the camera and DVD.

Six learners agreed to participate in the project.
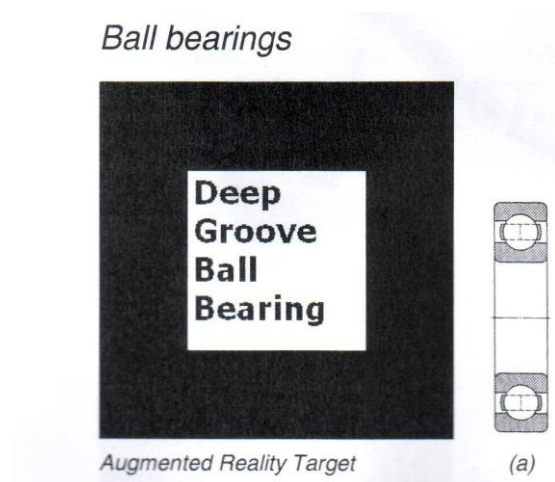
Fig. 4: An augmented reality target in course materials

Evaluation

Feedback from learners was collated, the project process evaluated, and recommendations made. See the conclusions and recommendations at the end of this report for the results of the evaluation process.

Findings

The findings are described in accordance with the ADDIE process used.

Analysis

Approximately 40 hours was spent analysing the best way to develop the process and deliver the material to the learners.

Design

The result of the analysis was the designed and developed process.

Development and implementation

Once the process had been decided, it took approximately 25 hours (two tutors working approximately 12 hours each) to complete the process. Much of the time was spent sourcing images, and it was found that having easy access to high-quality images was the key to the success of the process.

Once the AR targets were included in the course materials they were restapled and sent to the learners who had agreed to participate in the project.

While the use of black-framed words was chosen so that the learners would be able to differentiate between the images, figures and targets, the members of the project team felt that the use of images might be more complementary to the rest of the course material.

The findings from the pre-release user testing were positive, although there were some difficulties obtaining feedback from learners.

Pre-release user testing

One of the users had difficulty installing and loading the camera and loading the software. She also had some difficulty following the instructions and identifying where to focus the camera. The other two users had little difficulty. All users were able to see the rendered images on the computer screen and rated the material 'overall' between 2 and 5. The 5 (very bad) response appears, from comments, to relate to the quality of the instructions, not the quality of the AR targets and images.

User testing indicated to us that the instructions needed to be improved. But in spite of the difficulty experienced by one user, we feel confident that with improved instructions the material could be sent to learners.

Trialling with learners

While six learners had suggested they were willing to trial the materials, only one response was received. This feedback informed us that the files were opened with ease and the images helped the user to understand the material better. He had difficulty using the webcam and seeing the images. However, he said: 'It was great to see all the parts that go into a double acting thrust bearing'. The learner's response to a question asking whether he felt better about learning was 'Yes'.

There was an unanticipated difficulty in that the DVDs, burnt at the Open Polytechnic on Dell computers and using standard Roxio burn software and supplied DVDs, would not load on the learners' computers. There was insufficient time or funding to explore the options for all possible user system set-ups. While the tutor was able to talk the learners through issues and send them the content on CD-Rom, the difficulty they encountered made them unwilling to continue to trial the software.

As a consequence no follow-up questions were asked.

Evaluation

The team evaluated the problems learners experienced and identified ways of resolving these issues. See the conclusions and recommendations that follow for the results of the evaluation process.

Conclusions

The process of adding easily accessible 3-D graphics to augment the paper-based learning packages used for teaching trade engineering theory has potential. Due to issues with software not running and the insufficient number of responses, the learner trialling process would need to be repeated to have any validity.

There are other processes for accessing 3-D graphics that may be as easy to operate for those with minimal computer literacy. These may achieve much the same result for the learner using less complex user processes and may not require the use of a camera-type device – for example, using Flash-based images.

Recommendations

The recommendations arising from this project are:
1. Use the process developed for this project to insert augmented reality targets in course material.
2. Establish learners' computer hardware and software configurations and their capability to meet the technical requirements to augment paper based learning packages
3. Establish a repository of high-quality images that can be rendered in 3-D.

Reference

Nielson, J. (2000). *Why you only need to test with 5 users.* Retrieved November 4, 2009, from http://www.useit.com/alertbox/20000319.html

Appendix 1: Glossary

Augmented reality (AR): The real-world image or graphic is augmented by a virtual computer-generated image.

BuildAR: Software that enables the user to create augmented reality scenes on a desktop. It is produced by HITLab NZ. The basic version can be downloaded free. We chose to use this software because it is intuitive to use, it is free, and we were able to get valuable support and advice from HITLab NZ staff.

Julian Looser of HITLab NZ (julian.looser@HITLabnz.org) created an application that would enable the user to view the AR content from the DVD or CD-Rom without having to install any files on their system. It also enabled the user to go straight to the part of the application that 'read' the targets, without having to work through the entire program.

CAD software: Computer-aided design software that enables the design of real or virtual objects.

For this project we used AutoCAD because it was already in use in the Open Polytechnic. AutoCAD is produced by Autodesk (http://south-apac.autodesk.com).

Graphics: We have used this term generically to apply to all visual material – figures, images and targets.

Images: (1) The pictures of roller bearings and artefacts on the printed course materials. (2) The 3-D images seen on the computer screen

.ive: File format that contains data that describes dimensions, variables, attributes and data. Can be multiple or single files.

.obj: A simple data format that represents 3-D geometry.

.osg: OpenSceneGraph. An open-source file format used for visual simulation, virtual reality and similar applications such as games.

osgconv: This is a command line utility that converts 3-D models between different formats. It converts models into the native format used by open scene graph, the software library on which BuildAR is written. Files loaded into the .osg format will load faster than they would in their original formats. Files end with the extension .osg (for text-based type) or .ive (for binary type). The binary format takes less time and space and loads faster. Because it only holds textures, a single file only is required. For .osg files the textures are stored as separate files, but with the models.

The project team found that the use of either file format was acceptable and made no difference to the user.

Scalability: The ability to reproduce a process or object on a different scale.

Targets: For the purposes of this project we used this term to mean the images embedded in the print material that can be 'read' by a camera-like device (in this case a webcam). The target triggers the software to open a previously associated 3-D file and is used by the software as a reference point.

Trigger: To activate the response from the camera-like device and the software that 'reads' the code.

Appendix 2: Pre-release user testing observation sheet

You will be observing **one person** as they use the augmented reality material.
Please:

- try to answer as few questions as possible – we wish to ascertain how the user uses and reacts to the material.
- observe how they use the course material and note any ease or difficulties they may have
- record your notes and be ready to discuss any observations you have made.

_____

User/s identifier (initials, log in)   _____

Observer (name) _____Date _____

Observation	
Reads the introduction/instructions	
Loads the CD-Rom easily	
Directs the webcam to the correct graphic	
Image appears on screen	
User manipulates the image on the screen	
User moves to another image	
User closes software . . . etc, etc	
Ease of use	
How many times did users ask you for help? Where, when, why, how?	
Did the user get lost in the material? *'What am I meant to do now?' = either 'Where am I meant to go?' (navigational) or 'What task should I try to perform next?' (educational)*	

Bug reports

Additional comments

Appendix 3: Pre-release user testing survey

Open Polytechnic
User details
Purpose of the trial To evaluate the ease of use of the augmented reality material.

Please answer the following questions about the materials you have just used.

Some of the questions use a numbered rating scale:
1= Excellent   2= Good   3= Satisfactory   4= Poor   5= Very bad

Please circle the appropriate number for each question.

1. How easy was it to install the software?	1 2 3 4 5
2. Did it load easily?	Yes / No
If you answered 'No' please explain what happened.	
3. Was it easy to identify the graphics to view?	Yes / No
If you answered 'No', please explain why.	
4. Did the images appear on the computer screen?	Yes / No
If so, were they easy to see?	
Please explain what you thought of them.	
5. Were you able to move the images easily?	Yes / No
6. Did the images 'crash' while you were using them?	Yes / No
If you answered 'Yes', what were you trying to do when they 'crashed'?	
7. How would you rate the quality of the materials overall?	1 2 3 4 5
8. How would you change the materials to make them better?	
9. Do you have any other comments to make?	

Thank you for taking part in this trial

Appendix 4: Instruction manual

Augmented Reality Project 2009

Instruction Manual

Installing the video capture device (web camera)

Using the camera supplied

1. unpack and plug the webcam into the USB port.
2. your operating system should detect the device automatically (Windows XP and Vista)

Using your own camera

1. Verify that it is working by accessing 'Start / settings / control panel / scanners and cameras. (under classic view)

2. Double click on the correct device to activate the camera. You will see the live feed from the camera on the screen.

Running the BuildAR Viewer

It is not necessary to install the BuildAR software, it runs off the DVD.

1. Insert the DVD into the DVD/CD drive.

If the program does not start automatically

2. Double click the DVD/CDRom drive letter to open the CD/DVD drive.

You should see this file

Double click on BuildARViewer.exe to launch the application.

BuildARViewer .exe

NOTE: if the web camera is not installed correctly or is not compatible with the BuildAR software, when attempting to run the BuildAR software you will see this error.

Click ok and close the BuildAR application (press **q** on the keyboard once the program has loaded).

Verify that your video capture device is working by following the instructions under "using your own camera" then run the software again.

If you have your camera attached to the computer and working you will see the camera setup dialogue box.
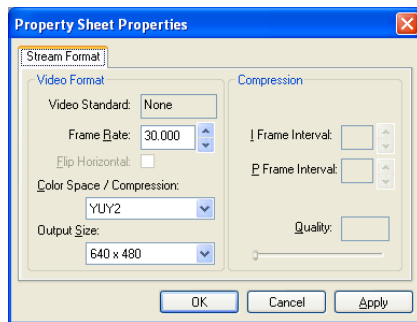
Click **OK**. (**Do not change any settings.**)

To select the scene for viewing, navigate to the CDRom/DVD drive / data / scenes

Select the file called **US19873 V3.xml** from the list of scene files and click **open.**

NOTE: Some files in this scene are large and will take a minute to load.

If you see this dialogue box click OK and let the program open.
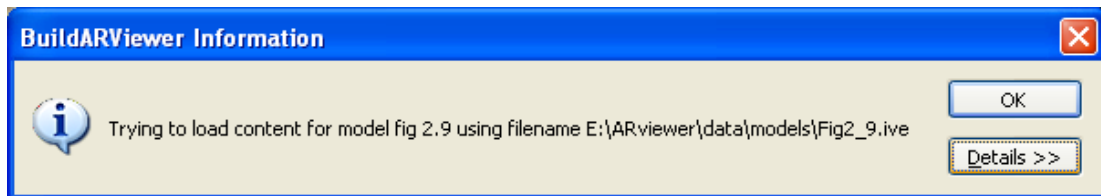
Once the files are all fully loaded the camera feed will again be 'live' i.e. the web camera feed will be showing the real-time environment.
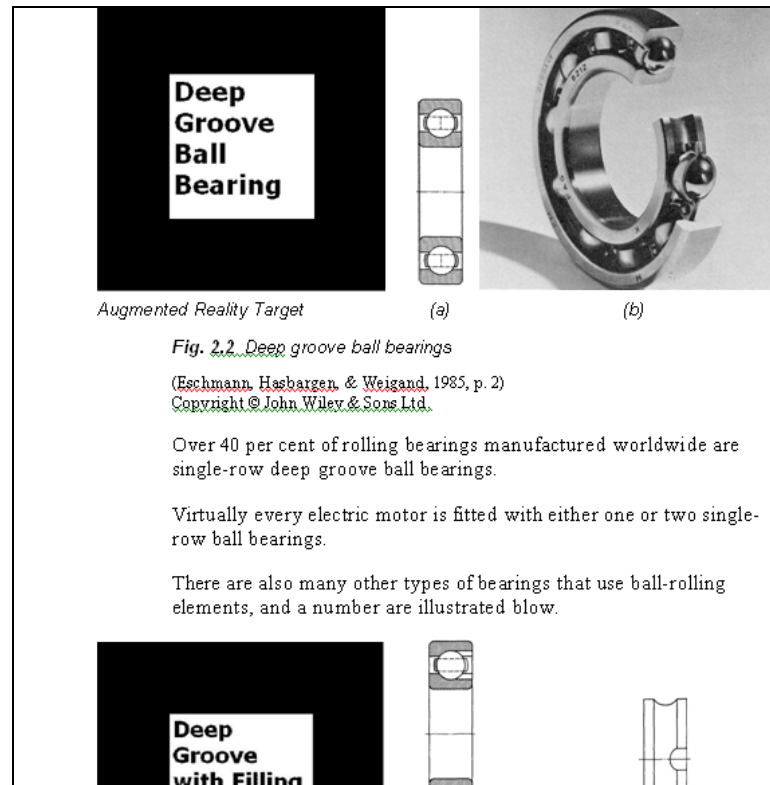
(You will see your hand moving if you wave it in the camera's view).

You are now set up.

To view the Augmented Reality content

You will need a copy of the materials with augmented reality target inserted.

The pages look like this:

Hold the camera so that you can move it easily.

Place the course materials on the desk or a solid surface.

Hold the camera approximately 30cm away from the paper's surface. Move the course materials into the view of the camera.

NOTE: there needs to be sufficient lighting and the entire black square of the target must be in full view of the camera.

To view only 1 image on a page with multiple targets, cover part of the 'target' you don't want to view with a piece of paper, mouse, pen or anything lying on your desk.


Augmented Reality Target

When the camera and the course materials are aligned you should see something like this:

Each target has a different 3-dimentional object associated with it.

As you read through the course materials each page, which has augmented reality targets on it, will trigger the augmented reality content to appear on your computer screen as an image.

To exit the program press 'q' on the keyboard.
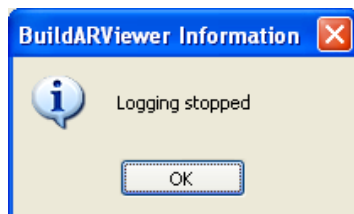
Click OK to confirm close

Trouble shooting

No camera view
– Check that the camera is plugged in.
– Check that it is working (refer to 'using your own camera')
– Close other programmes which are running and try running BuildARViewer again. (The system may not have sufficient memory to run the software).
– Pick the camera up. (It may be 'face down'). -

Three-dimensional content is not showing on the computer screen
– Make sure that there is plenty of light
– Make sure the 'target' is entirely in the view of the web camera (if you cannot see the entire black square of the 'target' on the screen it will not show the 3-D content.)
– Keep the pages flat. Bends cause distortion of the 'target' and it is hard for the camera to read it correctly.

Several 3D images appear where there is only 1 'target' on the page
The image is 'jumping' in and out of view.
– If the light is bright press 't' and OK to lower the threshold or (shift t) 'T' and OK to increase it if it is dark.

Appendix 5: Pre-release user testing report

Purpose of the trial: To evaluate the ease of use of the augmented reality material.

Three user testers agreed to test the process of using the materials integrated into the course materials for second-year apprentice engineering trade learners.

Three observers watched the users and made notes.

Each user was given:
- a set of instructions
- a set of course materials with integrated graphics
- a webcam
- a DVD with the viewing software.

The users were also asked to complete a user-testing consent form and user-testing survey. The numerical grading is:

1 = Excellent   2 = Good   3 = Satisfactory   4 = Poor   5 = Very bad

Summary
While installing and loading the software caused some initial problems, once the graphics were available they appeared on the computer screen and were easy to identify.

For two of the users the testing was relatively easy, and one had some difficulty installing the software and manipulating the images. In general it was felt that the instructions could be clearer and some extra images were required.

Table 3: Pre-release user testing report responses

Question	Response		
How easy was it to install the software?		I didn't install it	1
Did it load easily?	No.	Yes.	Yes.
If you answered 'No' to the preceding question, please explain what happened.	Very slow in loading.		Sandy just needs to remember the first screen shot for the camera set up dialogue box.
Was it easy to identify the graphics to view?	Yes.	Yes.	Yes.
If you answered 'No' to the preceding question, please explain why.			
Did the images appear on the computer screen?	Yes.	Yes.	Yes.
If so, were the images easy to see?	Yes, took time to load – instructions not clear. Purpose needs to be identified.	Not really. I had trouble holding the tag in the right position and the image kept disappearing.	
Please explain what you thought of the images.		Exciting. A bit like watching a video.	I thought they looked good and clear and think there should be adequate lighting at the start, not just in the troubleshooting section.
Were you able to move the images easily?	Yes.	No.	Yes.
Did the images 'crash' while you were using them?	No.		Yes.
If you answered 'Yes' to the preceding question, what were you trying to do when the images 'crashed'?			Tablet/laptop was a bit slow and I was freely moving the camera around the image by hand, so caused the screen to lock up from time to time.
How would you rate the quality of the materials overall?	5.	3.	2.
How would you change the materials to make them better?	Instructions need to be step by step and the purpose clear.		Unless using two images to compare objects I would put one per page where possible.
Do you have any other comments to make?	No		Looks good, well done team.

Table 4: Observers' report: Pre-release user testing

Observation		Outcome		
Reads the introduction/instructions.		Yes, some issues.	Installed okay.	Knows computers, so went straight to software to install.
Loads the DVD easily.		Yes.	Loaded DVD – trouble with the machine, however	Big file pops up.
Directs the webcam to the correct graphic.		Trouble loading camera.	Trouble with closeness/distance.	Yes.
Image appears on screen.		Yes.	Yes.	Yes.
User manipulates the image on the screen.		Yes.	Trouble with two images appearing – picking up second image.	Yes.
User moves to another image.		Yes.	Yes.	Yes.
User closes software, and so on.		No.	No.	Not enabled.
	How many times did users ask you for help?	While installing camera. While installing software.	Trouble with machine. Working on unfamiliar machine. Trouble setting up.	None.
	Did the user get lost in the material? 'What am I meant to do now' = either 'Where am I meant to go?' (navigational) or 'What task should I try to perform next?' (educational).	User instructions hard to follow. Needed to know what she was meant to see.	Had difficulty with getting two images at the same time.	No.

Bug reports. Can't close.

Additional comments
  1.   Note sure how to hold the camera.
  2.   Instructions had some bits missing.
  3.   Not sure how far away to hold the image/paper/camera.
  4.   Need to have the black bit around the instructions.
  5.   Trouble arcing to see around the image.
  6.   Can't understand how to read the materials while holding the pages up.