A POWERFUL VIRTUAL LEARNING ENVIRONMENT

Greta C. Kelly
Teaching and Educational Development Institute
The University of Queensland, AUSTRALIA
greta@uq.edu.au

Abstract

This paper describes the challenge of teaching abstract scientific principles and the design and development process of the award winning Virtual Power Plant Website. This learning resource is actually an amalgamation of four online learning environments developed by a number of universities and industry groups and is designed to help students understand and apply thermodynamic principles in realistic conditions. The situated learning framework has informed the design of learning and assessment activities that are contextualised within this virtual environment.

Keywords

Situated learning, virtual environments, online learning, multimedia development process

Introduction and website development

The design and development of the Virtual Power Plant Website '*www.ems.uq.edu.au/virtualpowerplant*' started in 1988 as an Action Learning Project. This paper describes how a prototype site was developed and tested and this process informed the design of the first iteration of this website. The second half of this paper deals with the future phase of the project which is the incorporation of the resource into a 3rd year mechanical engineering course.

The Virtual Power Plant Website is designed to help undergraduate mechanical engineering students understand thermodynamic principles through their exploration and manipulation of plant operations in a virtual learning environment. Conventional teaching methods use textbook representations and descriptions of plant operations to illustrate thermodynamic principles. In order to demonstrate the functional application of thermodynamic principles, third year students also visit a coal-fired power plant. However, the UQ Mechanical Engineering lecturer discovered that his students found it difficult to map their abstract, theoretical understanding of thermodynamics onto the plant operations they encountered on their field trip. Some components of the power plant were difficult to view because the working parts may be hidden from view for reasons of safety and mechanical design. Also the sheer magnitude of the plant makes it hard to conceptualise how different cycles and components work together.

The Action Learning team, consisting of educators, a librarian, an information designer and headed by the course lecturer initiated a design project for the Virtual Power Plant website. The following aims were established for the website: the students would (a) learn fundamental thermodynamic principles more effectively than when using conventional classroom teaching methods, and (b) succeed at engineering tasks that they would otherwise be unable to perform because of the textbook and field trip limitations. The cyclic nature of the Action Learning project was based on the Action Research process of planning, acting, observing and reflecting before starting the cycle again at the (re)planning stage (McGill & Beaty, 1992). The team practices of the Action Learning program provided flexibility, full group consultation, considered action and creativity. The continual cycle of action informed by group reflection, which was facilitated by a process mentor, allowed team members with different areas of expertise to have input early in the design phase. For example, the initial concept of building a three-dimensional 'walk-through' environment was superseded by the development of a multi-layered two-dimensional interface which connects to external software packages running in parallel in separate windows.

A power plant was selected as a universal and sufficiently complex industrial system to provide an ideal setting for the application and testing of engineering concepts. In this virtual environment, the students would have the opportunity to closely inspect and become familiar with the operation of the power plant as a whole, while also gaining in-depth knowledge of individual components. With this knowledge, students would then enter two separate environments where they would have the opportunity to solve 'practical' problems by designing, analysing and manipulating the layout and operations of a power plant. This contextualised application of knowledge, which is an example of what Lemke (1997) refers to as the "*clinical* components in science education", allows students to strengthen the "network connections between school activities and professional activities". One piece of simulation software that the website makes use of was designed at another university and the other application was developed by Industry.

The prototype website, which was designed and developed by the Action Learning team and the multimedia team from UQ's Teaching and Educational Development Institute, was tested by members of the target audience comprised of undergraduate mechanical engineering students. Because the students experienced some difficulty understanding the links between all the sections of the site, structural changes and navigation improvements were made.

The extensive library in the content intense section of the site (the Plant Room) was developed by an honours student as part of her thesis project. The instructional designer provided content grids with structural, textual and image guidelines and tips. Further support was provided by the subject matter expert who helped make decisions about the relevance of the content to thermodynamic principles.

Structure of the Virtual Power Plant Website

The Plant Room, which is the core component of the Virtual Power Plant, is a graphically intense environment through which the student navigates. Students narrow down their exploration to the component level where a library of photos, schematics and text descriptions can be studied in context. These searchable library items are hyperlinked to descriptions of other relevant components. A series of self-assessment quizzes, which are set in a companion WebCT site, allow students to evaluate their understanding of this content. A schematic view can be super-imposed over the detailed view so students can relate the initial graphical depiction to standard, textbook representations of thermodynamic components and cycles. There is also an animated view of the Plant Room where the movement of the elements through the system and the function of the components is shown. In this animated view temperature statistics can be viewed in real-time as the elements move through the system. All of this helps students visualise what is going on, which in turn enables them to construct a deeper understanding of complex concepts and their practical applications.

The orientation section of the site encourages students to first explore the Plant Room and then visit the Control Room (which is set inside an external package titled *VisSim*) and the Design Room (which is based on another external package titled *CyclePad*).

The intermediate pages between the Plant Room and the Design and Control Rooms introduce the *CyclePad* and *VisSim* software and provide contextually appropriate activities and help. The Design Room enables creation, and analysis of the different thermodynamic cycles underlying power plant operation. Existing systems can be explored and modified, components can be removed and the *CyclePad* software offers continuous context-sensitive support. The Control Room assists students in learning thermodynamic concepts through experimentation and through attempting the three working scenarios. The software appears as a largely simplified version of power plant simulation software used in industry. Here students manipulate the controls of the virtual control room in order to meet fluctuating power output and fuel demands.

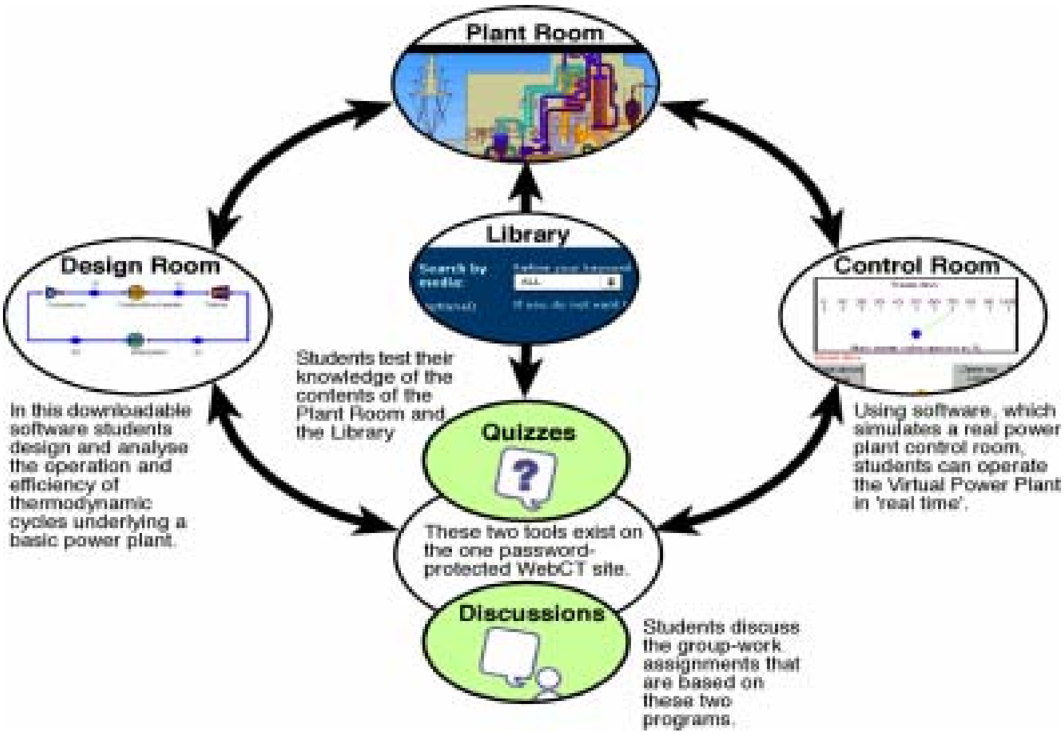

Figure 1 The Virtual Power Plant Website structure illustrating students' path through the four different programs/platforms.

Mapping Virtual Power Plant activities onto a situated learning framework

In 2002 the developmental phase was completed and the challenges of the application phase began. The incorporation of this learning resource into the total course delivery and the subsequent development of activities and assessment in this new phase is being informed by the following nine critical characteristics of situated learning (Herrington & Oliver, 1995 and Oliver & Herrington, 2001).

Authentic context that reflects the way the knowledge will be used in real life

The Plant Room provides a graphical setting which not only illustrates the workings of the components but also, with the provision of images and textual explanations, gives students a solid understanding of the components they then manipulate in the Design and Control Rooms. Rather than accessing information from text links or buttons, students click on the cycles or components themselves, creating an environment which preserves the authentic context of the plant and invites exploration. (Brown, Collins & Duguid, 1989)

The two simulation packages are realistic and provide motivation for the learners. For example, the interface of the VisSim program of the Control Room is based on the GUI of the standard software used in industry. The activities in the Design Room may invite the student to revisit the Plant Room where they can find reference material about the components and cycles they are designing and analysing.

Authentic activities

There are no right or wrong answers to any of the student-centred activities in the Design and Control Room. Instead, in the Design Room students will be encouraged to attempt activities which have open-ended outcomes. Students will set component parameters and have to revisit these once they've seen the effect on the overall performance of the cycle. Open-ended questions will invite students to think about the wider implications of their choices based upon such factors as the environment and safety.

The authentic challenge of the Control Room task is to optimise the ratio of fuel input versus power supply/demand. The program gives feedback on students' performance in the three scenarios in real-time. If students don't respond to these warning messages, the plant will 'blow up'. The complexity and uncertainty of the tasks in both the Design and Control Rooms mimic the nature of real-world problem solving (Herrington & Oliver, 1995).

Access to expert performances and the modelling of processes
Once students have presented their results to the class in a group presentation the lecturer will model similar tasks in both the Control and Design Rooms and invite students to compare and contrast the decisions taken by themselves, their peers and their teacher.

Multiple roles and perspectives
When students attempt the Design Room exercises they will get the perspective of an engineer whose focus is on efficiency. However, when they move to the Control Room the engineer operates the Power Plant in a realistic environment with unpredictable fluctuations in power demand etc, thus the student will experience the tension between efficiency and safety.

Collaborative construction of knowledge
Students will be required to work in groups to complete both the Control and Design Room assessment tasks. They will be encouraged to share their findings in a private Discussion Board forum which will be accessed only by students in that assignment group and the lecturer. The assessment of Discussion Board participation can lead to a situation where students post frequent messages but don't read and respond to other students' postings (eg. McLoughlin & Luca, 2000). For this reason Discussion Board participation will not be assessed but students will be advised that their collaboration in the private assignment group forums will provide evidence of an individuals' understanding of the topic which can help to inform the lecturer when allocating individual marks for the group assignments.

Reflection
Because students will self-assess their knowledge through the quizzes (to which they have unlimited attempts and which are marked automatically), they will have an opportunity to reflect on their understanding and repeatedly revisit the content and re-attempt the quizzes. Because of the 'anywhere, anytime' conditions of the online quizzes the lecturer is concerned students may cheat. For this reason a nominal mark encouraging several attempts of the quizzes will be given instead of a mark based on student performance.

The design of the Control and Design Room activities require students to compare their understanding of the scenarios with the other students in their assignment groups. Due to the non-linear structure of the website they are given the opportunity to refer back to the content-based Plant Room. The presentation and report structures of the two assignments by nature encourage reflection. Students will describe the process decisions they make and the results they achieve within a theoretical framework.

Articulation
Throughout the assessment task students are encouraged to take screen shots as they progress through the assignment. These will be used to illustrate the class presentation of the Control Room group assignment, a scenario which has a narrative structure. The group report on the Design Room activities (which is also illustrated by screen shots) gets students to critically analyse the performance of their designs.

Coaching and scaffolding
Several different Control Room scenarios were created by pre-setting the *VisSim* parameters. In the initial, easier scenarios students will have a realistic chance to perform adjustments and bring the system safely into a desired state because the simulation is slowed down and because only some of the control buttons, which regulate the power production process will function. Students are supported with on-line help, warnings and their actions will be evaluated. In *CyclePad* students are encouraged to take the guided tour of the software. The Control Room's intermediate page introduces students to *VisSim's* structure and functions and suggests an order in which tasks can be attempted.

Integrated assessment
The Control and Design Room activities described in the Authentic Activities section form the majority of the course assessment. The assessment activities are examples of constructive alignment where objectives, teaching and learning activities and assessment are fully integrated (Biggs 1999).

Conclusion

In July 2002, the Virtual Power Plant won *Best Tertiary Website* at *The Australian* Awards for Excellence in Educational Publishing. The iterative design process instigated by the Action Learning team and compounded by the development of the prototype and testing stages it went through, no doubt helped to achieve the website's high level of quality. Now the challenge is to incorporate this resource and its related activities into the course delivery and assessment. The next stage in this work is to evaluate students' learning outcomes and examine whether the collaborative and activity-lead approaches to understanding abstract concepts enhance students' ability to apply and also reflect on their ability to apply thermodynamic principles in a practical context. The role of the lecturer in implementing this resource is a key factor in the success of these learning activities, and therefore their involvement will also be assessed in the upcoming evaluations.

Acknowledgments

The author wishes to acknowledge the kind assistance of Ms Cathy Stephens for the development of the website structure map and the Action Learning and development teams: Dr Srdjan Nesic, Ms Lara Ross, Ms Cathy Stephens, Ms Helen Holland, Mr Paul Smith, Dr Graham Maxwell, and Ms Marilyn Hughes.

References

Biggs, J. (1999). *Teaching for Quality Learning at University*. Buckingham, UQ: Open University Press.

Brown, J.S., Collins, A., & Duguid, P. (1989) Situated cognition and the culture of learning. *Educational Researcher*, 18 (1), 32-42.

Herrington, J. and Oliver, R. (1995) Critical Characteristics of Situated Learning: Implications for the Instructional Design of Multimedia. In J. Pearce & A. Ellis (Eds.) *Learning with Technology, ASCILITE '95 Conference Proceedings*, (pp 395-403). Melbourne: ASCILITE.

Lemke, J.L. (1997) Cognition, Context, and Learning: a Social Semiotic Perspective, *Situated Cognition: Social, Semiotic and Psychological Perspectives* D. Kirshner, Whitson, J. A. Eds. Erlbaum: New Jersey.

McLoughlin, C. and Luca, J. (2000) Learning Through Self-Direction: The Influence of Task Design on Team-Based Professional Knowledge Building in an Online Environment. In Sims, R, O'Reilly & Sawkins, S. *Learning to Choose – Choosing to Learn ASCILITE 2000 Conference Proceedings* (pp 327-338), Southern Cross University.

McGill I. & Liz Beaty. (1992). *Action Learning: A practitioner's guide*. Kogan Page Limited: London.

Oliver, R. & Herrington, J. (2001) *Teaching and Learning Online.* Edith Cowan University: Western Australia.