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The Reflective Online Searching Skills (ROSS) Environment: embedding information literacy into student learning through an online environment

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Abstract

The Reflective Online Searching Skills (ROSS) Environment is an e-learning tool that fosters the development of student skill and knowledge in online searching. It was developed with the support of Faculty of Information Technology and the Teaching and Learning Support Services at the Queensland University of Technology (QUT). In 2007 ROSS is being developed for use within the first year curriculum of other faculties within QUT. This paper will provide a demonstration of the ROSS environment and how it was embedded within the curriculum of two contrasting disciplines: IT and Science. Many online information literacy tools are static, modular, linear and heavily text based, and have failed to incorporate an interactive approach to the learning process. This paper will demonstrate that ROSS pushes the boundary of online information literacy programs by guiding learners to know, reflect, and practice information literacy concepts through the use of case studies or problem based learning.

Introduction

In recent years information literacy has become a topic of considerable discussion within higher education. The current literature suggests that information literacy is an important skill for undergraduate students. For example, the Association of College and Research Libraries (ACRL) state in their Information Literacy Competency Standards for Higher Education that "developing lifelong learners is central to the mission of higher education institutions" (para 10), and that by ensuring "individuals have the intellectual abilities of reasoning and critical thinking, and by helping them construct a framework for learning how to learn, colleges and universities provide the foundation for continued growth throughout their careers, as well as in their roles as informed citizens and members of communities" (para. 10). According to the ACRL Standards, IL is a "key component of, and contributor to, lifelong learning" (para. 10). The response of the higher education sector to the need for development of information literacy skills in students is perhaps best reflected in the view of Johnston and Webber (2003)

who point out that information literacy is a social response to the need for effective use of the huge amount of information accessible in today's information society. As interest in information literacy continues to build, the scholarly discussion has begun to consider how information literacy can be developed using the latest technology to adapt to the diverse student learning styles.

This paper will report on an ongoing project to build an e-learning environment that can be used by to help support students – in any discipline – develop their skill and knowledge in online searching. The paper will discuss the challenges in developing a generic tool that can be used within the curriculum of different disciplines where those disciplines have very different student cohorts. The paper will reflect upon what the two contrasting student cohorts liked and disliked and what they found inspiring, boring or simply confusing with the online environment. The paper is divided into two sections. Section one will provide a brief discussion on information literacy within higher education and the growing interest in e-learning as a vehicle for information literacy development. The approach to information literacy at QUT is highlighted. Section two will provide a brief overview of ROSS, including the theoretical framework that informed its development. The section will also discuss two case studies that illustrate how ROSS can be used in two contrasting learning contexts.

Information Literacy and Higher Education: A Brief Overview

A Definition

Recent research indicates a diverse range of understandings of information literacy in higher education, including information literacy as a set of information seeking behaviours; as a skill involving technical expertise and as a discipline in itself. Information literacy is also recognised as being an important generic skill or student attribute (Edwards, Bruce, & McAllister 2005). Alternatively, CAUL (2001a) considers information literacy in terms of "an intellectual framework for recognising the need for, understanding, finding, evaluating, and using information", and Lupton (2004) found that information literacy may be understood as a "learning approach". Bruce (1997) noted that information literacy includes aspects of computer literacy, learning to learn, information skills, IT literacy, and library skills. It is important to note, that Bruce's broader meaning of information literacy incorporates an understanding that some of these aspects overlap, that information literacy may in fact be a series of "seven faces" that may be used as a repertoire of the ways of experiencing information literacy. Bruce's study highlighted aspects of information literacy which are especially pertinent for the university student. For the purposes of the present paper, we adhere to the view that information literacy is the set of skills and attitudes which enables the individual to "recognise when information is needed and have the capacity to locate, evaluate, and use effectively the needed information" (ALA 1989).

Models of Information Literacy

As Lupton (2004) notes, Information literacy is currently an important curricular focus in all educational sectors. She identifies three classes of models developed to conceptualise information literacy in educational terms: standards based, process based, and relational models. The standards based models include the CAUL standards (CAUL 2001b) which underpins information literacy at QUT (Queensland University of Technology). The Big Six Process Model (Eisenberg & Berkowitz 1988) and the Information Search Process (Kuhlthau 1993) both reflect the staged understanding of information use. The process models are most frequently used in primary and secondary education and stress information literacy as a series of steps. The relational model of information literacy proposed by Bruce (1997), focuses on the unique experience of the individual in the information transaction and has informed many recent studies in information literacy in the higher education sector.

Information Literacy and E-learning

Information literacy learning opportunities in higher education settings are commonly delivered by librarians or through collaborative programs between librarians and faculty in both face-to-face situations and via online tutorials. There is an apparent emphasis on information literacy teaching for undergraduates, particularly first-year students (Abbott &

Peach 2000; de Bruyn & Prior 2001) and effort is now centred on embedding these information literacy sessions within specific disciplines.

Kasowitz-Scheer & Pasqualoni (2002) note that information literacy is more frequently being offered online, and that this is in response to an increased demand for rapid sharing of information and access to online resources. Of interest then, is the finding by Gutierrez & Wang (2001) that undergraduates entering university from school prefer the electronic medium for library instruction. In terms of the current research, the study by Gutierrez & Wang is interesting because they took into account the findings of Chamlongsupalak (1997; as quoted in Gutierrez & Wang 2001) that students believe they learn best when there is a human interface. Gutierrez & Wang found that online learning in library literacy can be enhanced by having it embedded within a lecture structure so students have human intervention. Their study also supported the notion that research skills require the opportunity for repeated practice, which is a feature encouraged and supported within the ROSS Environment.
In response to the increase in the online or e-learning delivery of higher education courses, many information literacy modules/tutorials/packages have been developed for this sector. Packages such as QUT – PILOT (QUT Library 2003) or Kent State University's – SAILS (2002) are just a couple of the packages currently in use. Many of these packages are designed and made available through the library, often in collaboration with faculty or teaching and learning support staff and technical support staff. Commonly, these packages possess a modular, linear and heavily text-based structure. The level of interaction encouraged through use of Flash (used in the Texas University TILT program (Rensselaer Research Library 2002)) and similar technologies is at best only moderately interactive.

Overall, these information literacy programmes may actually have even further potential if we view them as a form of learning object. Learning objects are considered by some people to be mere "granules of knowledge", able to be shared throughout an organisation. However Clark (1998: 60) points out that in educational contexts, learning objects may be viewed as instructional. These objects can be stored, revised, and even mixed and matched to create new learning experiences for our students (Veronikas & Shaughnessy 2004); this way of viewing learning objects is interesting when information literacy packages that are used throughout an educational institution are considered.

Information Literacy at QUT

The learning and teaching of information literacy at QUT is underpinned by the Australia and New Zealand Information Literacy Standards (CAUL 2001b). Information literacy is recognised as a generic skills requirement of QUT graduates. Each faculty has been given the responsibility of identifying and promoting generic capabilities and of encouraging students to reflect on their development of generic skills at QUT (QUT 2004a). Embedding of information literacy skills across all programs/courses is a current challenge of information literacy learning and teaching at QUT. This is occurring within a learning and teaching environment also demanding an increasingly flexible, inclusive and student-centred approach (QUT 2004b).

The Reflective Online Searching Skills (ROSS) Environment

Introducing the ROSS Environment

ROSS was developed as a means of fostering students' skills and knowledge of online searching and is based on qualitative research into how students learn online information searching (Edwards 2006). ROSS was developed with financial support from the School of Information Systems, and with technical support from the university Teaching and Learning Support Services. Students complete a series of eight interrelated modules that requires them to use the online information searching process to meet an information need. Each of the modules are interactive, requiring students to answer questions, make observations, and complete exercises. Each subsequent module builds on the learning in the previous module. On completion of the ROSS modules, the student will have experienced first hand the process of online searching to meet a specific information need. In addition to working on the ROSS scenario the student can apply what they are learning in ROSS to their own

assignment via a Reflective Workspace. The students are also provided ample opportunity to critically reflect upon the development of their own online searching skill and knowledge.

The Theoretical Framework

Teaching and learning research to date has found that the *best way to learn something (*be it a skill or a concept) is to experience what you are learning in qualitatively changed ways (Marton & Booth, 1997; Shulman, 1985). By experiencing a skill or concept in different ways, an individual is able to compare their original (or old) experience of that skill or concept to their new experience of the skill or concept. The individual therefore, is given the opportunity to discern the variation between the old and the new experiences, and according to Runesson,(1999) it is this process of discernment that is a significant attribute of learning.

Edwards (2006) has applied this view of learning to information searching. Using the phenomenographic method Edwards identified variation in the experience of information searching in the online environment. Participants in the study were 32 students from six of the eight QUT academic faculties, with a total of 44 interview transcripts. Different cultures, ages and genders were represented. Four categories that captured the variation in the students' different ways of searching and learning to search for information were identified. The categories include:

Category 1: Information searching is seen as looking for a needle in a haystack
Category 2: Information searching is seen as finding a way through a maze
Category 3: Information searching is seen as using the tools as a filter
Category 4: Information searching is seen as panning for gold.

A detailed summary and discussion on each category and the different meanings assigned to each search experience can be found in Edwards (2006). In short, Edwards concluded that for students to successfully develop information searching skills the teaching and learning environment needs to be designed to encourage "students…to see things happening differently to what they have previously experienced in order to discern a difference" (Edwards, 2004, p. 112). That is, students need to experience the wide variation of online searching experiences so they may compare and contrast these different experiences to their own. Edwards contends that "if we can do this, we will move our students into a deeper understanding of the searching experience, we will provide them the opportunity to discern a variation in what they have previously experienced, and, hopefully, we may encourage learning" (Edwards, 2004, p. 112). Edwards provides four guiding principles when designing a learning experience that will allow students to experience variation: provide students with opportunities for reflection; improve assessment to make it both authentic and to encourage students to see the variation; use online tools to further enhance the learning experience; and finally, encourage staff development to enable understanding and application of the findings. The principles outlined by Edwards were used to guide the design and development of the ROSS environment.

Case Study One: The Bachelor of Information Technology

The Bachelor of Information Technology (BIT) is the primary course offered within the QUT Faculty of Information Technology. The course is completed in three years full time or six years part time. All students complete a common first year of 8 introductory units. From this base, students choose a major in areas such as data communications, information systems, software engineering, electronic commerce, or emerging technologies. The BIT is aimed at providing students with the theoretical skills and practical knowledge required to become successful practitioners in the ever-changing IT industry. Graduates from the BIT can enter a diverse range of careers, including: systems programmer, computer scientist, systems analyst, information manager, games developer, multimedia specialist, data base manager and web developer.

ITB322 Information Resources

ITB322 Information Resources is an elective unit offered within the QUT Faculty of Information Technology. The unit introduces students to the value of information both personally and professionally by encouraging them to explore the wide variety of information

resources available, independent of the resources format. There is a major focus on the identification of user needs and the development of information searching skills across a wide variety of online resources, including bibliographic databases, the Internet and traditional print materials such as grey literature books, journals and conference proceedings. The unit can be taken by any undergraduate enrolled at QUT, and has an average enrolment of 50 students per semester.

The Teaching and Learning Approach

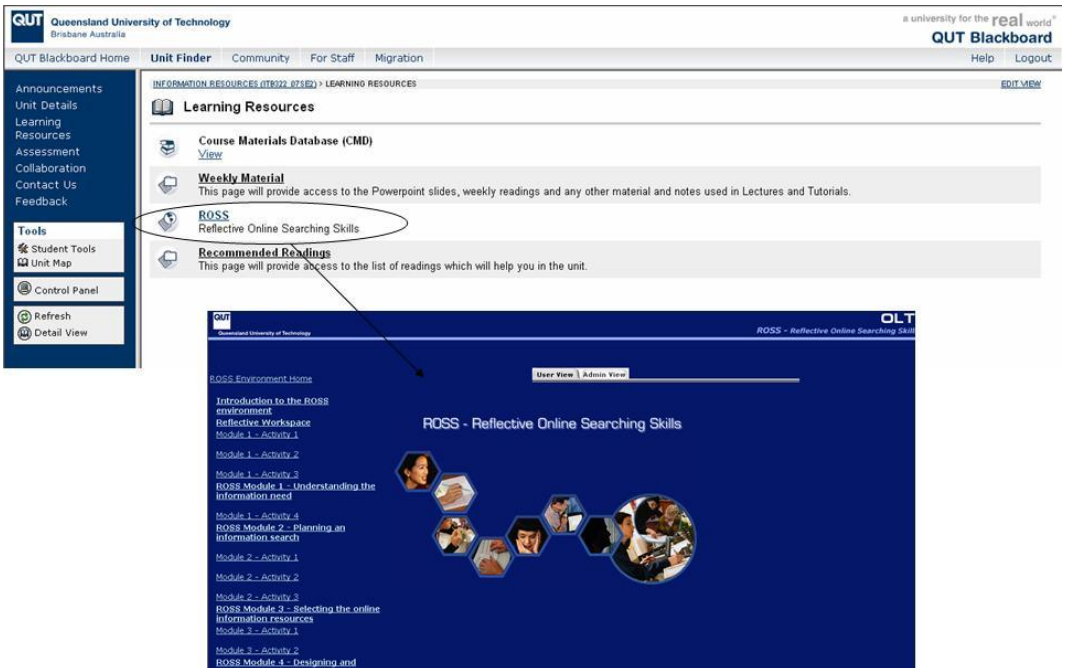
Students enrolled in ITB322 are required to attend three hours of classes (lectures and computer based practicals) per week for 13 weeks. During the course of the semester students complete three assessment items. Table 1 provides a brief description of the three items. The assignments provide the students the opportunity to reflect upon, develop and practice their information searching skills. The assignments are designed to provide authentic learning experiences based upon 'real life' practices of industry professionals.

Assessment 1: Resource Guide	**Conducted:** In small groups	**Weighting:** 40%
Summary: Students are required in teams to develop a resource guide on a topic of their own choosing. The resource guide should provide only the best quality resources on the topic and should be able to guide anyone interested in the topic (i.e. a business in that area) to find answers to any questions they may have.		
Assessment 2: Information Consultant's Report	**Conducted:** Individually	**Weighting:** 40%
Summary: Students are asked to pretend they have recently been appointed as an Information Consultant for a large information service. They have been approached by their first client and are required to meet their specific information need (i.e. they are to select from 3 possible scenarios provided to them by the unit coordinator). To meet this need students are required to design and conduct a sophisticated search of online resources (i.e. bibliographic databases or Internet search tools) that will produce high quality results. Students are asked to recommend only the top 20-25 results.		
Assessment 3: Reflective Learning Journal	**Conducted:** Individually	**Weighting:** 20%
Summary: Each student is required to write and submit six journal entries over the course of the semester. Entries are submitted fortnightly. Students are asked to write their critical and reflective thoughts on what they are doing, seeing, reading, hearing and learning.		

Table 1: ITB322 assessment items

Using ROSS in ITB322

The ROSS environment was used to directly support the third assignment – the Information Consultant's Report. A link to ROSS is provided from the unit's blackboard site (see figure 2). ROSS was incorporated into the learning environment during Weeks 7 through to 13. Each week during this period students attended a three hour computer laboratory based class.



ROSS requires the students to take on the role of an information consultant who has been approached by a client with a specific information need. Figure 3 shows the role play synopsis of the client and the information need.

TO: Jane, Information Broker <info@info.com.au>
FROM: Mr E. Jones (Secretary to Dr Jonas Faultless) <e.jones@promhospital.com.au>
SUBJECT: Request for Information

Dr Jonas Faultless is a world class medical scientist working for a prominent Australian hospital. Dr Faultless has just been informed that due to a colleague's severe illness he will have to give a speech at this year's annual national medical convention. The topic of the presentation is the use of nanotechnology in medicine - this unfortunately is not Dr Faultless' area of expertise. The Doctor would like to obtain information on nanotechnology and its application in medicine. The Doctor is also interested in obtaining some data on who is currently using nanotechnology to aid medical practice. As the presentation is for an Australian conference, Dr Faultless is particularly interested in current use of nanotechnology in the Australian medical context. The Doctor is interested in obtaining the views of experts and researchers in the area and any key organisations. Case studies of the use of nanotechnology in medical practice would be helpful.

Figure 3: ROSS Client information need synopsis

The student is required to locate information to meet the client's information need by selecting and searching online resources (i.e. Internet search tools or bibliographic databases). The Reflective Online Searching Model guides the student through this process and consequently forms the basis for the ROSS environment. Students are introduced to the overall structure and purpose of the environment in the *Introduction to the ROSS Environment* page which is presented in Figure 4.

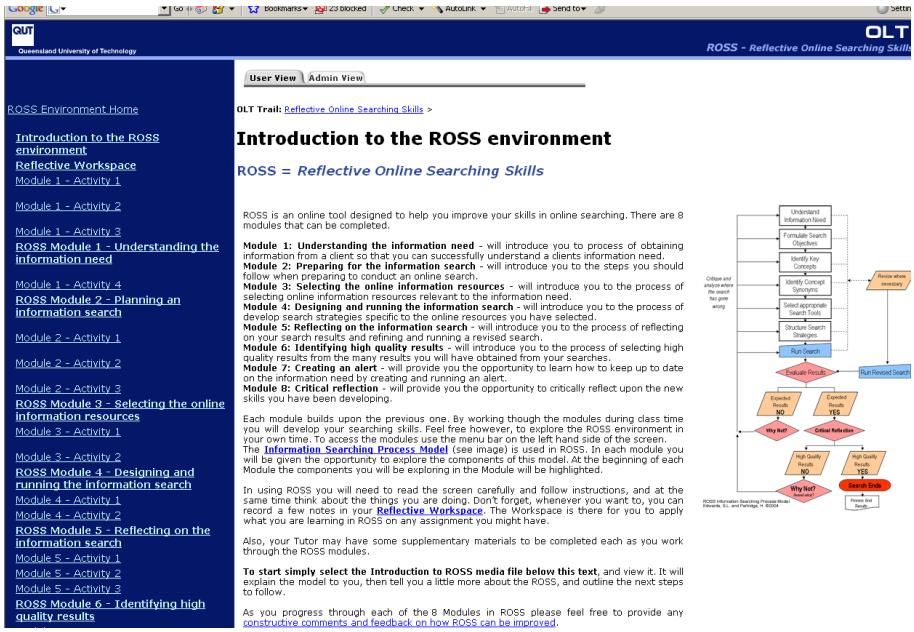


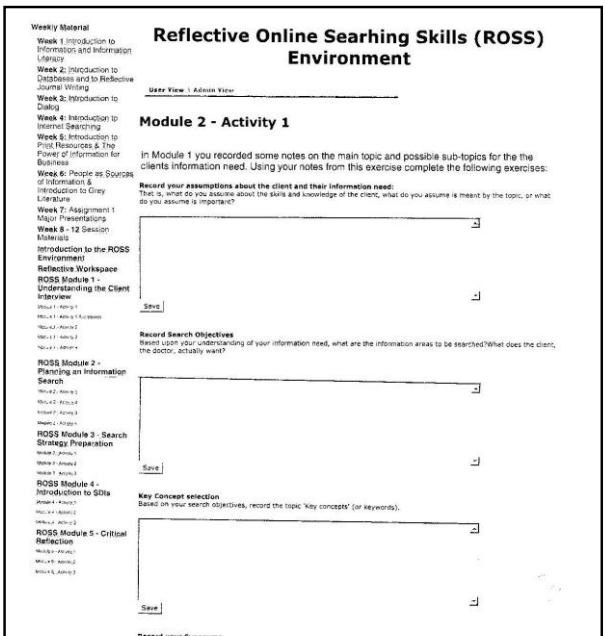
Figure 4: The introduction to ROSS page

ROSS consists of eight modules. The modules are inter-related, with subsequent modules building upon the former. A brief summary of the eight modules can be found in Figure 5. A short video introduces the students to each module, explaining the purpose of the module and the activities to be completed. Although the students complete the modules in class time, they are also encouraged to use the ROSS environment as a self-paced learning tool that they can access at any time during the course of the unit.

Module 1: Understanding the information need – introduces the process of obtaining information from a client to successfully understand a clients information need.
Module 2: Preparing for the information search - introduces the steps to follow when preparing to conduct an online search.
Module 3: Selecting the online information resources – introduces the process of selecting online information resources relevant to the information need.
Module 4: Designing and running the information search - introduces the process of develop search strategies specific to the online resources selected.
Module 5: Reflecting on the information search – introduces the process of reflecting on search results and refining and running a revised search.
Module 6: Identifying high quality results - introduces the process of selecting high quality results from the many results obtained from the searches.
Module 7: Creating an alert – introduces how to keep up to date on the information need by creating and running an alert.
Module 8: Critical reflection – provides the opportunity to critically reflect upon the new skills developed.

Figure 5: The eight modules of ROSS

Each module is interactive, requiring the students to answer questions, make observations and complete exercises. For example, in Module 2, students are introduced to the steps involved in planning and preparing the online search. Students are invited to view a short video introducing the Module and its learning objectives. After watching the video, students are asked to complete Activity 1 by selecting the appropriate link on the menu on the left-hand side of the screen. Students are required in Activity 1 to respond to a serious of questions which encourage the student to engage with, and reflect upon, the video content. Responses to each of the questions are recorded in the notepads provided. By selecting the Save Button, the students' answers are permanently recorded for them to return to at a later date. After completing Activity 1 students are invited to commence Activity 2 by selecting the appropriate link on the menu on the left-hand side of the screen. Figure 6 shows an excerpt from Module 2 Activity 1.



A Reflective Workspace is provided for the students (Figure 7). The Workspace acts as a 'sandpit site' where students can apply what they are doing within the ROSS Modules (such as Module 2 above) to their own assignment.

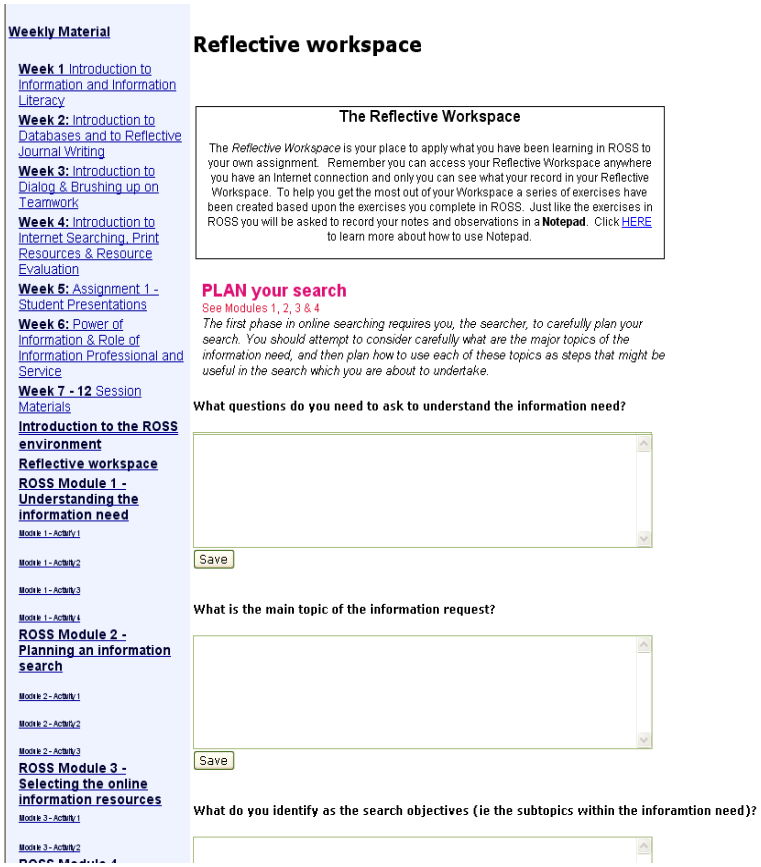


Figure 7. The Reflective Workspace

The Evaluation of ROSS in ITB322

The ROSS Environment has been used in the unit for four years. According to Edwards (1991), evaluation seeks to "describe and explain experiences of students and teachers and to make judgements and [interpret] their effectiveness". With this purpose in mind a number of evaluation strategies were used to obtain data from both stakeholders in the intervention – the teaching staff and the students. Student evaluation was obtained by eliciting comments via the fortnightly Reflective Learning Journal and from self administered questionnaire and semi-structured interviews with students at the end of each semester. The results of the evaluation are available from Partridge & Edwards (2005). In short, both the students and the teaching staff viewed the experience of using ROSS favourably. Student responses clearly indicate that ROSS is an online learning tool of merit, they found the environment "easy to use and understand" and to "increased flexibility in my studies within this unit", "helped me to

understand the unit's content" "improved the teaching and learning value in the unit". Comments received from the students included:

> *"I now realise that there is more to searching online than typing the keyword to be searched in google.com and pressing the search button"*
>
> *"I really like how…ROSS [has] been developed to directly relate to what you are doing in the assignment, this is a very good way of putting into practice what you have learnt in class"*

Students however did indicate areas for further improvements, with comments such as the following being provided: *"some modules were too large and could be broken into small modules" and" it is time consuming".* The majority of comments focused on the time-consuming nature of the modules and the repetitive questions and activities between the modules. Students frequently commented that the need to "do the assignment" stopped them from working through all the modules and activities. Students also indicated that whilst they valued the self-paced instructional aspect to ROSS they felt it was equally important to attend classes to ensure a rich and well rounded learning experience. These comments are being used to make refinements to the ROSS environment and its application with ITB322.

From the teaching perspective, ROSS provided a wonderful means of introducing new energy into the unit. However, it also posed challenges in how best to integrate the technology into the curriculum in a manner that balanced the virtues of self-paced instruction alongside the benefits of maintaining a collaborative learning community in which peer discussion and small group work play central roles. It was noted by the teaching staff that whilst students worked on the modules during class time, the different student working styles and paces directly impacted on the extent to which the learning environment could be designed to provide students the opportunity to actively engage in peer discussion on the work being undertaken. The most significant observation noted by the teaching staff was the impact of ROSS upon student learning. Anecdotally, the overall quality of Assignment 2 had improved, with many of the students showing a sound understanding of the online searching model and being able to effectively apply the model to the information need outlined in the assignment guidelines. It is, however, acknowledged that the small class size for the unit may have allowed the development of a learning context in which a more individualised, and consequently more effective learning environment arose.

Case Study 2: The Bachelor of Applied Science

The Bachelor of Applied Science (BAS) is the primary course offered within the QUT Faculty of Science. The course is completed in three years full time or six years part time. Students choose a major specialisation from the ten discipline areas: biochemistry; biotechnology'; chemistry; ecology; environmental science; forensic science; geoscience; mathematics; microbiology; and physics. The BAS is aimed at providing students with the theoretical skills and practical knowledge required to become successful practitioners in the broad and ever-changing domain of science. Graduates from the BAS can enter a diverse range of careers including forensic scientist, geologist, chemist, physicist, microbiologist or environmental scientist.

NRB100 Environmental Science

NRB100 is a first year core unit offered within the Faculty of Science. The unit introduces students to the broad field of environmental science, the concept of the environment, and its component parts and the influence of human activities. It is a foundation unit to further studies in science, and develops from a basic knowledge of science at secondary level. The unit also has a focus on generic capabilities such as communication, team work and the ability to search for, and critically evaluate, information from a variety of sources. The unit is core unit taken by BAS students in the ecology, environmental science and geoscience specialisations and is one of several elective students can take in the other specialisations. The unit has an average enrolment of 220 students per semester and is taught concurrently at two campuses (Gardens Point and Carseldine). The BAS first year curriculum is currently being reviewed and it is expected that NRB100 will become one of four core units that all BAS students will

complete. This will lead to an average enrolment of 300 (or more) students in next year's offering of the unit.

Teaching and Learning Approach

Students enrolled in NRB100 are required to attend a three hour lecture each week, one hour practicals and tutorials and three hour practicals at various stages throughout the semester. The unit is team taught with three lecturers sharing the teaching load. During the course of the semester students complete five assessment items. Table 2 provides a brief description of the five items. The assessments provide the students the opportunity to develop not only their discipline knowledge but to also reflect upon and develop practical skills and knowledge in

Assessment 1: Mid semester examination	**Conducted:** Individually	**Weighting:** 10%
Summary: A mid semester multiple choice examination of all theory covered during the first half of the unit (i.e. weeks 1 to 5 approximately).		
Assessment 2: Practical log book	**Conducted:** Individually	**Weighting:** 15%
Summary: Students complete exercises during the practical sessions. Feedback will be provided from a lab demonstrator at the close of each practical. Upon the mark of "satisfactory" being awarded for your annotated results and rough, interpretive discussion at the close of the practical session, you will be given the opportunity of modifying your work in your own time and presenting a more detailed write-up in your practical log book, which will be submitted at the close of the semester.		
Assessment 3: Tutorial participation	**Conducted:** Individually	**Weighting:** 10%
Summary: You will participate in a series of tutorials throughout the semester. These tutorials will draw and expand on material presented in the lectures. Your level of participation in each tutorial will be assessed.		
Assessment 4: Fish Kill	**Conducted:** Individually	**Weighting:** 20%
Summary: You will use web-based resources to investigate a hypothetical environmental incident and determine its likely cause. This project will enable you to develop skills associated with scientific investigation, problem-solving and information literacy. You will write a detailed scientific report on your findings that will be submitted and assessed at the close of the semester.		
Assessment 5: Final Examination	**Conducted:** Individually	**Weighting:** 45%
Summary: Cumulative examination which assesses both your surface and deep learning through the use of multiple choice, short answer and problem-solving essay questions.		

Table 2: NRB100 assessment items

Using ROSS in NRB100

The ROSS environment was used to directly support the fourth assessment item – Fish Kill. The Fish Kill assignment has been designed to provide an authentic learning experience based upon 'real life' practices of science professionals. Using problem based learning the students are presented with a hypothetical environmental incident (outlined in Figure 8). The students are charged with the task of determining the most likely cause of the incident by using the scientific method.

It is the year 2013. Computer technology has evolved to a remarkable degree - video conferencing, internet newspapers and internet radio broadcasts are now commonplace. But at the same time environmental problems have become more frequent and more serious.

You have recently started work with the newly formed "Environmental Response Group" (ERG) which has been formed by the State Government to deal with the rising number of serious environmental problems that have been occurring in the south-east corner of the state in 2013.

Overnight, there has been a fish kill incident that has been widely reported in the media. Hundreds of dead fish have been washed up on the river banks. You have been given the responsibility of finding what caused this incident and recommending how similar incidents can be prevented from happening in the future.

Figure 8: The Fish Kill hypothetical environmental incident

Students are introduced to the environmental incident and work through the assignment requirements via an online environment that is available from the unit's online teaching site

(see Figure 9). The environment was developed to be an interactive, visual and authentic learning experience for the students. The Fish Kill environment was funded by two QUT Large Teaching and Learning Grants (1998-9 and 2005-7).

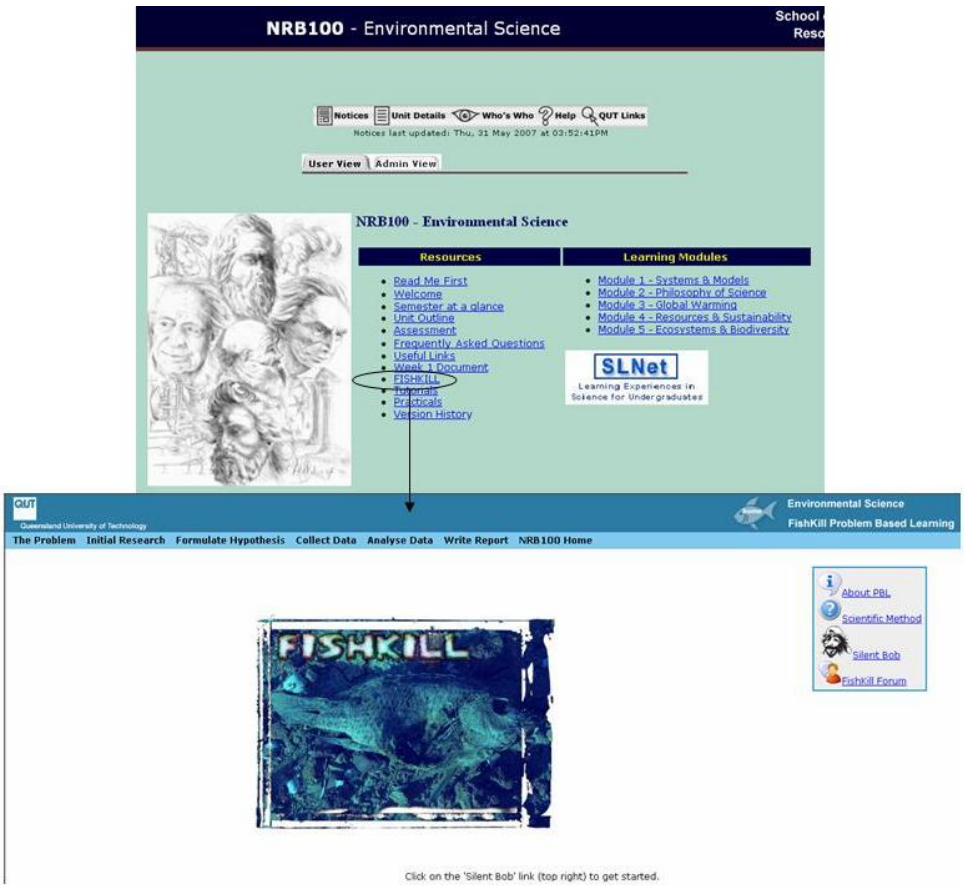


Figure 9: The Fish Kill Environment

Students are introduced to the Fish Kill assignment (and the online learning environment) in week 8 of semester. ROSS is embedded within the Kish Fill environment (see Figure 10). ROSS is introduced to students as a stand alone, self-paced learning tool that they can use to support their development of online searching skill and knowledge. Students do not use the ROSS environment within their classroom learning.

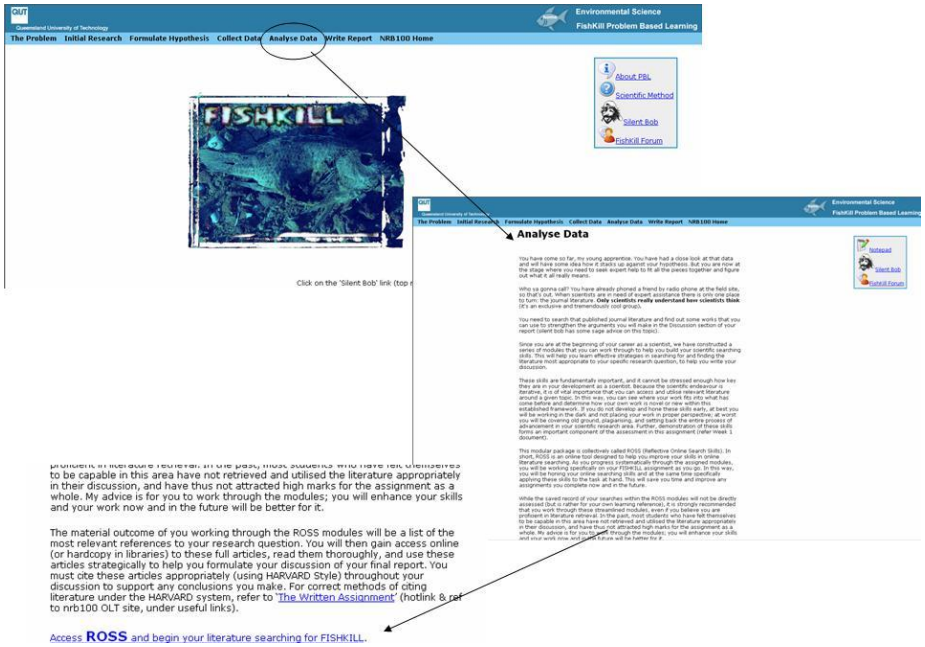


Figure 10: ROSS within the Fish Kill environment

Several modifications were made to the ROSS environment to establish a better learning fit with the Fish Kill assignment specifically, and the science context generally. Firstly, the content was revised. This included removing one of the modules (on Selective Dissemination of Information or Alerts) and reworking the *Introduction to ROSS* page to include a targeted discussion on the role of ROSS in the Fish Kill assignment specifically and online searching within the scientific method generally (see Figure 11). The Reflective Workspace was also removed. Secondly, the 'look and feel' of ROSS was modified to establish a seamless fit within the Fish Kill environment. This included removing the main page (see Figure 2), altering the background colours and introducing the Fish Kill 'guide' "Silent Bob' within each of the modules.

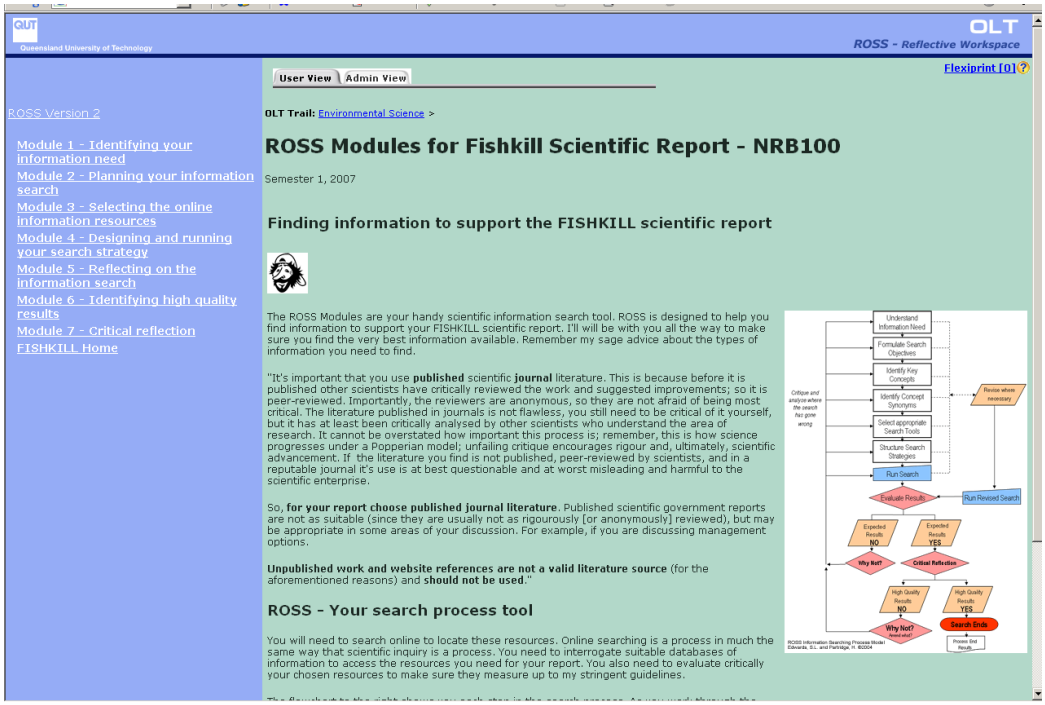


Figure 12: The revised Introduction to ROSS page

The Evaluation of ROSS in NRB100

The Fishkill assignment has been used as an assessment task within NRB100 for five years, with the ROSS component for the last two years. Although a number of improvements have been made to Fishkill over its lifetime (not least transferral online), it is nonetheless possible to make a few preliminary observations about the influence of ROSS on student learning outcomes in the unit. Anecdotally, the teaching staff has noted that the quality of Fishkill reports submitted has improved over the past years. There are a number of attributes to submitted assignments that are generally of higher quality: hypothesis development, correct use of Popperian falsification and the scientific method; presentation / analysis of collected data and scientific language; quality and quantity of literature used strategically in the assignment discussion to place the current study in context. The first two of these improvements (and skills in contextualisation in the third) have arisen, at least in part, from the introduction in the last year of online exemplar assignments. Incorporation of exemplars necessitated the introduction of a wholly novel environmental problem, analogous to, but distinct from, Fishkill. Both good and bad exemplar assignments have been introduced into the Fishkill environment. These exemplars are supplemented with thorough critiques, aligned with assessment criteria. Students have used these exemplars successfully as a reference point and gauge for their own work; they learn what makes a good assignment and what pitfalls to avoid submitting below par work. The third area of improvement, quality and quantity of sourced literature, has been positively affected by merging and contextualising ROSS within Fishkill. A key element of scientific research lies in the investigator making

specific reference to relevant, published journal literature. This is because it represents a formal and critical component of the iterative modern scientific method, namely interpretation of data in light of previous, peer-reviewed, anonymously critiqued research; this for subsequent modification of theories under models of future testing. The improvements in this component of the students' submitted work are striking; very few students are now using inappropriate web sources (a major problem in pre-ROSS iterations of Fishkill); the vast majority of students are now accessing not only journal articles and published government reports of high quality and relevance, but the relative quantity of appropriate literature has increased and it is used more strategically for interpretation of their data.

Unlike the IT case study ROSS in this instance was used as an optional self-paced learning tool that students could choose to engage with during their studies. Initial data suggests that approximately half of the NRB101 students chose to use ROSS. Comments received from the students indicated they found ROSS a valuable learning aid: "it outlined every part of the process"; "*it guaranteed good sources"; "has taken me to a right track approach*". It is also important to note that students indicated areas for further improvement with comments such as the following being provided: *"asked to many questions"; "when it asks you to write down sentences that's too time consuming"; "it was a long drawn out process".* Like the IT students the majority of comments provided focused on the time-consuming nature of the modules. The Science students however raised a second area of concern - the extent of reading required. It should be noted here that many of the comments in regards to this latter point were made in reference to the Fish Kill/ROSS online environment generally. This is an interesting observation as it suggests that the students were viewing and experiencing ROSS and the Fish Kill environment as one online learning environment. Thus, suggesting that the efforts made to streamline the two systems into one were successful.

The Significance of ROSS

Many online information literacy tools are static, modular, linear and heavily text-based, and have failed to incorporate an interactive approach to the learning process. While allowing the flexibility inherent in online learning, they do not involve the student in an interactive and dynamic way to reflect on their own unique experience. The development of ROSS may be seen as a significant response to the need for student-centred learning environments which promote the development of generic online searching skills acquisition through reflective practice. It can also be viewed in terms of the evolution of an online learning tool as a dynamic and valuable learning object which facilitates information literacy development for students, across the full range of university and higher education courses.

ROSS enables students to focus on the process of information seeking, an important activity supporting the need for "critical discernment and reasoning" which has been stressed as the most important aspect of information literacy (CAUL 2001a). The ROSS environment also pushes the boundaries of online information literacy programs by guiding learners to know, reflect, and practice information literacy concepts through the use of case studies or problem based learning. The ROSS Environment also lends itself well to being customised for use across all programs/courses; a necessary feature of valuable learning objects.

Conclusion

The development of the ROSS Environment has occurred within a higher education environment currently demanding increased focus on student-centred and flexible learning opportunities. This demand stems from increased moves towards e-learning, based on benefits which have been widely discussed in recent literature (Imel 2002). In conclusion, to date this research has seen ROSS evolve from an embedded delivery learning environment to now be considered as a learning object that may be used in other contexts within the university to enhance the development of generic information literacy skills. While the project is ongoing, ultimately the development of these skills will enhance the graduate capabilities of any QUT student who uses the ROSS environment.

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