Multiplying project experiences for Engineering Students: Accumulated Experience Sharing @ Nanyang Polytechnic

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***Abstract**: Nanyang Polytechnic's (NYP) practice- and application-oriented teaching and learning philosophy emulates the real-world work environment on campus to provide students with an authentic experience of the nature of their future work and of the workplace. An important and integral component is industry project work with cost, quality, reliability and deadline constraints, and often requiring multi-disciplinary capabilities. The accumulated experience and knowledge from extensive industry project development is systematically captured in NYP's Accumulated Experience Sharing or AES(R) system, a rich repository of application-oriented and established solutions over a wide range of engineering and other disciplines, conveniently accessible electronically to authorised users. This paper describes NYP's AES(R) concept and project studies, and how the system is used to multiple engineering students' exposure to project work. It also shares some lessons learnt for successful implementation.*

Introduction

The importance of engineering students learning from project work is found in the literature and discussions around transforming engineering education. At Nanyang Polytechnic's (NYP) School of Engineering, with an enrolment of over 4,600 full-time students, project work has long been successfully integrated into the engineering curriculum. As part of NYP's practice- and application-oriented teaching and learning philosophy, the real-world work environment is emulated on campus to provide students with an authentic experience of the nature of their future work and of the workplace. NYP's close working relationship with industry produces a pipeline of real-life industry project experience for staff and students. To further widen students' exposure to project work, an innovative Accumulated Experience Sharing or AES(R) system for capturing, codifying and sharing this vast project experience has been put in place.

Project work at Nanyang Polytechnic

Project work has always been an important and integral part of teaching and learning at NYP. Project-based learning started in 1988 with real-world industrial automation projects at the training institutes that subsequently formed NYP's School of Engineering. Leveraging on its systems capabilities, NYP is able to create value for companies through projects for industry, which enjoy a one-stop service approach and a higher level of confidence on the delivery of the project outcomes. Through its close networking and collaboration with industry, NYP is able to attract industry partners who provide real-life projects that are developmental rather than operational in nature, and thus of high learning value to students.

Key elements of the successful implementation of the project-based learning approach include the following:

- All engineering students undertake a full-time Final-Year Project (FYP) in their third year. Supervised by staff, they work closely in teams which are often multi-disciplinary in nature. The industry projects provide an effective training and evaluation platform for students. It demands

that all aspects of the project are taken care of, including performance, cost, quality as well as on-time delivery.

- To facilitate industry participation, the FYP students' semestral schedule is planned such that project teams are available to work on industry projects throughout the year. The clustering of NYP's technology Schools in a Technology Park further facilitates multi-disciplinary and cross-disciplinary industry project work.

Sharing of project knowledge and experience

One of the constraints of project-based learning implementations is that the scope of a student's learning is limited to the one or few projects that the student works on. To overcome this limitation and widen students' exposure to project work, the Project Sharing Programme (PSP) was started in 1989. The PSP formalised learning from accumulated project experience: In addition to their own project, students were required to study a few other selected project reports.

Learning from shared project experiences is further maximised, if the following two challenges associated with conventional print-copy project reports are also addressed:

- Capturing project experiences comprehensively. The final print-copy project report submitted would record final solutions. However, important tacit knowledge - from discussions, thinking processes, alternatives generated (which include those of potential in future projects), error rectifications, etc - were not necessarily captured in the final project reports. Supervisor's input and experiences were also not necessarily included
- The inconvenience and difficulty of access to printed reports. The reports were centrally located, had to be physically accessed, and were available to single users only at any one time. Project knowledge and experience were captured in print, or if available, distributed in other physical forms such as video-tapes, and out-sized engineering drawings. Searching was difficult.

These challenges are effectively addressed by the Accumulated Experience Sharing or AES$^{(R)}$ system, which migrated to an electronic format in 1998.

Features of AES$^{(R)}$

The AES$^{(R)}$ is one of NYP's earliest Knowledge Management systems and today a rich repository of project knowledge, accumulated experience and tacit knowledge gained from extensive industry project development. It systematically captures a wealth of intellectual capital, including unique design concepts and considerations; innovative approaches, project solutions, work practices and technology applications, and discussions on alternative solutions and trade-offs. This repository is shared with staff and students, who use the knowledge to solve real-life projects during their project phase, and in turn generate more project studies to the repository, as illustrated in the figure below:

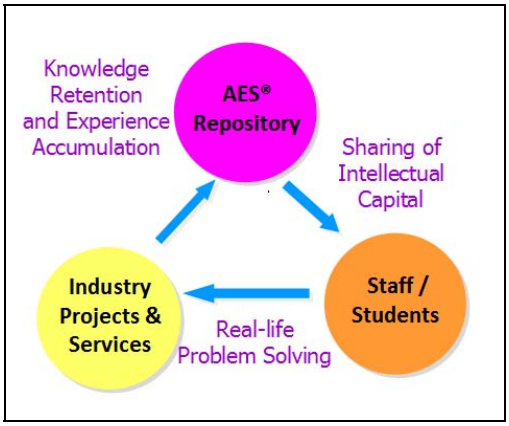

Figure 1: The AES$^{(R)}$ framework

The AES(R) comprises School-specific databases. The AES(R) system at the School of Engineering is divided into various portfolios, covering engineering domains such as Robotics and Automation Systems, Precision Engineering, Manufacturing Software Engineering, and Electronics.

Since migrating to the electronic format, key developments to the system included a search engine and securitisation.

The search engine with multiple search options facilitates retrieval of information. In terms of security, repository contents are classified into different security levels. Access is only for registered users, who have pre-approved security levels.

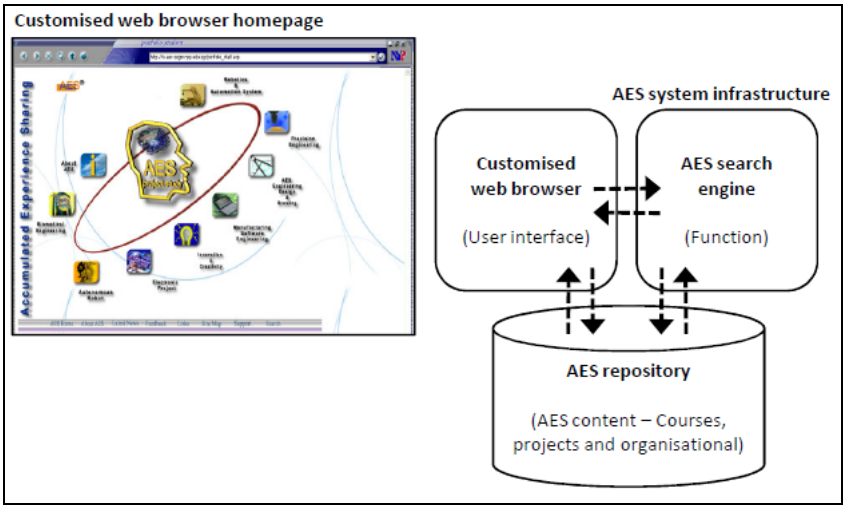

Figure 2: The AES(R) system

Access to the AES(R) knowledge base is on the campus intranet, via an NYP-developed customised browser. Approved project studies can be extracted and packaged for secured Internet access in NYP's e-learning Course Management System or for encrypted offline access in students' notebook computers.

A project in the engineering portfolio would typically contain the following sections:

- Background information
- Project summary
- Implemented solution
- Technical specifications and details
- Design considerations
- Audio/Video vignettes
- Engineering drawings, product models, designs, circuits, software codes
- Discussion topics
- Self-assessment questions and quizzes
- Teaching Studio

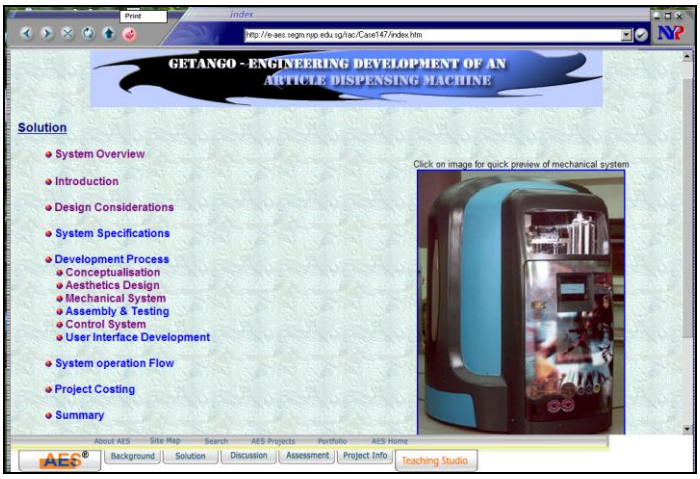

Figure 3: Screenshot from a Project Study

The explicit project knowledge is enhanced by a combination of appropriate media, such as text, graphics, images, schematic diagrams, engineering drawings, videos, and animations. Besides comprehensiveness and appropriateness to content, the use of multi-media generates interest, and also caters to different learning preferences.

In the Discussion section, key learning points and tacit information are distilled for experience sharing. In the Teaching Studio, aspects of the project study which are particularly relevant to specific modules of study are highlighted and elaborated on. Often, subject matter experts are involved to write up this section. A review of the relevant theoretical concepts, for example, is followed by an exposition of their application in the project concerned. Teaching staff can thus conveniently search the AES$^{(R)}$ repository, identify and select real-life industry applications to bring into and reinforce classroom theoretical instructions, or integrate into the e-learning materials, thus further infusing NYP's practice- and application-oriented pedagogy into the curriculum.

Key Implementation Issues

Over the years, the NYP has developed innovative solutions to several issues and challenges common to the implementation of knowledge management systems. Some of the key issues identified and successful addressed are stake-holder buy-in and usage, ensuring extensive use, and sustainability of content creation.

Buy-in and usage by staff and students

Driving the adoption of the AES$^{(R)}$ system by staff and students are the relevance and value of the accumulated project experiences and knowledge. For project students and staff, the AES$^{(R)}$ is a valuable resource for project research, shortening the learning curve and referencing industry best practices and technology applications. For teaching staff, it is a valuable teaching resource of real-life practical applications undertaken by students.

A second key strategy for user buy-in is the emphasis on convenience and efficiency at each stage of content creation and retrieval. Templates for the project studies, complete with guidelines and instructions for use, are provided. Users are also supported by training, and a helpdesk. Access is fast and efficient, with multiple search avenues. Teaching staff can request to extract a project study into a pdf file, which can then be embedded to support e-learning via a hyperlink through NYP's Course Management System used to support e-learning.

Ensuring extensive use

For FYP students and staff doing project work, the AES$^{(R)}$ is a useful resource for self-directed project research. In addition to that, as part of the formalised project-based learning, FYP students are required to review and discuss a specific number of project studies in the AES$^{(R)}$ system, before commencing on their project work. Some of the project studies may be selected by supervisors for

their particular relevance. All final year engineering students thus use the AES(R) knowledge base, and gain sufficient familiarity with it for their own project research phase.

For engineering students in non-FYP semesters, selected AES(R) project studies are made available in their e-learning modules via the Course Management System (CMS), or as off-line iBook contents in their notebook computers. Lecturers also show segments of AES(R) project studies to illustrate classroom sessions.

Sustainability

The AES(R) is a living and growing repository because of the pipeline of industry project work at NYP. In addition to their final print project reports, FYP students build on the knowledge base by submitting their project studies to the AES(R). The project study is started as e-documentation that forms their print report, with added sections that clarify tacit knowledge and other key learning points. Staff supervising the projects add on their perspectives or video summaries. The quality of AES(R) content is sustained through validation by a staff team before a project study is authorised for addition to the repository. Management support is strong. Because of the success of the AES(R), which has since extended to the sharing of accumulated organisational knowledge and experience in administrative, non-industry project areas, staff and students have a strong sense of ownership and pride in their FYP and respective AES(R) contributions.

Evidence of Success

Over the years, the AES(R) has grown to over 3,500 project studies in the engineering portfolio. It is well utilised for the purposes for which it was developed, as seen by the user statistics in the chart below:

Table 1: User Logins / Year for the Engineering Portfolio

Acad Year	2004	2005	2006	2007	2008	2009
Logins/Year	33370	35015	35743	34407	30245	28441

The slight decrease from 2007 corresponded to phasing in of the Student Notebook Ownership Scheme. As part of the scheme, the School of Engineering developed and introduced the iBookShelf, a software system that enabled students to download relevant e-resources as encrypted e-content residing in their own notebooks, to allow convenient anytime, anywhere access to course materials. Selected AES(R) project studies were extracted and embedded in the Course Management System or in the iBooks, making direct access even more convenient. As in Academic Year 2010/2011, for example, 106 project studies have been extracted from AES(R) at the School of Engineering (Manufacturing). They are embedded into 64 academic modules via the CMS and iBooks. Together with the formalised project study programme for FYP students, this means that all engineering students benefit from the accumulated project knowledge and experience in the AES(R).

Students rate the AES(R) favourably. In 2009, 90% of 404 current engineering students from opportunity samples agreed or strongly agreed with the statement that AES(R) materials were useful.

External organisations in Singapore as well as overseas have also visited NYP to find out more about the AES(R). They include government agencies, companies as well as institutions of higher learning.

In 2009, the AES(R) won the MIS ASIA IT Excellence Award in the Best Knowledge Management category.

Benefits

The AES(R) has thus fulfilled its objectives very well as a knowledge management system to capture, codify and share accumulated project experience and knowledge to meet the objectives of multiplying project experience and thus project-based learning for students. It is an integral part of knowledge sharing for engineering students, and for NYP's practice- and application-oriented training, which we believe has made a significant distinction in the quality and industry-readiness of our engineering

graduates. Its pervasive use gives students and staff ready exposure to real-life industry applications throughout their course of studies, and can be a powerful tool stimulating creativity and innovation.

The AES(R) has also fostered and institutionalised a culture of sharing of organisational experience and knowledge, across disciplines and departments.

Conclusion

As a user-friendly gateway to, and living-and-growing rich reservoir of, intellectual capital, best practices and invaluable experiences, the AES(R) system has multiplied NYP engineering students' exposure to project-based learning, and created a share-and-learn culture among students, academic staff and non-academic staff; boosted NYP's productivity, efficiency and capability; improved industry project delivery, benefitting industries; and raised students' industry-readiness, employability and market value.

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