Development of HAZOP Study Teaching Module

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ABSTRACT

This project involved the development of an animated software teaching package to teach a process safety technique to students.

Safety teaching involves significant amounts of materials, covering legislation and a series of guidelines and instructions for students / trainees. Therefore, while it is frequently considered an extremely important area of instruction, particularly for practising engineers and scientists, it is generally also considered a difficult area in which to stimulate interest and excite the students' minds.

The teaching module was designed to overcome these preconceptions. It was developed in three phases; each extending the original development of the package based on evaluations by peers and student users.

(i) Phase 1 – Development of HAZOP Study Teaching Module (12 months)
(ii) Phase 2 – Extension of the HAZOP Study Teaching Module (6 months)
(iii) Phase 3 – Adaptation of the HAZOP Study Module to include New Case Studies (3 months)

At each stage extensive testing and evaluation of the model was carried out and feedback information incorporated into the next phase of development.

Evaluations were undertaken locally as well as in Australia, France and the U. K.

Keywords

Animated safety module, project extension and modification, international evaluations

1.0 INTRODUCTION

This paper discusses the development of an animated teaching module to teach process safety. It is used in conjunction with a set of course notes, to enhance the quality of the students' teaching and learning experience. The process safety technique to be developed into the teaching module is called HAZOP. This is a key safety analysis technique used by

practicing chemical engineers and other engineering disciplines worldwide. Some background explanation is provided here through a set of "Questions and Answers" which introduce the new teaching module.

What Does HAZOP Mean?

The term is short for HAZARDS and OPERABILITY study. It is an analysis method to identify and minimize the hazards of a process AND/OR improve its effectiveness/efficiency. "Develops high quality technical expertise in safety engineering".

What is the Principle of a HAZOP Study?

The Hazard and Operability (HAZOP) Analysis technique is based on the principle that several experts with different backgrounds form a team to interact in a creative, systematic fashion and identify more problems when working together than when working separately and combining their results. Although the HAZOP Study technique was originally developed for evaluation of a new design or technology, it is applicable to almost all phases of a process's lifetime.
"Develops experience by working in a multi-disciplinary environment"
"Develops teamwork experience"
"Performing different roles within a team – Chairperson, Technical Secretary, Lead Engineer, Process Engineer, etc."

What Do You Do at a HAZOP Study Meeting?

The essential features of the HAZOP Study approach is to review process drawings and/or procedures in a series of meetings, during which a multi-disciplinary team uses a defined protocol to methodically evaluate the significance of deviations from the normal design intention.
"Performing well in meetings".

What is the Benefit of a HAZOP?

The primary advantage of the brainstorming associated with the HAZOP Study is that it simulates creativity and generates new ideas. This creativity results from the interaction of a team with diverse backgrounds. Consequently, the success of the study requires that all participants freely express their views and good supportive teamwork practices are adopted. This creative approach combined with the use of a systematic protocol for examining hazardous situations helps improve the thoroughness of the study.
"Develops creativity, innovative thinking".
"Develops communications ability – oral and written, body language".

2.0 BACKGROUND

The motivating driving forces used to develop this teaching module were based on widely adopted techniques via a series of lectures and a practical application in the students' Final Year Project.

Due to its complexity and time-consuming nature, many universities merely give HAZOP a

passing introduction. However, in the process engineers outside world, HAZOP is the main safety weapon and it is a key tool used throughout process industries worldwide.

Challenges when running the HAZOP exercise in the existing course are:

- student difficulties in using all the information they have acquired and adapting to this qualitative assessment
- somewhat heavy and dry theory within the HAZOP lectures
- time-consuming study; final year students may miss some key sessions due to job hunting
- the absence of an absolute answer to HAZOP, which results in difficulties and time spent by faculty developing numerous alternatives
- There is often no absolutely correct answer to a HAZOP – there are a number of potentially correct solutions as well as many incorrect ones (a concept that students often have difficulty with). We proposed developing these in an interactive manner – using dynamic simulation and computer graphics to demonstrate HAZOP visually

To solve these problems, this project developed a new, animated HAZOP software kit tailored to undergraduate teaching. Through this, students can work in a multi-disciplinary team in a simulated work context. It also encourages their communication, systematic thinking and problem-solving skills.

3.0 PROJECT OBJECTIVES AND PLANNED OUTCOMES

3.1 Project Objectives

Based on the range of teaching and learning issues outlined in the previous section, the development of a HAZOP Study Teaching Module represented a difficult and challenging task. But taking into account the requirement to integrate this wide range of issues, the module is designed to offer an enlightening and uplifting experience for the students. The key objectives to be addressed and incorporated in the Teaching Development project were:

1. Role play experience – Chairperson, Technical Secretary, etc.
2. Performing well in Meetings and Communications – two way, verbal, written
3. Working in a team
4. Multi-disciplinary activity
5. Working in a real world “Design Office” environment
6. Systematic thinking, problem solving skills and analysis
7. Very wide-ranging knowledge base applications
8. Evaluation and reflection assessments for the HAZOP Teaching Module

3.2 Planned Outcomes

Major outcomes and deliverables (Phase 1):

1. Develop course materials
2. Develop animated HAZOP software package
3. Application testing of HAZOP module to 61 students in CENG303
4. Prepare and implement evaluation and usefulness reports
5. Analysis of item four to assess effectiveness of enhanced teaching and learning

4.0 PROJECT MANAGEMENT

4.1 Development of Plan of Actions

A plan of actions was developed in order to address how these Teaching and Learning issues would be incorporated into the teaching module and then implemented.

1. Guidelines on role tasks are included.
2. Guidelines on "performing well in meetings" are included.
3. Team selection and good team characteristics are presented in the course module.
4. Participants from other subject disciplines are invited to HAZOP meetings to make them multi-disciplinary.
5. Time schedules and constraints are re-imposed to achieve targets and deadlines typical of Design Office pressure.
6. Examples are provided in the module to direct students to think independently, systematically, and to solve problems.
7. Development of a specialist animated graphics unit within the teaching module to provide case study examples. This integrated the many course facets the students need to apply to appreciate HAZOP Study Analysis.
8. Evaluation and reflection assessment processes were carried out by holding a series of meetings with students taking the HAZOP Teaching Module.

4.2 Development of Project Implementation

This Teaching Module was developed jointly by two teams from Chemical Engineering and CELT. It was important that they developed a detailed list of assigned tasks and a schedule at the project planning stage. This was carried out and the programme of activities to deliver the full HAZOP Teaching module was established, with regular scheduled progress review meetings.

Particular emphasis was placed on the activities which interfaced between the two project groups. This particular area involved the development of the key animated case studies. A section of the project management timeline is shown in Table 1.

Table 1 Project Timeline and Major Milestones (Phase 1)

Period	Milestones
Weeks 1 – 2	Detailed definition of scope of all project components (2 weeks) – **CENG**
Weeks 3 – 10	Development of course materials in note and presentation format – including HAZOP study method schematics (8 weeks) – **CENG**
Weeks 11 – 22	Interactive 2 or 3 demo case studies (12 weeks) – **CELT** Flow Chart of HAZOP Study Method Animated HAZOP Examples HAZOP Study Minutes Sheet
Weeks 11 – 18	Develop Case Study Example - **CENG**: Process Description [PD] (1 week). Technical Specifications (3 weeks). Process Flow Diagrams [PFD] (2 weeks). Solution (2 weeks).

5.0 IMPLEMENTATION METHODOLOGY

The implementation methodology was carried out in accordance with the project schedules developed as represented in Table 1. As both teams agreed they worked well, project management procedures were basically the same for each of the three phases.

The development methodology of the HAZOP Study Teaching Module for each phase will be briefly discussed.

- **Phase 1: To Develop a HAZOP Study Teaching Module**

  This first phase focused on the content and development of the HAZOP Safety Study module. What would make it different from a "stand-up, front of class" delivery and what should we introduce to make the student "want" to go on himself/herself?

  Coordinating, planning and exchanging ideas between the CENG team and the CELT team were important issues. Understanding the strengths and problems of each group was also important.

  We decided to design the module based on
  (i) a "good guy" versus "bad guy concept" (Figures 1 and 2)
  (ii) a series of questions and answer prompts for the students to make a selection; for example:
  What are the causes of NO FLOW in the pipeline?
  What are the consequences of a valve being closed?
  (iii) incorporation of some humour

Figure 1 A bad guy in the HAZOP Study Teaching Module

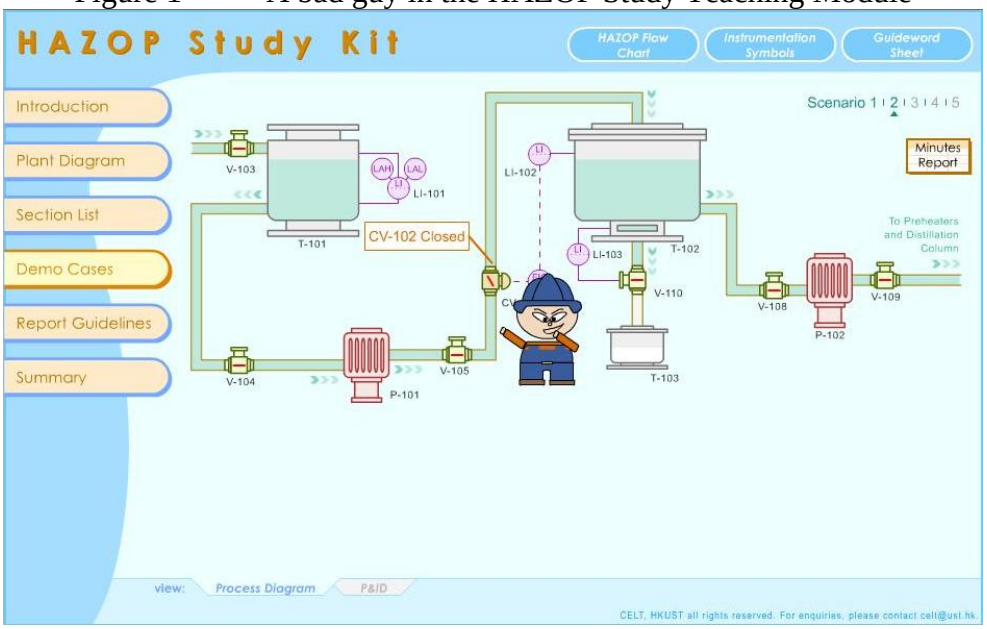
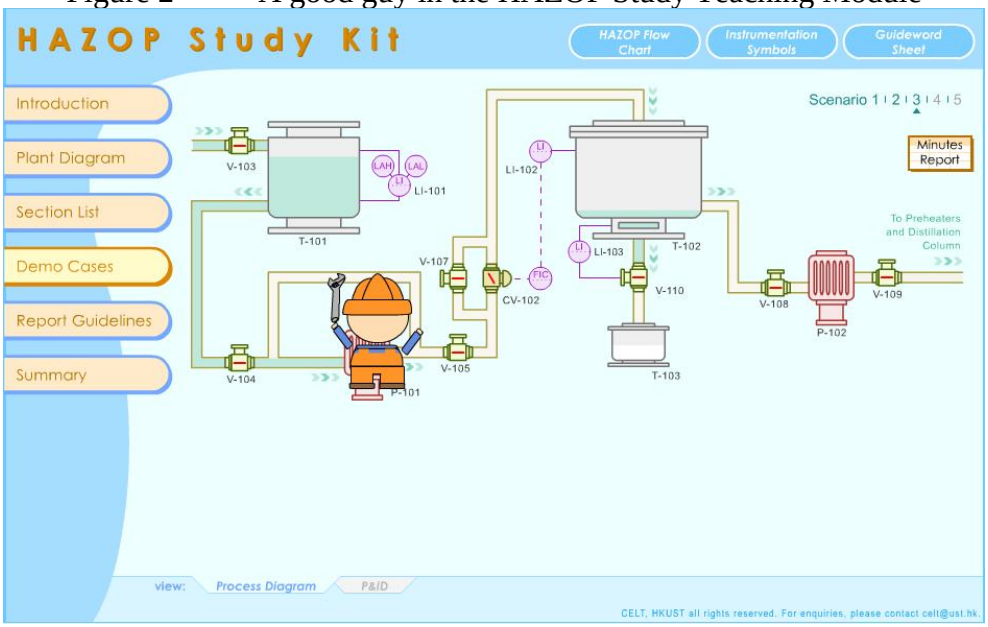


Figure 2 A good guy in the HAZOP Study Teaching Module



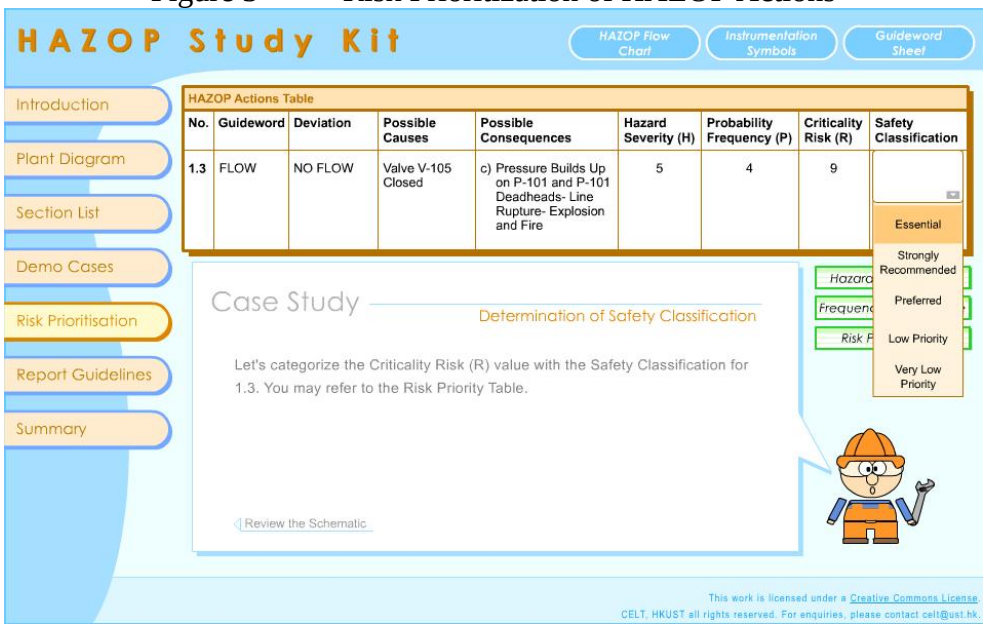
A number of links were developed in the module: e.g.

(i) to process flow diagrams
(ii) to offer technical assistance on guidewords
(iii) to produce a self-generating Technical HAZOP report

- **Phase 2: Extension of HAZOP Study Animated Module to Incorporate Prioritization of HAZOP Study Actions**

After completion of Phase 1, a number of evaluations were carried out and feedback was obtained from student users and at peer level from teachers and industrialists. Details of this will be discussed later. The results of the evaluations resulted in our proposal for an extension award of the original project to incorporate a methodology for prioritizing the HAZOP Actions, as shown in Figure 3.

Figure 3 Risk Prioritization of HAZOP Actions



- **Phase 3: Sub-project. Adaptation of HAZOP Study Module to include New Case Studies**

  The third phase of development of this teaching module began with a review of evaluations from both the first and second phases. Only one comment occurred frequently and far outweighed any other issues. This was a request for other case studies in safety areas different from the ones currently in the module.

  This was incorporated into this phase of the project.

6.0 EVALUATION PROCESSES AND ACTIONS

Several reviews/surveys were carried out to monitor progress in developing the teaching module and also on the effectiveness of the module itself. The procedures for review were similar for each of the three phases although the objectives varied according to the phase and also the stage of the phase. The methods used are discussed.

6.1 Progress Review Meetings/Reports

On average the teams met once per month to review progress. This frequency decreased during long tasks, e.g. the development of the script by the chemical engineering department.

It increased during the more interdependent activities, e.g. the development of the animated case studies jointly by both CELT and CENG

6.2 Collect Data to Assess the Effectiveness of Planned Actions and Outcomes

CELT led the development of a range of comprehensive survey/questionnaire forms to assess the effectiveness of many aspects of the project over a three-year period including:

(i) Department of Chemical Engineering, HKUST
- Special Subject Group, Process Design
- Curriculum Committee
- TLQPR Committee

(ii) Survey Questionnaire for Students to Complete
- Small Student Group for initial appraisal (5-8 students)
- Final Year Course Component in CENG303, HKUST (60 students)
- Final Year Design Groups in Department of Chemical Engineering, University of Sydney (9 students)
- Final Year Design Groups in Department of Chemical Engineering, Queen's University of Belfast, Ireland (12 students)
- MSc in Project Management, Multi-Disciplinary, Ecoles des Mines de Nantes, France (12-18 students)

(iii) Survey Questionnaire for Industrialists to Complete (6 industrialists)

(iv) Survey Questionnaire for Peers to Complete (4 peers)
(2 HKUST, 1 University of Sydney, 1 Queen's University of Belfast)

(v) Feedback from HKIE Professional Accreditation

This series of surveys provided feedback for analysis and action on many areas in the development of the teaching module.

For example, the small student group provided wide-ranging feedback on the first prototype model. The group comprised non-chemical engineering students, chemical engineering students who had not taken any HAZOP course and chemical engineering students who had completed the HAZOP course. The feedback included comments on:

visualization and colour	
user friendliness	– making it go back as well as forward
	– provide easier access to prompts
accessing data sources	– more apparent labeling
comprehension	
technical feedback	– more model scenarios
	– no quantitative data provided; something could be included

These last two points led to the implementation of Phases 2 and 3 of the project.

6.3 Close Out Interview

At the end of the project a major close-out interview was held to assess the effectiveness of all its aspects, for example:

- enhanced learning
- quality of outcomes
- teamwork between CELT and CENG

7.0 CONCLUSIONS

I simply state TWO points from the close-out report:

- At the end of the first phase, which dealt with the major development of the project, there were several things of which the chemical engineering team members were unaware in terms of liaising and management and also from the CELT side. As the project developed in the first phase, we had a good team relationship and we solved the problems fairly quickly. Phases two and three ran very smoothly and were carried out very effectively. Taking this into account, I can't think of anything we could do better in the last two phases.

- The evaluations provided by CELT were very comprehensive. This is where we got the information needed to develop stage two and stage three. We also incorporated the case study through the results of the evaluation. We actually did four evaluations in the first four phases, with an even wider range of people, from my final year class, an MSc class in France, the chemical engineering department in Queen's University, Belfast, and in collaboration with the chemical engineering department at the University of Sydney. The first two had intensive evaluations, resulting in very wide feedback. The last phase, which includes the addition of the case study, was then undertaken by the groups already mentioned. The last two evaluations were very, very good.