Speclad: an Online Collaborative Problem-Based Learning Environment

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***Abstract**: This paper describes an online collaborative learning environment – Speclad – for problem and peer based learning. Speclad was originally developed as a platform to support student learning when constructing object-oriented class diagrams in software engineering and information system development. A number of enhancements have recently been introduced, which extends the functionality of the Speclad environment, including: the use of diagram annotations and a collaborative web space. Here, we discuss the motivations for developing the environment, key aspects considered during the design stage before presenting an overview of the system in action. The generic features of the Speclad environment are transferable for many modelling and design tasks encountered by undergraduate engineering students.*

Introduction

In many undergraduate engineering subjects, students encounter modelling and design problems with alternative valid solutions. Typically, the students are asked to "sketch" a possible solution, which is then evaluated in terms of accuracy and effectiveness using a variety of contextual factors. For example, when students are introduced to the object-oriented paradigm in software engineering and information systems development, they are frequently required to model a scenario based on a short narrative. In an instructor led environment, the student's class diagrams (models of the scenario) may be collected and annotated. In some circumstances, alternative student solutions may be distributed to other students for comments.

As students encounter modelling and design problems, it is beneficial to have access to a range of similar problems (both style and complexity) and alternative solutions (Enkenberg, 2001). Learning by examples is a significant component of this discipline (Kirschner, Sweller, & Clark, 2006).

The ability to share solutions and seek feedback on preliminary drafts is obviously beneficial for teaching and learning outcomes. Each of the independent solutions generated by a student for a given problem provides a useful starting point for discussions. However, providing an effective means of distributing the alternative solutions and collecting feedback on draft diagrams has many inherent challenges.

In this paper, we describe a collaborative learning environment – Speclad – which was designed to address these challenges. Speclad is an online environment where a large community of users can discover, post, discuss, review and collaborate when working on various problems and solution sets. In the following section, we briefly describe the first phase of the Speclad project (originally reported in Balbo et al 2007). This is followed by a detailed discussion of key design principles/critical success factors associated with the development of the environment. We then provide a description of generic nature of the Speclad environment and the enhancements recently introduced. Finally, an overview of future development work is provided.

The Speclab environment

In the first phase of the development of the Speclad environment, two components were implemented: (1) a software tool in the form of an Eclipse plugin (see http://www.eclipse.org/), which guided a student through the numerous steps of designing a class diagram, and (2) a collaborative web space (http://speclad.org). The collaborative web space provided the means for students to share their draft class diagrams (solutions to the modelling problem). A detailed description of this phase of the project can be found in Balbo et al. (2007).

Much of the development effort in the first phase of the project was focussed on the generation of class diagrams. That is, our primary goal was to develop a suitable interface for students to navigate their way through a problem specification, with the key outcome being a unified modelling language (UML) class diagram. Students were then able to upload their class diagrams for other students to comment on via a forum.

In the second phase of the Speclad project (the focus of this paper), we present an important enhancement – the extension of the web space. Here, our goal was to provide an easy to use web space where class diagrams posted by students could be annotated and appropriate feedback collected. Important underlying principles embraced in the design of the Speclad web space were to support critical thinking and problem solving; to support the learners and to embrace the learning process. As mentioned in Balbo et al (2007):

"*Metacognition is central to the notion of learner self-management, consisting of two principal components: self-monitoring and self-regulation. These components are critical determinants for effective learning, decision-making and problem solving* (Nelson & Narens, 1994)".

Subsequently, we have attempted to implement generic components to support metacognition, following Hartman's belief that metacognition is embracing instructional design:

"*Metacognition is especially important because it affects acquisition, comprehension, retention, and application of what is learned, in addition to affecting learning efficiency, critical thinking, and problem solving. Metacognitive awareness enables control or self-regulation over thinking and learning processes and products."* (Hartman, 1998, p. 1)

Using Speclad

This subsection briefly describes the collaborative web space based on a case study using a software UML-Class diagram. As identified above, a user (either a student, an instructor or an expert) will publish a textual problem description which will be categorised by it's discipline area. An example of a posted problem is shown in figure 1. Once the problem is published, users can view the problem and submit solutions containing textual and diagrammatic components (see figure 2). The posting of solutions and problem descriptions is done via a web form and does not require any HTML or advanced technical knowledge (see figure 3).

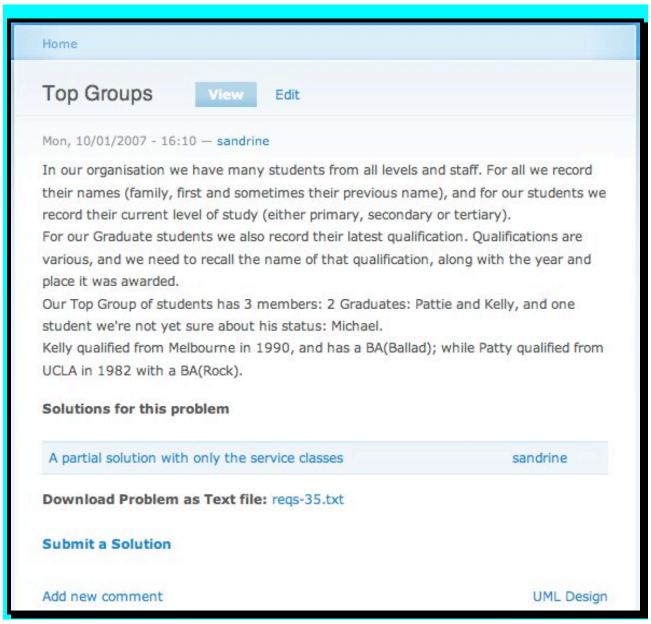

Figure 1: A posted problem.

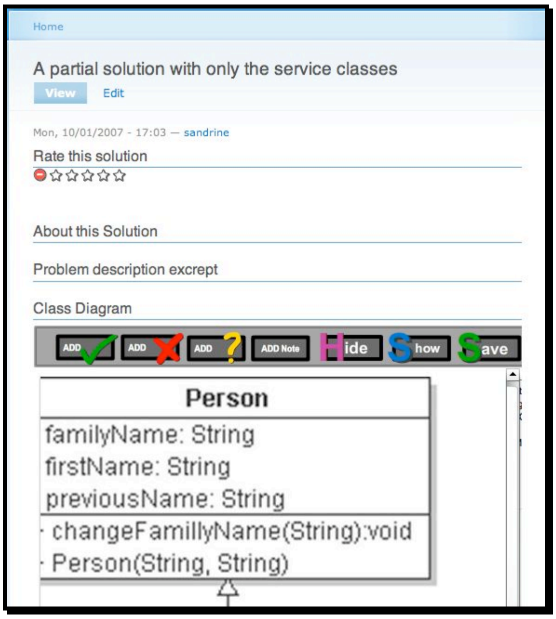

Figure 2: A posted solution.

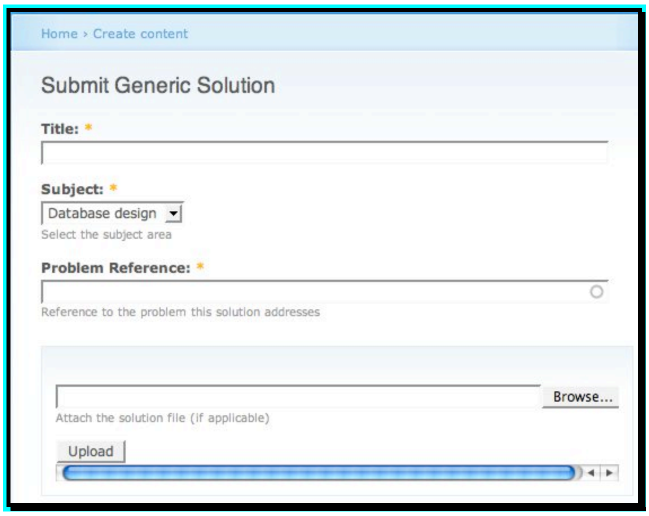

Figure 3: Posting a solution.

Once a solution is posted, other users can access the solutions via the problem description page or by browsing solutions for a given discipline area. Users are able to rate the quality of solution. Users can also initiate and participate in discussions around particular solutions. Additionally, users can annotate solution diagrams by placing markers such as ticks, crosses or question marks along with word balloons for organising discussion threads (see figure 4). The aim of using the graphical annotation tool is to make the environment as intuitive and easy to use as possible.

It should be noted that the Speclad environment is not geared to be used as an assessment tool and therefore considerations that relate to plagiarism have not been addressed.

Discussion

The current version of Speclad is based on the combination of (a) the development of UML class diagrams, and (b) the web space. However, there is scope to change the underlying modelling technique built into the collaborative learning environment. For example, instead of developing UML class diagrams, electrical circuits or systems biology models could be used. Consequently, we now discuss the generic features of collaborative learning environments.

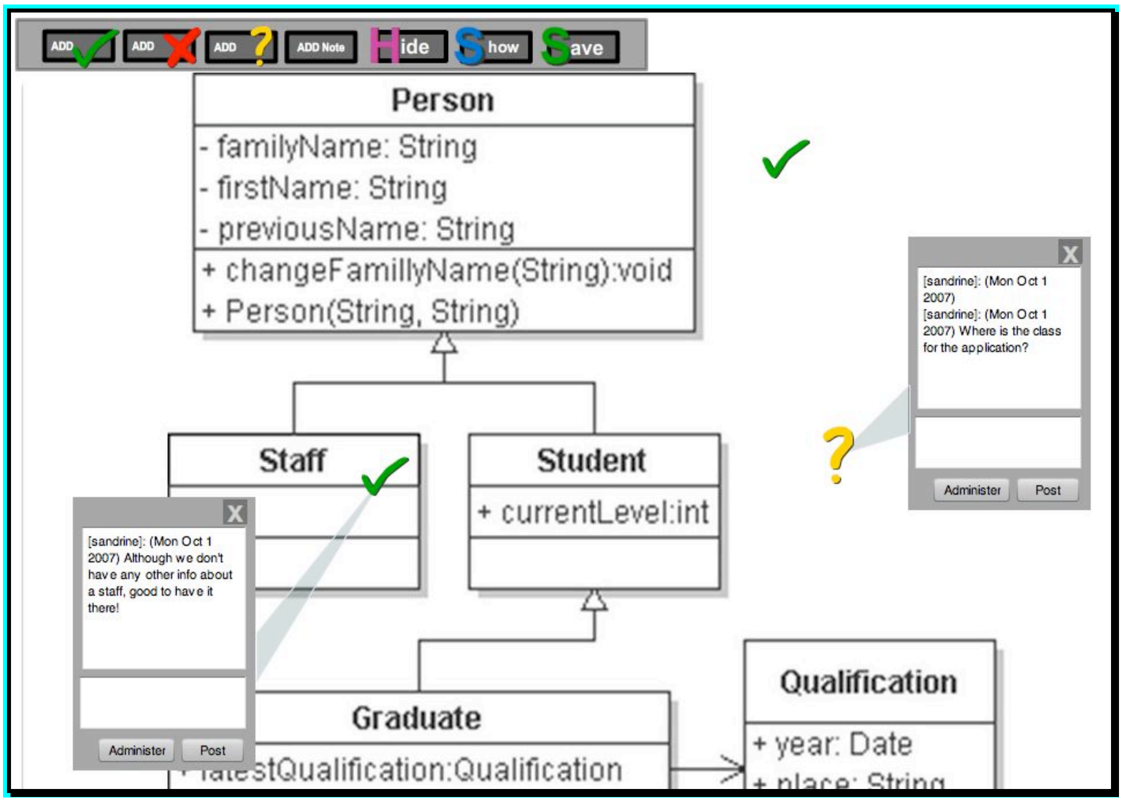

Figure 4: Annotating a solution's diagram.

A range of critical success factors must be considered when designing and developing collaborative online learning environments. Key factors include:

- Can a community of learners be expected to mediate among themselves and choose the correct solutions from alternative (possibly incorrect) approaches?
- Most design models have diagrammatic components. How can an online environment mimic effective collaborative practices used offline with physical pens, paper and whiteboards?
- How can the environment itself drive user adoption? How can we ensure it is useful for the average learner?
- How can users discover relevant problems and solutions?

Each of these critical success factors has played an important role in the design and development of the Speclad environment. We now address these factors in further detail.

Ensuring correct solutions are identified by the learning community

The collaborative learning environment will be driven by independent learner contributions. Thus, a large portion of the available solutions (alternative models/class diagrams) will be "learner generated". To ensure the usefulness of the environment, one must ensure that learners can easily identify correct/accurate solutions from a plethora of solutions with varying degrees of accuracies.

In a classroom environment, this can be addressed by an instructor selecting the correct solutions. Similarly, the environment can have moderators endorsing and reviewing solutions that have been submitted by users. However, as the number of users contributing grows, the effort to moderate the community will grow as well. Given this issue, a sustainable method for identifying correct solutions with low overheads was sought and a user rating scheme presented itself as the answer. A user driven rating method will allow individual learners to rate other's solutions and browse solutions as endorsed by their ratings (see figure 2 as an example).

Creating a collaborative environment for diagram based solutions

Capturing and recording user feedback is a critical part of the environment (Bransford, 1990). A user must be able to comment on various aspects of the solution with other users. Given the fact that the class of problems considered here have textual and pictorial/diagrammatic components in their solutions, it is critical that one can comment on individual parts of the solution effectively. Popular existing technologies such as discussion forums and wiki's allow this, but are typically limited to a textual form. When considering diagrammatic or pictorial solutions, one can rarely find good technology matches. Typically, feedback on such a solution is best provided on the diagram itself, mostly with tick marks, highlights, crosses and written comments as it would be done in a physical setting. In the Speclad environment, a user can naturally comment and provide feedback on the diagram itself with comments and discussion threads (as shown in figure 4). This is also useful in providing instructor/expert feedback similar to assessing a physical paper version of a solution diagram.

Ensuring user adoption

Ensuring usefulness of the system is a priority as it will be a primary driver of adoption for the system. The collaborative web space's usefulness for a given user is dependent upon the amount of relevant content available and the number of users using it (Davis, 1993). The usefulness of the system increases for all users as the number of users of the system increases (Markus, 1987). This ensures that more content is created and more useful discussions take place within the environment. While the above was derived from Markus's Critical Mass theory for interactive media, we recognise that when applying it to Speclad, we need to consider the two types of users in the system. A balance of learners and experts is critical to ensure a high degree of utility from the system. Therefore, sufficient attractors must be in place for both categories of users in the web space.

Given that the system needs to reach a critical mass of content with a sufficient number of users to drive user adoption and acceptance, we believe it is possible for us to bootstrap the system by using it as a learning aid in classroom environments. Therefore, for a given discipline, a number of courses would adopt the system and post problems and solutions to enable better interaction and participation among the learners of the course themselves. While the learners of the course will find it useful in their local context, it will also add to the amount of available content and active users of the system globally driving the system towards the aforementioned critical mass of content and users. Additionally, this will also ensure a sufficient number of experts or advanced learners are within the system given the involvement of instructors and learners who have completed their courses.

Enabling discovery of relevant problems and solutions

As the number of problems and solutions in the system grows, learners using the environment will face the issue of information overload, possibly decreasing the overall usefulness of the environment. To tackle this issue, effective search and browsing methods must be considered when designing the environment.

A two-tiered approach was adopted to improve the quality of the search and discovery of content within the Speclad environment. Initially the contributor is required to classify the problem/solution based on a predefined discipline/subject-area taxonomy. Visitors of the content pages are invited to 'tag' a given solution or problem with useful contextual information. These efforts build up the meta-data available for effective searching of content. The user rating scheme also contributes in this aspect by informing learners of 'usefulness' of the content. In addition to search functions, the environment needs to have mechanisms to browse problems and solutions by problem type, number of solutions, age and rating of solution.

Conclusion and Further Speclad enhancements

In this paper, we have described a web-based collaborative problem based learning environment that was developed at the University of Melbourne. The basis for its design and its functionality was briefly discussed. It is our hope that this tool will be widely adopted by the learners and be perceived as a repository of knowledge in its associated disciplines and as a destination for a fulfilling peer assisted learning experience (Topping, 2001). We have a long list of potential enhancements to the current system. To conclude this paper, we now discuss briefly enhancements that were not presented in our first paper (Balbo *et al*, 2007).

First of all, to avoid the possibility of the entire community of learners being misguided in their ratings, an instructor/expert ratings method needs also to be integrated into the environment. Therefore, a given solution would have an expert rating as well as a learner rating making sure that learners are able to discover correct/accurate or interesting solutions easily.

Additionally, while the system provides an effective way to discuss alternate solutions for a given problem, the learning experience can be greatly improved by allowing learners to compare and contrast multiple solutions from a single view (Fuchs, Fuchs, Mathes, & Simmons, 1997). This has been identified as the next step of this project and we understand that this is the most ambitious aim yet. Such a comparison feature will require codification of problems and solutions so that individual parts of the solutions are comparable. Additionally the comparative interface of the diagrammatic annotation tool will have to take into consideration that it will be very difficult to compare a diagram in terms of sub-units. Yet, to be useful one needs to compare specific sections of a diagram with another, and parameters for these comparisons will be learner driven rather than being pre-defined.

Finally, the utility and adoption rate of the system may be greatly increased if it is integrated with existing course management systems such as Moodle (Moodle 2007) or Blackboard (Blackboard 2007). With such integration, the registered participants of the course will be able to collaborate with their direct peers, enabling them to share common language, interpretations and understandings which apply to their own sub-community which will inevitably increase the familiarity and ease of use in the system for these groups. This avenue will be explored in greater depth in the future by the research team.

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