Wiki-based Collaborative Learning: Incorporating Self-Assessment Tasks

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ABSTRACT

When assigning technological articles as the collaborative writing task, students may find that the available knowledge repositories leave little room for them to contribute and therefore write nothing. To provide guidelines for students to discover topics, as well as tools to practice problem solving skills, we integrated a computer assisted assessment module into the Mediawiki and employ self-tests as the collaborative tasks. In these task, item models are used to automatically generate test questions. The items deriving from a same model share a common structure; however, the randomly initialized parameters of the model make them differ from each other. These differences result in that the answers of an item are usually inapplicable to other items deriving from the same model. Therefore, examinees have to solve these generated items on a case by case basis. Further, how to solve questions deriving from certain models can be served as the topics about which students write articles.

The wiki self-assessment system was used in a course on Computer Networks offered to junior students majored in computer science. Five self-test tasks were assigned to 98 students, and they were encouraged to write wiki pages to explain their solution methods. Evidence from this preliminary application indicates that the presented approach has a positive effect on learning outcomes.

Categories and Subject Descriptors

K.3.1 [**Computer Uses in Education**]: Collaborative learning; K.3.2 [**Computers and Education**]: Computer and Information Science Education

General Terms

Design, Experimentation, Human Factors,

Keywords

Wiki-based collaborative learning, computer assisted assessment, formative assessment, item model

1. INTRODUCTION

Recently, wikis have been widely used in the realm of education, and serve as a medium for collaborative learning. In a scenario of wiki-based collaboration, students are divided into groups and assigned tasks. Outcomes of these tasks are usually represented by series of articles. These articles chronicle the progress made by students and enable them to reflect upon their learning process, which leads to reflective learning[21]. When contributing to an article, students must read related materials carefully and therefore yield high achievement[13]. Further, knowledge acquired through a collaborative learning process will be retained for a long term[17]. These benefits encourage more and more educators to adopt wiki-based collaboration.

Researches on Computer Supported Collaborative Learning (CSCL) indicate that to form validate learning, there must be measures to coordinate learners, for example, to group students, assign roles, and divide learning process into several phases[8]. Wiki-based collaboration is not an exception. It depends on instructors to moderate the activities of students to reach an effective learning process[5, 19]. Our early experiences on using wiki show that without explicitly stated directions, the outcomes of the collaborative free writing could be trivial. When we initially assigned the grouped students to write any related topics about the course, a fatal problem was that most students wrote nothing. Our interviews with the students reveal two major reasons that cause this problem.

- The first is that it is almost impossible for most of the students to add new ideas to the available knowledge repositories. Some students had search the Internet to collect information about certain topics. After reading these materials, they believed that there is no room for them to write – the collected materials perfectly explain all aspects of the subjects. And students consider rewriting or listing URLs is a trivial task.

- The second is related to time allocation. Most of the students knew little about the course at the beginning of the semester, and had no idea what to write. It was nearly the end of the semester when they were able to write something. Because they were busy to prepare final exams, they just omitted the optional writing assignments.

These experiences suggest that if educators adopt collaborative writing as a supplement to lecturing, motivating students and orienting objectives are vital to the success. To raise achievement standards – one of our main purposes to use the wiki-based collaborative learning, formative assessment is an essential ingredient[2]. The literature provides evidence that computer gradable self-assessment can motivate students and improve their academic achievements[24]. Inspired by the reported projects, we integrated a self-test module into the Mediawiki and assign self-assessment tasks to students. Passing self-test is the direct objective, and writing articles to explain how to resolve test questions is the side product.

However, there raises a problem that students may lose their will to independently solve an item due to the answers posted by someone else who has solved it ahead. Hence, the value of a good item will be significantly decreased as the number of student increases. This problem can be solved by item model – technologies used to automatically produce items[1]. Item model has several useful features particularly suitable for formative assessment in CSCL environments. For example, a vast amount of items can be derived from an model via mutating its parameters. These items share a similar structure; however, the randomly initialized parameters make them differ from each other. The benefit of these properties for formative assessment in wikis is twofold:

- The answers of a previously solved instance of a model are usually inapplicable to any other instance. Examinees must solve each item on a case by case basis.
- A model can be designed to cover a comprehensive subject, which makes itself a good topic for students to discuss.

Therefore, this kind of self-test can be used as collaborative task without out worry about the exposure of item.

We used this system in a course on Computer Networks offered to junior students majored in computer science. Five optional self-assessment tasks were assigned to 98 students, and they were encouraged to exchange their solution methods. The analysis of the data collected from logs and final grades reveals that the presented approach improved the students' academic achievements.

The rest of this paper is organized as follows. Section 2 is devoted to related work, including educational wiki-based collaboration, automatic item generation, and computer gradable formative assessment. Section 3 describes the architecture of the wiki self-assessment system and its implementation issues. Facts found in our practical use of the system are presented in section 4. We close this paper with a conclusion.

2. RELATED WORK

Researchers seem to agree that collaboration can foster learning[6]. There are different explanations on why it is happening. Cognitive constructivists believe collaborative learning encourages a student to read learning materials critically and make them understandable to others, which makes both peers yield high achievement. Social constructivists credit these benefits to the process in which students construct a shared understanding of a given topic[18]. To prove that learning and knowledge construction really happen, collecting quantitative data – for example, the number of articles written by students – is insufficient. Instructors must read the transcripts thoroughly to assess the quality of learning. This process is called content analysis[6].

2.1 Wiki-based collaborative learning

Mediawiki has many useful features which make it a popular platform to support collaborative learning, for example, its usabilities [5] and the discussion page[19]. Here we would like to highlight the features facilitate content analysis.

- Comparing the differences between two versions of an article. This function can provide a clear view of the progress made by students. Students and instructors can find a track by which the article reaches its final state. This information can be used by students to reflect on their works, and to improve their learning performance in the future. Instructors can use it to identify evidences to support that learning and knowledge construction do happen. Other kinds of social software packages rarely provide such a powerful tool.
- Section and section editing. Granularity affects the accuracy of content analysis [6]. The unit of analysis can be a meaningful phrase, a sentence, a paragraph, or an article. Wikis make it easy to organize an article into sections and subsections, which may prompt students to cluster ideas into sections. Therefore, well-organized articles are expected[11]. Finding meaningful segments in a well organized article is much easier. Further, this feature can be used by instructors to make frameworks for students to fill with materials, and leads to sophisticated scripted collaboration.

Currently, collaborative writing is the most common application of educational use of wikis[21]. Tasks can be composition[10, 11, 14], storytelling[7], and authoring subject entries of encyclopedias[3, 19]. During learning processes, peer interaction can motivate participants, and finally co-construct a shared knowledge base. These settings are reported to be able to form effective collaborative learning processes. Further, being aware of the fact that articles can be read by the public, students may read critically and write responsibly[13].

Wikis can also serve as a log for group members to record their project progress, share and reuse experiences, and support self-reflection activities[22, 27]. WikiTrails[23] suggests a conceptual collaboration schema – share and reuse browse tracks. A track connects multiple articles, and these articles are usually on a specific topic. Therefore, these tracks may be served as a guide for novices to browse certain topics.

The main purpose of our application of wiki-based collaboration is similar to [5]. However, we use formative assessment as the assignments. Mediawiki provides an extension interface which makes it easy to develop and install an assessment module in it. The integrated Mediawiki enables students to practice their problem solving abilities and share their experiences. There is already a quiz extension provided by the Mediawiki, it uses a wiki-genre to express a question[9]. However, manually authored quizzes are inapplicable in our situation – we lack the resources to construct a large item bank. More over, after a student answers a fantastic question and posts his or her solution, the question becomes trivial for those students who have seen the answers.

2.2 Automatic Item Generation

Automatic item generation can be applied both in formative and summative assessment. To automatically generate items, machine needs a model – explicitly stated or embedded in programs. An item model usually consists of a paragraph to describe a subject, several parameters, and some type of restrictions on these parameters. Part of parameters will be randomly initialized by a model compiler, and their values will be filled in the paragraph. Other parameters describe the expectations of the model – difficulty and discrimination. Therefore, there are differences between instances of a model; however, all instances share the same difficulty and discrimination. Further, item response theory can be used to quickly and accurately evaluate examinees' knowledge levels[1].

Researches have shown that computer generated questions can both ease the burden of instructors and motivate learners. However, most of these cases do not emphasis on using explicit models. CAPA uses templates to produce physics problems as personalized assignments for students. Via permuting the labels of the templates, a problem can be mutated into multiple versions[16]. OASIS is an on-line self-assessment system for teaching electronic circuits. It has a large question database and each question has 200-300 numeric variations. Hence, students can try a problem many times until they are satisfied with their skills[24]. QuizPACK is developed for computer languages learning. An instructor can submit programs with several mutable parameters, and students are required to calculate the result of the program whose parameters are randomly initialized[4]

Our work shares the idea of providing parameterized questions for students to practice. Because each item produced by a model is somewhat different, students must do some calculations to get answers. This feature enables personalized assignments. The significance of our work is that we provide the infrastructure and encourage students to share their solutions. This arrangement can motivate advanced students to explore several possible solutions to a model, as well as provide valuable hints for other students to solve problems.

3. ARCHITECTURE OF THE WIKI SELF-ASSESSMENT SYSTEM

As depicted in Figure 1, the wiki assessment extension calls the item generation engine to retrieve items, and then renders them for examinees.

3.1 The Item Generation Engine

We use XML format to store item models. Each item model has a section declaring parameters, a question body represented by text mixed with parameter references, and options. The value of a parameter can be any reasonable string, for example, an integer in string form. For each type of parameter, certain restrictions can be applied. Currently the engine supports two types of items, multiple choice and match maker questions, the options of the models are also represented by text mixed with parameter references.

Figure 2 depicts the model cs-bigc-edu-cn-1181891839667 in a compact format, it is about the bandwidth utilization of the sliding windows protocol [25]. The parameters *win*, *frame*, *overhead*, *delay*, and *bpsi* will be randomly initialized for each instance of the model, so that *paramRef*s, formulas referencing them will be changed accordingly. At the same time, the labels of choices will be permuted. These measures make it almost impossible to copy answers from one instance to another driving from the same model. Therefore, a task consists of a common set of models can be assigned to a group of students, and they can discuss their solutions. It is worth to note that the items derived from a same model can be non-isomorphic, however, this property has positive effect in our applications. We will discuss it later in section 4.

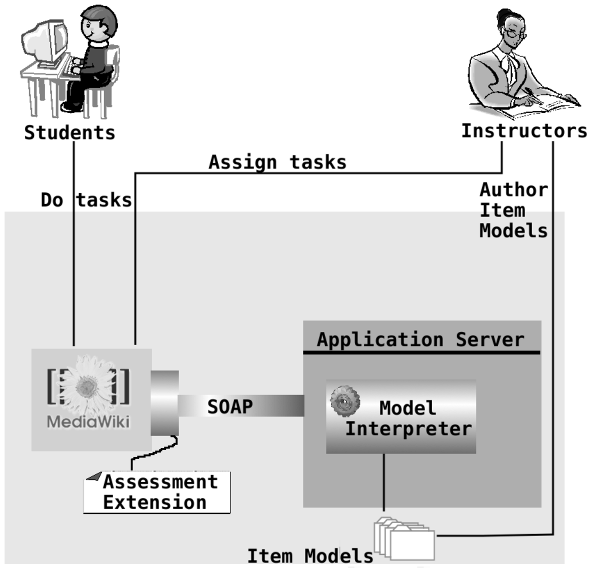

Figure 1: Architecture of the Wiki Assessment System

The model interpreter and other supplement components are deployed in a Java application server, and the server exports item related functions as web services. When an item request arrives, the model interpreter will find the required model and parse it to produce an item. The elements in these models can own a language property; we use it to realize multiple language support. When processing an item model, the parser will try to select elements who match the preferred language. Then the interpreter randomly initializes all declared parameters, and substitutes each parameter reference in the selected elements with the value of the corresponding parameter. After all parts of an item are ready, the parser wraps them into the IMS QTI format[15]. Indeed, we slightly extend the QTI format, to enable the Scalable Vector Graph (SVG) in item body and choices. The reason is that we need pictures in items, for example, a question may contain a graph representing a network topology. We will detail the item engine and the item model in a separate paper.

3.2 The Integration of the Item Generation Engine and Mediawiki

Mediawiki provides an extension interface; it can be used to program and install new modules which are in the form of special pages. The assessment extension consists of 4

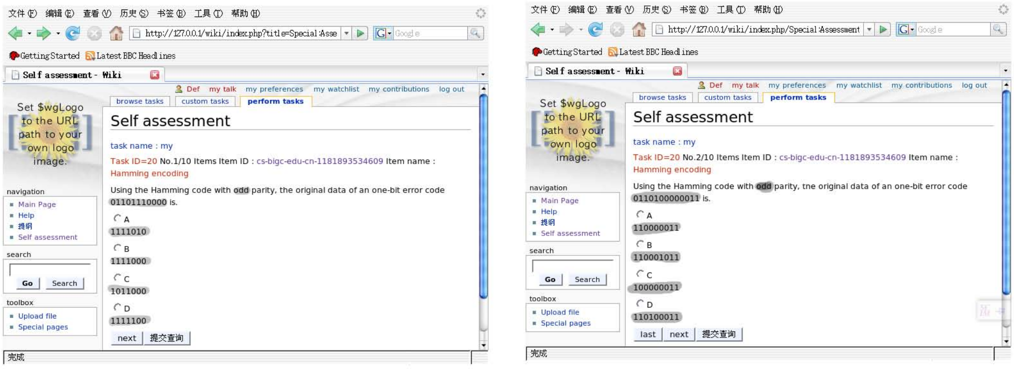

Figure 3: Two instance of the Model cs-bigc-edu-cn-1181893534609

ID: cs-bigc-edu-cn-1181891839667
Topic[zh_CN]: 滑动窗口
Topic[en_US]: Sliding Windows

Parameters:

win:integer min="1" max="10":
frame:integer" min="1000" max="1200":
overhead:integer" min="12" max="24" :
delay:integer" min="1" max="5" :
bpsi:integer" min="8" max="12" :
bps:formula" value="bpsi/10" :
tfr:formula" value="win*frame/b...
fr:formula" value="if(tfr>1, 1, wi...

Itembody[en_US]:

Two sites are using the sliding window ...
The number of the sending windows is <paramRef>win</paramRef>; the length of frames is <paramRef>frame...
...
the delay of a single trip is <paramR...
Supposing the receiver acknowledges ...
the maximun utilization of the channel is ?

Correct Answer:

((frame-overhead)/frame*fr):formula

Distractors:

*(frame-overhead)/frame*fr*(1+rand...*

Figure 2: Model cs-bigc-edu-cn-1181891839667 in a compact format

parts: item rendering module, task management module, task summary module, and item retrieving module.

Self-assessment is organized into tasks. A task contains several items, referenced by model IDs. When a task is beginning, the retrieving module calls the item engine to instance the required models to generate items. As shown in Figure 2, each model has a unique ID and all items derived from it will contain the ID. When rendering an item, the corresponding model ID will be an article name and appear in the head of the page as an inner link. Students can click the link to look up the solutions posted by other students, or write their own. The discussion page provided by Mediawiki enables students to discuss and argue. Different models can share a same topic, and all derived items will inherent the topic. Topics will also be article names and appear in the item pages as inner links. They are intended for students to connect multiple models regarding different aspects of the topic to write a comprehensive paper. This could be clear evidence of higher-order cognitive activities [12].

Figure 3 depicts two instances derived from one model. These items are in English format, because the user set the localization preference to “en”. The shaded parts were randomly initialized. These variables guarantee that examinees must perform certain algorithms on a case by case manner to get the right answers. Being able to pass these items indicates that the examinee can apply the knowledge conveyed in the corresponding models to solve related problems.

3.3 Using the Wiki Self-assessment System

The system is deployed on a dual core XEON server with 4GB RAM. The software environment is totally constructed by free and open software [20], includes:

- CentOS 4, a distribution of GNU/Linux.
- Mysql Database server 5.
- Mediawiki 1.09.
- Jboss 4.2 GA, an open source java application server.
- Phpbb2, an open source internet forum software package.

Instructors can assign tasks to any group of students, and students can custom tasks for their own. A task usually has 5 to 15 items about one or multiple topics. Instructors can specify the period during which a task is valid, and limit the maximum duration after a student begins to complete

Table 1: Students Activities and Scores

	Unused	0	1	2	3	4	5
Num Students	10	4	1	12	15	4	52
Avg Score	26.1	44.3	61	54.5	61.5	73.7	70.8

a task. During the active period of a task, students can try as many times as they want, even if they have completed it. Every attempt will be scored and recorded. However, the highest score is recorded as the final score of the task.

The result of each attempt is visible to students. They can look up the differences between their answers and the given answers. If a student is fail in a try, this information is helpful for her or him to speculate on the reasons. Hence, a higher score can be expected in the next try. There is also an alternative to browse methods posted by others. With more and more students pass an item model and post their comments, the solutions described in the articles are nearly perfect. Therefore, the related concepts are clearer to students; and their skills of solving these problems are improved simultaneously.

Instructors can view the statistical data of a task, including how many students have accomplished it, the average duration that students have a try, and the number of attempts needed by a student to pass it. The historical attempts of a student are also visible to instructors. This data generally reflects the knowledge level of the students and their attitudes to the course, and can aid instructors to adjust the lecturing. It can also be used to evaluate the effect of the collaboration.

4. FACTS OBSERVED FROM THE PRELIMINARY APPLICATION

In the spring semester of 2007, we used this system as a supplement to the course titled “Computer Networks” offered to the students majored in computer science. Five self-test tasks were assigned to 98 students, and they can decide whether or not to complete these tasks. However, we gave a bonus for those who completed one or more tasks, and the bonus will be accumulated into the final grade as the class participant points.

4.1 Effect on Learning Outcomes

Among the total of 98 students, 88 students tried to complete the tasks, 10 students did not touch the system at all. In the second line of table I, each numeric represents the number of students who completed at least n tasks. The third line is their average grades in the final exam.

Table 1 shows that more than half students accomplished all tasks. Most of them are proactive students, and they had reached the up limit class participant points before the late tasks were assigned. This fact reflects that they believed these tasks are helpful for learning the course. Several students complained that they missed one task just because they were busy for personal affairs during the period. Despite the 5 exceptions (column 3 and 6 in Table 1), we can conclude that as the number of completed tasks grows, students can generally get higher scores in the final exam.

At the end of the semester, we called the students to voluntarily take part in a survey whose results are depicted

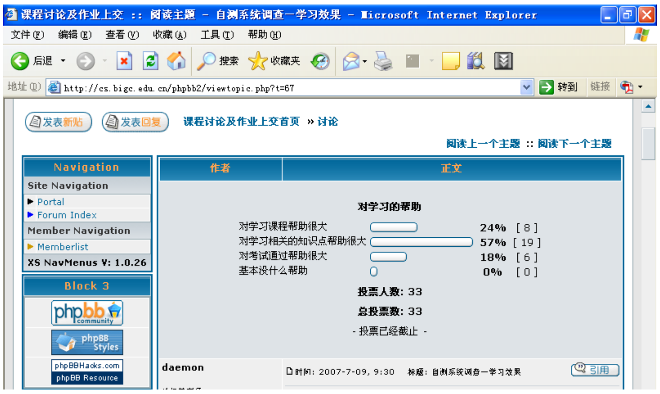

Figure 4: Survey on the Effect

in Figure 3, and 33 students responded. Eight (24%) students agreed that this system helps them to learn the course; 19 (57%) students agreed that the self-assessment tasks are helpful for them to learn related topics; and 6 (18%) students considered these tasks as the remedy to the final exam[1]. No one voted for the option that the system is useless.

The Students also wrote short comments on the reasons why the wiki assessment tool has positive effects on their learning. Here we excerpt and interpret the top five mentioned reasons.

- The wiki assessment tool is interesting and further makes the students love the course.
- The assigned tasks help the students to identify their weak points, and therefore, they spend more time on the related topics and have better understanding.
- The students are willing to share their methods and thus try their best to solve the test questions.
- Solutions posted by others encourage the students to stay in the tasks, and they find items become much easier after they have tried several times and get hints from the articles.
- The items act as catalysis to assist students to connect related concepts, integrate and elaborate old and new knowledge.

4.2 Collaborative Activities

We encouraged students to write wiki pages to describe their methods by which they solve an item, and every one can amend an article if he or she has comments. All items derived from a model share the same model ID, and this ID will appear in the item pages as an inner link for students to write articles. However, some students were very aggressive; they wrote all solutions of a task in one article. Figure 4 is the screen copy of the revision log of an article whose title is “strategies for the third batch of network self-test (problems)”. It reveals that 3 students constantly tried the

[1]In Chinese, this is an euphemism for ”the self assessment tasks are intended to leak information to make the final exam easier”. We believe that if students have a negative opinion about teachers’ work, they will express it when it looks less offensive. And the survey results confirm this belief.

Figure 5: An Article Revision Log

task from 2:34 pm to 4:27 pm, and revised the article until they believed that their methods are perfect.

This observation is different with the evidence presented in [13] that students found it was difficult to change articles written by peers. This difference may be caused by the different topics about which students write articles. For articles that describe general topics and have authentic sources, for example, the definition of a terminology, to expand them is difficult for students. For articles that explain how to solve concrete problems, there are many cases that a student can contribute. For example, the original method described in an article may be partial correct, in some cases it is invalid. Or there are other ways to solve a problem. Therefore, students can amend these articles without hesitation.

The model cs-bigc-edu-cn-1181891839667 illustrated in Figure 2 can be an example to explain how students collaboratively solve test questions. The model is about the relationship between the bandwidth, the delay, and the buffer of sliding windows protocol. The detailed information about this problem can be found in [25]. Here we only use the conclusions to indicate that there are different situations in the model. When an item is derived from the model, the randomized parameters can form the situation that the sender receives ACKs before the sending window is zero. In this case, students can deduce the optimal bandwidth utilization should be $(frame - overhead)/frame$. On the other hand, these parameters can also form the situation that the sending window is exhausted before the ACKs return, and the former answer is inapplicable to these instances, and vice versa. Therefore, students can improve the initial solutions via combining different situations. This combination helps students to understand the process of the protocol, and related issues like how to optimize performance according to the properties of channels. Therefore, these non-isomorphic items used in formative assessment help students to extend their knowledge. However, some students only remember under which conditions applying which formulas, regardless of the underneath knowledge. Hence, these self-tests are less useful to them, and we are taking measures to tackle this problem.

5. CONCLUSIONS

Collaboration can foster learning in case that the activities are moderated by educators [8]. To form effective learning, we use formative assessment as the collaborative tasks. There are actually two tiers of objectives for these tasks.

- The surface level is to learn by self-assessment. Because of the generated items, students can try these tests as many times as they need. Borrowing methods from others is also acceptable. Therefore, students who wish to pass can always pass, and receive the same grade. These settings avoid the drawback that students who gain poor results in formative tests are led to believe that they are incapable to learn the course [2].

- The deep level is to construct a co-owned knowledge repository. Students are encouraged to post their methods, to act as a tutor to guide others. As more and more students contribute their solution methods, they finally construct a co-owned knowledge base. This process leads to higher-order cognitive activities, motivates students to think critically, to connect, integrate, and elaborate knowledge fragments. [12]

The wiki benefits this learning design in three ways: a) the fact that everyone can edit pages makes the solutions evolve quickly, and hence keeps students with difficulties to stay in these tasks; b) the revision logs credit students for sharing their solutions, and thus encourage them to explore different solutions; c) the style in which the wiki organizes articles facilities students to connect and elaborate knowledge fragments.

In the preliminary application of the presented approach, we observed the following facts:

- Most students improved their academic achievements via completing assigned tasks.

- The combination of formative assessment and collaboration leaded to higher-order learning.

- The wiki-based collaboration encouraged students to develop a spirit of cooperation and sharing.

These facts indicate that the wiki-base self-assessment is a promising tool for collaborative learning.

The experiences gained from this study suggest that when educators assign students to write technological articles, the preferred topics shall be those which require students to read critically, to analyze available materials, to infer and test to reach the resolution. Otherwise, if the content can be directly obtained from the Internet or authentic sources, students will find that the room for them to contribute is too limited, and therefore feel frustration. This study also suggests that immediate reward is important for students to stay in collaborative tasks, for example, getting a pass in a self-test, discovering the increase in the number of accesses to an article.

Our future work includes: a) developing a graphic user interface for model authoring so that users without XML knowledge can write item models and release the item engine as open source software; b) developing rubrics for students to write models to form a kind of peer assessment [26]; c) helping those students who are otherwise absent the self-tests or merely remembering solutions regarding certain models to improve their academic achievements.

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