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AUGMENTING A WEB-BASED LEARNING ENVIRONMENT THROUGH BLENDING FORMATIVE ASSESSMENT SERVICES

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Web-based training gained popularity due to pervasive hypertext information systems, as well as its flexibility of time and place. However, the lack of orientation and interactions leads to higher dropout rates in those self-directed learning environments. From the perspectives of learners, formative assessment generates criticism and suggestions that guide them toward ultimate learning goals, which improves their sustaining rates in self-directed learning environments. This research work aims to investigate how a Web-based learning platform can blend external formative assessment services to foster learning activities as well as facilitate interactions between learners and mentors. Besides proposing a conceptual model, a proof-of-concept prototype has been developed, in which both fully-automatic and human-involved formative assessment works could be blended into a self-paced, Web-mediated learning process. An experiment indicated that the prototyped e-learning context did help to sustain learners. The result of this research implies that, with abundant pedagogical Web services in an open framework, high priced e-learning resources could be easily shared and flexibly orchestrated to fulfill various educational goals.

Key words: Web-based learning, dropout, pedagogical service, Web service, formative assessment, SCORM
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1 Introduction

In the past decade, Web-based training (WBT) gained popularity due to pervasive hypertext information systems, abundant hypermedia materials for pedagogical purposes, as well as the flexibility of time, place, sequence and pace provided to learners via WBT.

However, studies showed that the dropout rates of Web-based e-learning environments are higher than those of traditional learning environments [10, 24, 37]. The experiment conducted by Murphy [31] even indicated that the e-learning course without face-to-face interactions have low completion

rate; at only 10%. There are various kinds of factors that contribute to the higher drop-out rate of e-learners. Consequently, researchers and practitioners have being interested in exploring the factors that have significant impact on the drop-out of e-learners [23, 26, 50] in order to reduce the dropout rates and the wasted educational resources. The literature survey by Jun [22] provides an informative summary of the factors that have influence on the dropout or retention of e-learners. The survey categorized all of the factors into five groups: individual background, motivation, academic integration, social integration, and technological environment.

Not surprisingly, many research works pointed out that, among various factors, the lack of interaction, support, and feedback from mentors is the major culprit of the higher drop out rate in those self-directed learning environments. The research conducted by Towles et al. [45] showed the positive impact of faculty-initiated contact on freshman learners' retention. Black [4] emphasized the importance of interaction with learners. Vrasidas & Mclssac [47] found that the responsive feedback from mentors plays an important role in learners' participation. Horton [19] claimed that the human interaction is more important than technical factors, even in those technical-supported learning environments. Research conducted by Shea et al. [40] showed that the direct interaction between learners and mentors influence learners' satisfaction level about the attended courses, and the satisfaction level is a key determinant of sustaining or dropping out. Lim, Lee, and Nam [27] have conducted an empirical study to prove that the communication between trainers and trainees do have positive impact on the learning performance.

Besides the researchers who focus on exploring the issues of high dropout rates in e-learning environments, many researchers [13, 25, 34, 35] investigated learning effectiveness from the perspective of social dimensions. The significance of social dimensions in e-learning suggests that lack of interactions with mentors will result in an isolated, unsupported atmosphere, which is unfavourable to many learning activities, especially those constructive ones [28]. Despite the researchers in the two groups have different perspectives and approaches, one common point of their arguments is that the communication during the course of learning is critical to a successful learning program, in terms of learner's completion rate and training effectiveness. The social norms, including trust, are also significant to a well-established learning community that are helpful to sustain learners. The research conducted by National Council of Teachers of Mathematics [30] showed that forming the atmosphere of mutual trust and respect between instructors and learners are critical to successful learning since learners are willing to explore and construct in such an environment. Hewson and Hughes [18] also believe that learners' trust on facilitators is fundamental to build a basis for engaging learners in educational activities.

The findings in the mentioned works did motivate researchers to resolve the issue of higher dropout rates in asynchronous Web-based learning environment. Among many available options for addressing the issue, formative assessment is suitable to strengthen interactivity of e-learning environments because it can assess learners' achievements, as well as establish communication channels between learners and mentors. However, most of Web-based learning platforms applied limited functionality to facilitate communication between learners and mentors [36][46], even fewer functions to manage the interactive processes and support learning communities [18]. Worse than that, the currently available solutions for supporting formative assessment in WBT environments take

proprietary approaches to conduct the formative assessment works, which hinders the sharing and reusing of those costly pedagogical resources.

In response to the above issues, this research work aims to explore a new approach to blend formative assessment services, which could be either automatic or human-involved, into widely-adopted Web-based learning platforms. A prototype for realizing the proposed approach will be presented. Furthermore, the responses of learners to this blending also will be discussed.

The remaining parts of this paper are organized as follows: the subsequent section will review the literatures relevant to formative assessment and its usage in e-learning contexts. The following section will describe the current status of conducting formative assessment in WBT. Next, a model that blends human-involved formative assessment services into WBT environments and its design rationales will be presented. Then, a prototype based on the proposed model will be described. The impact and responses of applying that prototype will be analyzed and discussed. The last section concludes this research work with discussion of contributions, implications, and suggests for future research and development.

2 Formative assessment and its applications in WBT environments

Generally speaking, formative assessment refers to the activities through which criticism and suggestions could be collected from mentors and used as feedback for improving learning effectiveness. In the later discussion of this article, the "mentors" refers to those who can provide formative assessment toward learners' assignments. For example, they may be instructors who direct courses, teaching assistants, tutors, or any body possessing adequate subject knowledge for assessing learners' works. Traditionally, there are several ways to conduct formative assessment, such as observing students' reaction to lectures; marking students' writing works; analyzing students' programs and providing specific suggestions for improvement, etc [6]. Studies show that formative assessment benefits both learners and mentors [5, 8, 32, 38]. From the perspectives of learners, formative assessment provides feedbacks which not only identify the gaps between current status and learning objectives, but also guide them to strengthen the identified weakness in their subsequent learning processes. Therefore, formative assessment activities make learners feel be cared about and supported, which definitely will be helpful to sustain them in their situated learning environments.

To conduct formative assessment for a particular learner's achievement, it is necessary to assess that learner's submission, which reflects her/his capabilities for handling (e.g., comprehending, applying, and synthesizing) learned materials. Then, mentors need to identify the incorrectness or weakness shown in these submissions and provide concrete suggestions for the improvement. The survey done by Mike Thelwall [44] provides an overview about formative assessment in computer-based assessment (CBA). Depends on the characteristics of learners' submission, three major types of formative assessment are applied.

First of all, there are a number of formative assessment tools that have been developed for handling questions with unique answers such as multiple-choice questions. Because performing this kind of assessment works relies on unambiguous criteria, it is easy to develop and integrate this kind of assessment works into available WBT environments. However, even the formative assessment

mechanisms applied in Web-based learning environments are very simple, their efficacies for enhancing learning performance have been proved in different learning environments [9, 49].

Secondly, for those submissions without unique answer but with rigorous rules for regulating their formats and syntaxes, such as computer programs, it is more difficult to perform assessment and criticism automatically by applying computer software. However, the acceptable solutions are still feasible. For example, WebToTest [12] can check programs' correctness, PILOT [42] can assess and grade students' programs. In addition, Submit! [51] can provide personalized criticism for students' programming works.

The third type of formative assessment activities is necessary for those submissions without rigorous formatting rules or syntaxes. These submissions include literature essays; business proposals; legal case study reports, etc. Even with state-of-the-art artificial intelligence techniques, it is still very difficult if not impossible, to develop software tools that can comprehend, assess, and then criticise this kind of submissions precisely and consistently. In other words, the involvement from people who possess domain knowledge and capability of comprehending subtlety in submissions is inevitable to perform the corresponding formative assessment works, which later are called human-involved assessment in this article.

Not only being necessary for handling the particular type of submissions, human-involved assessment activities also play a significant role in establishing communication channels between learners and mentors, which is helpful to build up an oriented and supported learning atmosphere according to prior studies [22, 25, 45, 47]. Because of its necessity and value to sustain learners, it is worthy to investigate how to augment current Web-based learning environments by merging human-involved assessment services.

The subsequent section will investigate how human-involved assessment activities could be performed in currently available Web-based learning environments as well as the corresponding shortages. After that, a new approach for resolving those shortages will be proposed.

3 The feasibility of conducting human-involved assessment works in current Web-based learning platforms

Conventional assessment methods such as true/false and multiple-choice questions are easy to embed into Web-based learning management systems (LMS) due to it is straightforward to assess and grade those types of questions automatically. Basically, they could be developed by using HTML, JavaScript, or Flash codes. Thus, the assessment and grading works could be performed immediately follow the raised questions without mentor's involvement. Because of its pedagogical value for an instructional course and high practicability, automatic assessment works are popular in e-learning environments.

Taking the sharable content object reference model (SCORM) [1] as an example, there are assessment-related data elements including "Scaled Passing Score" and "Success Status" defined in its run-time environment (RTE) data model [14]. Through these data elements, assessment results with respect to predefined learning objectives, could be sent back to the learning management system (LMS) that deliver the assessment modules to learners. After the assessment activities being performed on the learner's side, the LMS are able to use assessment results as well as the predefined

sequencing/navigation rules to determine which instructional or remediation module should be delivered next.

On the contrary, there are very few works have been done to facilitate or conduct human-involved formative assessment activities within Web-based LMS. For example, due to its focus on self-directed, Web-based learning, the SCORM provides limited support for conducting human-involved formative assessment activities. There are two elements: "Comments From Learner" and "Comments From LMS" defined in the RTE data model. The two fields could be used to convey simple textual messages passed between learners and LMS. However, they are insufficient for conveying information that are necessary in conducting various formative assessment activities since they can not hold complex information such as numerical data, time stamps, and other composite data structures (e.g. array). In addition, the SCORM does not govern the dialogs between learners and external formative assessment tools, no matter the tools need mentors' involvement or not.

In summary, due to the target application scope, the SCORM lacks two key features for regulating human-involved formative assessment activities in Web-based learning environments. One is the data schema for representing complex submissions and assessment feedbacks; another one is the protocol for supporting the communication between learners and the external 3rd-party assessment tools. In consequence, even there are developed functions for conducting human-involved formative assessment activities; the proprietary solutions will lack the interoperability, which will obstruct people from sharing and reusing those costly resources.

The importance of human-involved formative assessment works and the insufficient support for conducting them motivate a new approach for blending formative assessment activities into Web-based learning environments.

4 Blending formative assessment services into Web-based learning environments

Given that the current solutions do not address the formative assessment issues in Web-based learning environments, this research work aim to propose a new approach to resolve them. A service-oriented approach for linking formative assessment tools with Web-central LMS is presented in this section. The corresponding design rationale, operational modes, and the conceptual model will be described, respectively.

4.1 Design rationale

It is good to augment the effectiveness and applicability of Web-based learning platforms by blending external pedagogical services. However, the blending should not violate the principles that are important for retaining the benefits of Web-central learning platforms. The three principles are identified as follow:

(1) Openness: for the sake of interoperability between Web-central LMSs and supportive external services, an ideal solution should take an open approach to bridge them together. The openness enables major subsystems such as LMS and its complementary assessment tools, which might come from different vendors/organizations, to be bound together and cooperate with ease. As a result, the openness will facilitate the sharing and reusing of costly pedagogical resources.

(2) Autonomy: autonomy of a software subsystem, refers to a system that can perform its own core functions without relying on close collaboration with other systems. This feature allows users to flexibly configure their e-learning platforms based on various circumstances and requirements. To maintain the autonomy of assessment tools and LMSs, a loosely-coupled approach is preferred for bridging the required components together.

(3) Traceability: prior studies show that it is important for learners and mentors to utilize learning portfolios [16, 17, 41]. Being able to reference their learning experiences that contain prior problems and mistakes, to some extent, will help learning activities [3, 11]. Therefore, all data exchanged during the assessment interactions need to be persisted in an organized way for later references and analysis. In addition, the accumulation of data associated with formative assessment works is meaningful for automatic construction and mining of frequently-asked-questions (FAQ), which will be helpful to reduce the human-involved works for completing assessment activities.

4.2 Synchronous and Asynchronous Operational modes

While proposing a generic solution for blending formative assessment activities into the Web-based learning environment, it is necessary to take into account that the supported assessment activities might be conducted in two different modes: synchronous or asynchronous. The operational mode depends on the types of interaction between learners and the service provider, as shown in Figure 1. In synchronous mode (1a), learners can get instant feedback after sending their submissions to the service provider that are able to assess and then criticize learners' submissions automatically. In asynchronous mode (1b), learners need to wait longer for getting feedback if the handling of their submissions need human's involvement. The actual waiting time depend on how fast the human-fabricated feedbacks could be completed and sent back. In asynchronous mode, a learner who submitted her/his work should receive an acknowledgement from the service provider right after the submission. These acknowledgements inform learners that their submissions have been received, but longer processing time is expected.

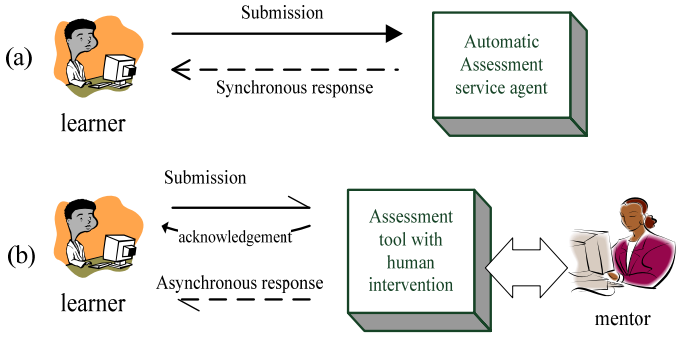

Figure 1 Synchronous (a) and Asynchronous (b) Formative Assessment Interactions

4.3 Conceptual model

Taking the first two of the above three principles: openness and autonomy into consideration, the service-oriented architecture (SOA) [7, 15, 21, 29] emerged as a good choice for bridging the Web-

based LMS and external formative assessment services in the proposed solution. That is because when people try to integrate a number of existing pedagogical systems in order to fulfil particular requirements, they will face a variety of available systems with different aspects and proprietary interfaces, and obviously, it is not a cost-effective and prompt solution to revamp the existing systems for constructing a blended configuration. Fortunately, SOA techniques were developed toward software system integration via linking distributed, autonomous, and heterogeneous modules together. Besides, the SOA also bring benefit such as platform and implementation independence, which remove some irrelevant restrictions when users are selecting the most appropriate solution from a list of available pedagogical resources. In other words, users can focus on evaluating the pedagogical values provided by the candidate tools, instead of their platform or implementation characteristics such as operating systems, programming languages, database management systems, etc. Although there are rare concrete achievements have been reported, few scholars [2, 20, 39] did propose that an e-learning instructional process could be built up by taking a service-oriented approach, and this research work made a step toward that direction.

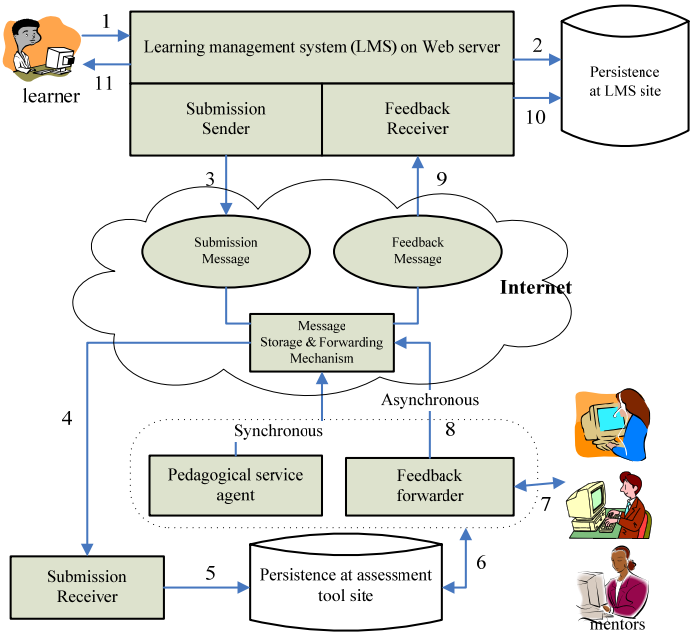

Figure 2 Conceptual model of service-oriented e-learning environment

The principle of traceability makes it rational to use databases, which have been widely equipped within most of Web-based learning platforms for storing instructional materials and learners' profiles, could fulfill the functionalities of storing assessment data. Besides the persistence, database systems also enable the structured storage and retrieval of data for recording assessment activities. In the conceptual model and prototype configurations, two separate databases were installed on both the LMS and the assessment tool sites. The two databases store common data associated with submissions and feedbacks, but have different data for fulfilling other functions that are specific to each site.

Based on the two supported operational modes and the above deductions about how to architect the new learning environment, a conceptual model of the new e-learning environment could be illustrated in Figure 2. The numbered arrows in Figure 2 indicate the sequence of a typical formative assessment interaction in asynchronous mode: a learner initiates an interaction through submitting an assignment to a LMS, then; the submission will be forwarded to a remote formative assessment service tool, via the Internet. Once the submission arrives at the site offering formative assessment services, it will be persisted first, and later will be retrieved and processed by mentors. The processed submission; i.e., the feedback to learner's assignment, will be transferred back to the LMS, also via the Internet. The feedback, once was transferred back to the LMS, will be persisted for later retrieval by learners.

The conceptual model could be adopted to support all the three types of formative assessment mentioned in the section 2. As Figure 2 illustrated, an agent for automatically assessing learners' works could be included in the service provider site to synchronously fulfil the first two types of formative assessment. If the assessment of learners' works requires involvement from human, then another module, named as "feedback forwarder" in Figure 2, needs to be used to fulfil formative assessment in asynchronous mode. In this research, in order to highlight the feasibility of augmenting Web-based LMSs through linking human-involved pedagogical services, the prototype was implemented to provide learners formative assessment services that come from a remote site and need involvement from human.

5 The concept-proving prototype

The architecture of the prototype for realizing the above concept is illustrated in Figure 3. As the Figure 3 shows, there are two sites involved in a service-oriented assessment activity; one serves as the LMS that learners interact with, another one serves as the assessment service provider through which mentors can prepare feedback messages as responses to learners' submissions. Each site has an installation of Web server, which is essential to perform the SOAP (Simple Object Assess Protocol) [48] message transmission over the HTTP for realizing the Web service concept.

On the LMS site, the SCORM 2004 sample run-time environment was installed. That was released by the advanced distributed learning (ADL) technical team [1], and mimics a simplified but function-sufficient LMS for this prototype. The installation includes an Apache Tomcat Web server and other servlets for fulfilling the fundamental functionality of a LMS. Besides, to support the transmission of submission and assessment messages within a Web service framework, a Java API for implementing messaging mechanism: JAXM (Java API for XML Messaging) [43] was used in this prototype. In reality, a set of JAXM client and provider was installed on the LMS site to conduct the asynchronous transmission between the LMS and the assessment service provider. The JAXM client on this site is responsible for sending learners' submission in the form of SOAP message and receiving the assessment messages from the assessment tool, while the JAXM provider behaves as a messaging server that hold and forward received messages to the destination.

On the service provider site, the installation includes an Apache Tomcat Web server and other servlets to support the fundamental functionality of a formative assessment tool through which mentors can correct and make comments on learners' submissions. To communicate with its counterpart: the LMS site, a set of JAXM client and provider was also installed on this site. On this site, the JAXM client is responsible for receiving learners' submission messages. After mentors finish their assessment

works, which need to be packed into SOAP messages before sending them back to the LMS site via the messaging mechanism.

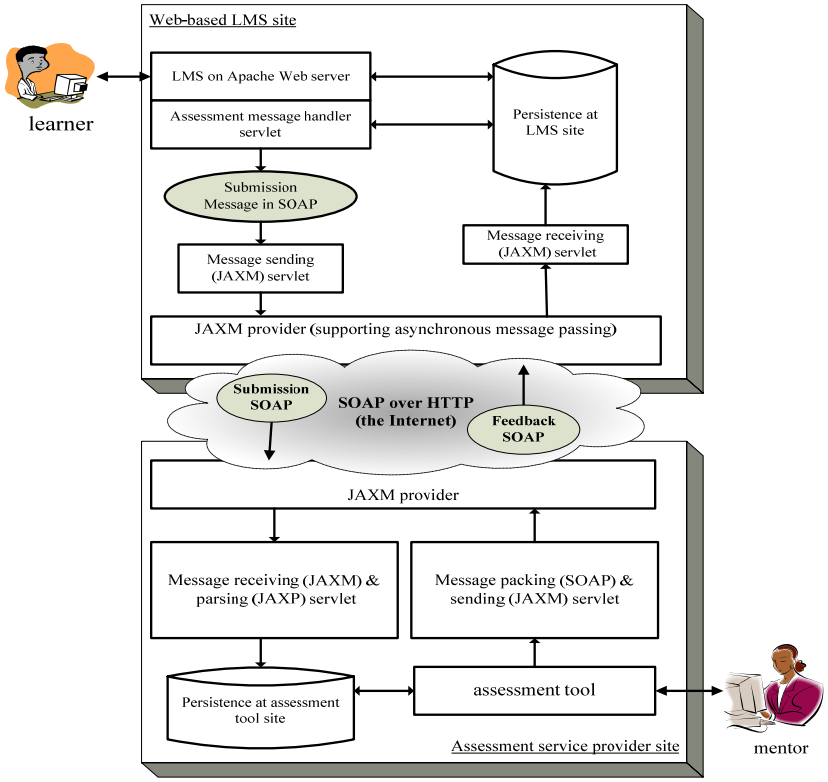

Figure 3 Architecture of the concept-proving prototype

Besides the Web applications for pedagogical and messaging purposes, a database management system is also necessary in this prototype. The Microsoft ACCESS, a popular personal database application, was installed on both sites to store the submissions and their corresponding assessment works for tracking and archiving purposes.

To illustrate how users use this prototype to conduct the service-oriented assessment, two screen snaps are shown and the associated internal operations are explained as follows. Figure 4 shows that a learner is preparing to submit an assignment to the LMS, which then pack the submission as a SOAP message and deliver that message to a remote assessment tool via the JAXM providers and the Web. To accentuate the necessity of human involvement in particular formative assessment activities, the submissions could be programs, essays, business proposals, or any forms of contents that need human intelligence to judge, criticize, and correct. Within the same interface, the learner can also see the list of prior submissions and corresponding responses. Thus, a learner can easily track a series of interactions between her/him and the mentors.

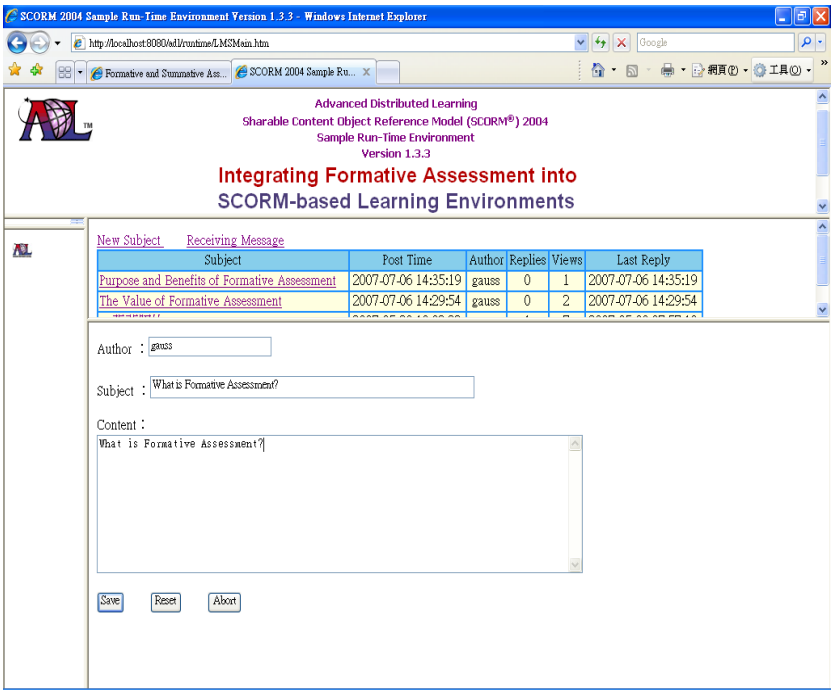

Figure 4 Learner submit an assignment

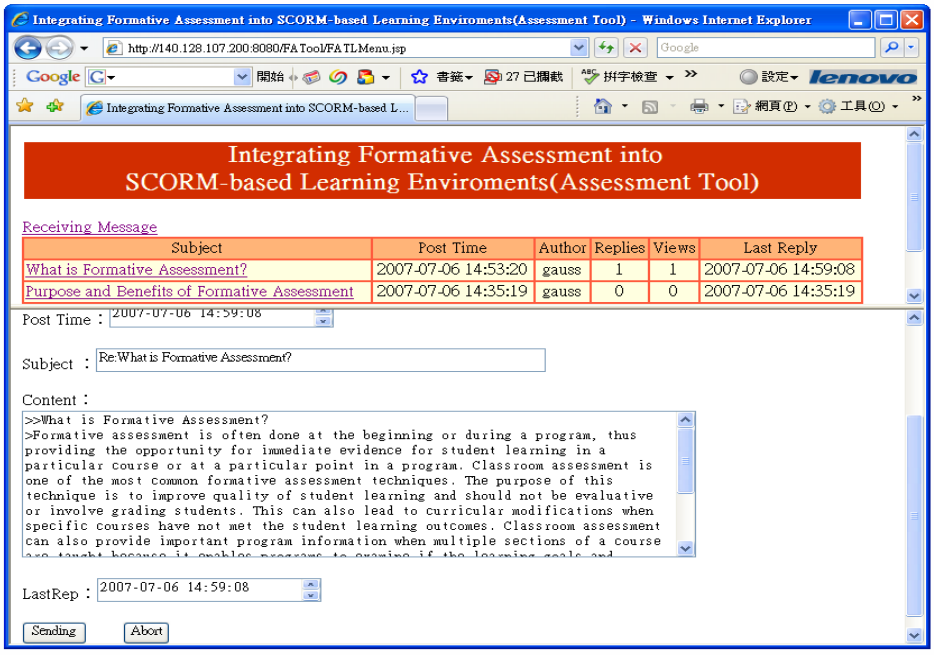

Figure 5 Mentor assess a submission.

Figure 5 shows that when a mentor is preparing to read and assess a submission by using a Web-based assessment tool. The assessment tool loads new submission messages from the JAXM provider, then unpack and display them in a list of received submissions. Within the same interface, the mentor can pick and assess (edit) a submission. After finishing the assessment work, the mentor can send it back to the learner by simply clicking one button. While the activities that are invisible to the users include the assessment tool packs the assessment work as a SOAP message, which then be delivered to the LMS site by the JAXM provider on the assessment tool site. Once the assessment message arrives at the LMS site, it will be stored in the database and then be sent to a learner by the JAXM provider whenever a learner asks to do so.

6 Evaluation: impact and perceptions

As mentioned in previous sections, many research works have proved that formative assessment has positive impact on both sustaining learners and improving their learning performance in different learning contexts. However, it is still interesting to investigate whether formative assessment activities are still effective to sustain learners in this particular setting: a Web-based learning platform blending with an external human-involved assessment service. Additionally, we also collected subjects' opinions and suggestions about the tool and the effect brought by it.

6.1 Quantitative analysis of the impact on dropout

An experiment was conducted to find out if there was any significant impact on the drop-out rate when human-involved formative assessment service was provided during a learning process.

6.1.1 Participants

Overall, 64 participants were asked to enroll a WBT course that teaches the skills of object-oriented programming in Java. That WBT course was designed as part of a regular, mandatory object-oriented programming course since we aimed at measuring the participants' sustainability instead of their willingness to engage in the experimental course. The participants were divided into two groups: the experimental group and the control group; each group had 32 members. There were 10 girls and 22 boys in the experiment and control groups, respectively. All participants were sequentially picked from a pool of 64 undergraduate students majored in computer sciences, according to their average grade on the prerequisite courses, and then were balanced assigned to the two groups.

Despite attention was paid to balance the subjects of the two groups according to their prerequisite knowledge, it is critical to make sure the two groups of subjects did possess the same level of mastery on the trained topic before the experiment. Thus, a pre-test, which comprises 20 multiple-choice questions, was conducted to understand the subjects' mastery levels on basic object-oriented concepts. The statistical analysis of the pre-test results indicated that the Levene test for equality of variances did not reach a significant level ($F = 1.077$, $p = .303 > 0.05$), followed by an independent-samples t-test for equality of means ($t= -0.410$, $p = 0.684 > 0.05$), which suggested that there was no significant difference between the two groups' level of mastery on the trained topic before the experiment.

6.1.2 Instrument

The sustaining rate was used to measure the overall impact of the mentor-provided formative assessment service on the participants. The sustaining rate is equal to the number of sustained learners at a particular check point divided by 32, which is the number of participants in each group at the beginning of the experiment. Obviously, this simple rate can validly and reliably measure how much percentage of learners are able to engage in a course at a particular check point.

6.1.3 Procedure

Before the experiment, the instructions about how to use this particular setting were given to all participants. The participants in both groups used the similar WBT learning environment, except the participants in the experimental group had one extra facility: a supportive mentor on a remote site. The duty of the mentor was assessing subjects' submissions and responding inquiries that were relevant to the course materials. The participants in the experimental group communicated with the mentor who sat behind on a remote assessment tool, and they did not know how the communication details worked. In order to observe the timing effect of the mentor-provided formative assessment service, five checkpoints were set during the ten-week experiment; the sustaining rates of each group were recorded every two weeks since the inception of the experiment.

6.1.4 Results and discussions

As the trend shown in Figure 6 indicates, the difference between the sustaining rates of the two groups is negligible in the first two checkpoints, or the first month in other words. However, more subjects in the control group gave up as the course proceeded into more difficult levels, which account for the more significant gap between the two groups' sustaining rates in the last three check points. The trend of sustaining rates in both groups indicated that the positive effect of formative assessment could be observed in this particular setting, as the same in other pedagogical environments.

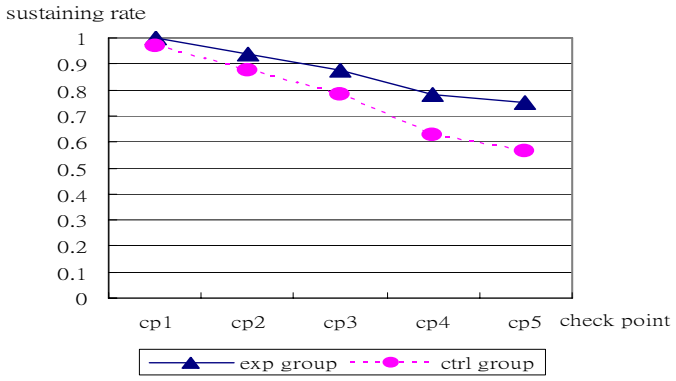

Figure 6 The impact on sustaining rates

Although the result showed that the proposed model is feasible and its realization is effective in sustaining learners, two limitations in this experiment need to be mentioned. The first one is the possible bias due to the unbalanced gender distribution of participants in this experiment (F=20, M=44), further study is necessary to affirm whether the gender difference exists in this setting or not. The second limitation is that the mastery level was taken as the only criterion for ranking and grouping the participants, but other possible confounding variables such as self-motivation of the learners were neglected for simplicity in the pre-test.

6.2 Qualitative analysis of learners' perceptions

In addition to the previous experiment for measuring the effectiveness of the formative assessment service on sustaining learners, a questionnaire was designed to survey the responses and opinions of the subjects in the experimental group.

6.2.1 Participants

24 of the 32 subjects in the experimental group who completed the previous experiment were asked to rate how they perceived the tool and its functionality, as well as how they thought the tool should be enhanced. We did not take the eight drop-outs into account since we could not predict when and how many participants will drop out in advance. Consequently, it is much more efficient to select the subjects of this questionnaire after the previous experiment. In addition, dropout participants' partial involvement might lead to incomplete perspectives also concerned us.

6.2.2 Instruments

A seven-item questionnaire consisting of six relevant items in five-point Likert-scale and one open-ended question was developed by our self and aim to understand subjects' opinions and suggestions. The measure comprising the first six items was found to be reliable with Cronbach's alpha equal to 0.7522 [33]. Both face and content validity of this measure were also verified by five educators with average six-year experience in college-level computer science education. Besides, all of them have average three-year experience in using Web-based learning environments. According to their expertise, the descriptions of the measure were proper and clear to express what the items are supposed to measure and the items are all essential to explore why learners sustained in this experimental course.

6.2.3 Procedure

Not only being validated by educators with domain expertise, the questionnaire was pre-tested by students who have the same background as the subjects did. After the pre-test, minor changes were made to clarify the descriptions. After removing the 3 invalid questionnaires, 21 of the collected questionnaires were analyzed.

6.2.4 Results and discussions

The contents and the responses of the questionnaire are summarized in Table 1. The responses and opinions provided a rational explanation about why more learners tended to sustain and how the current works should be improved. According to the results of questionnaires, the top two factors

contributing to the lower drop-out rate are the availability of an extra communication channel through which mentor's instructions for specific problems could be provided, and the supported atmosphere formed by the interactions with the mentor. In addition, the low standard deviation values indicated that the subjects have high consents to the two questions: Q5 and Q6. These findings, are in agreement with prior research works, once again confirmed the benefit of formative assessment, but highlighted the effect of interactions with mentors in this particular experimental setting.

The answers of the seventh, an open-ended question were collected and grouped into the following four major categories: (1) faster response, (2) more functions to locate data, (3) more interaction types, and (4) others opinions that received less consents. Although most of learners highly appreciated the mentor-provided assessment service through a Web-based LMS, the answers of the open-ended question suggested that most of learners expect faster responses and synchronous interaction, which are also consistent with prior research and could guide the corresponding future works.

Table 1 The questionnaire and results

Descriptions of items (Q1 ~Q6 are in 5-point Likert-scale; 1 indicates strongly disagree and 5 indicates strongly agree)	Avg.	Std. dev.
Q.1 I sustained through this course since the materials interested me.	2.81	1.03
Q.2 I sustained through this course since the materials are easy.	2.71	0.90
Q3. I sustained through this course since the presentation are attractive and astonishing.	3.14	0.79
Q4. I sustained through this course since the LMS are user-friendly, comparing to my previous experiences.	2.95	0.67
Q5. I sustained through this course since there was a mentor provided specific feedback to my problems via formative assessment service.	4.05	0.74
Q6. I sustained through this course since the interactions between me and the mentor make me feel was supported and guided.	3.86	0.57
Q7. In your opinion, what is (are) the most wanted task(s) for improving the current formative assessment service?	**A.** faster response (76% , 16 out of 21) **B.** more functions including FAQ, search, tag, etc (62%, 13 out of 21) **C.** Web-conferencing, Skype (52%, 11 out of 21) **D.** others (under 50%)	

7 Conclusion and future works

Formative assessment is helpful to strengthen both learning and teaching activities. The constructive feedbacks generated through formative assessment not only guide learners toward their ultimate

learning goals, but are critical to sustain those learners who need to go through the learning process with orientation and adequate support from mentors. However, the typical circumstance that e-learners are facing is there are no sufficient directions and assistance from mentors to guide them. Moreover, there are no standards or even common practices for merging formative assessment services into Web-central learning platforms, which hinders the sharing and reusing of those high-priced pedagogical resources. This research work proposed a model in which various pedagogical services including formative assessment could be blended into a Web-central learning platform via a set of standardized protocols.

A working prototype was implemented to demonstrate the feasibility of the concept. By adding Web service clients and providers in the Web-based LMSs and those external 3rd-party assessment tools, learners are allowed to communicate with remote mentors and external formative assessment tools. Besides, all data exchanged during the sessions of assessment are persisted and traceable and thus could be utilized for evaluation and analysis. The techniques used in the prototype allow developers to keep each subsystem's interoperability and autonomy intact, which is important for protecting users' investment on existing Web-based learning platforms. The responses from the subjects of the experimental prototype showed that one external assessment service provided by mentors did help to sustain learners who need instructions, feedbacks, hints, or any other types of constructive input when they encounter problems during the course of learning.

This research indicated that the functionality and application scope of Web-based learning systems could be extended via service-oriented pedagogical resources. The broader implication is that the types of Web-mediated instructions can go beyond the currently available options with blending external pedagogical services. On the other side, various pedagogical services could be developed individually and then be bound flexibly together to fulfill a wide range of instructional purposes.

The limitations of this research and the corresponding future works include first, although many prior research works already confirmed that formative assessment has positive impact on learning effectiveness. A larger-scale and longer-term experiment is worthy to precisely evaluate the effectiveness of alike e-learning platforms in terms of sustaining rate. Second, establishing a caring and supportive environment is beneficial to learners, however, its cost is heavy-loaded mentors, which definitely will further slow down the human-fabricated responses to learners' requests. In our experiment, the logs show that learners needed to wait 19 hours in average to receive the first response of a submission while there were two mentors and each worked 4 hours per day during the course of the 10-week experiment. Although the waiting time could be reduced by properly arranging mentors in 3 shifts (morning, afternoon, night) per day, the waiting time in hours still will make learners feel anxious and even frustrated when they need prompt response to resolve their problems. Consequently, it is a significant issue to reduce mentors' burden within such an environment and thus speed up the response. Fortunately, there are many promising techniques including text mining, text categorization, and ontologies that are helpful to automate some assessment works, as such, the average waiting time for a response could be reduced. The third limitation is that all subjects in this experiment are computer sciences (CS) majored; they had been familiar with intensive interactions with computer-based learning environments before participating the experiment and supposed to be more adaptable to various Web-based experimental environment, whether this have favourable effect on the evaluations needs further investigation in which recruiting a group of non-CS majored participants is appropriate.

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