Evaluating Feedback Efficiency in Learning Notification Express Delivery Service

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Abstract: Giving students suitable feedback information is one of the research issues in CAI. This research tries to evaluate if feedback did help in the course. For this purpose, this paper constructs an e-learning environment with feedback mechanism based on the previous research [10]. Students' learning activity will be recorded by the system and suitable feedback will be sent to students via short message or e-mail. There are four fifth grade classes participated the experiment. The experiment analysis contains two parts, the first one is evaluating the feedback efficiency for all groups; and the second part separates the students into three clusters based on their academic achievement.

Key-word : e-Learning, Petri Net, Feedback, Misconception

1 Introduction

The development of information technology makes both teachers and students get used to learning on Internet. They can use information communication technologies to help themselves getting more resources via web. [1] Teachers can easily manage their teaching materials on the web and spread the teaching materials out to students all over the world. [6][8][9] Students can also get suitable feedbacks when they are learning on the web. [3]

This paper tries to evaluate the feedback efficiency of a computer-based feedback mechanism, the Learning Notification Express Delivery Service. Section 2 introduces the learning feedback mechanism we use in this paper. Using this mechanism, this paper designs a workable system to support the delivery service in Section 3. Section 4 describes the experiment design and evaluates the experiment results. In the end, a simple conclusion and future works are described in section 5.

2 Learning Feedback Model

Petri-Net a diagrammatic tool for system analysis in state-oriented. [7] One of the e-learning application in Petri-net is learning flow control [5]. The e-learning flow control system takes different states to represent different web-based teaching resources; takes transitions and tokens as learning control rules. Chen (2004) used the Petri-net to analyze the experiment procedure in the virtual experiment environment [2][4]. The virtual experiment environment uses Petri-net to monitor student's experiment process and diagnose what mistakes that a student made during the experiment process.

A learning activity sequence can be modeled by a Petri-Net. Figure 1 shows a practical learning activity example, "Delivering Homework". When a token is at s_1, the student has no homework. After teacher assigns homework (t_5), the token is then transited to s_2 (have homework). If the student delivers his/her homework on time (t_8), the token goes to s_4 (homework finished). Otherwise, if the student does not finish the homework before the deadline (t_6), the token goes to s_3, the "Homework Tardiness" state.
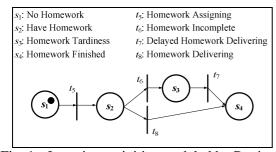
s_1: No Homework t_5: Homework Assigning
s_2: Have Homework t_6: Homework Incomplete
s_3: Homework Tardiness t_7: Delayed Homework Delivering
s_4: Homework Finished t_8: Homework Delivering

Fig. 1   Learning activities modeled by Petri-net

In recent research, Wu *et al.* (2006) designed some additional states and transitions into the original Petri-net-based learning activity in order to develop a learning notification express delivery service [10]. This learning notification express delivery service knows what kind of information should inform the student based on what state the student is in. Fig.2 shows additional two states and three transitions which are added into the original Petri-net and insert between the transition t_{n+k} and the destination state s_j, where s^r_{n+k} is a state to check whether the notification rule used by the transition t_{n+k} is activate or not. If there is no rule here, the token would be able to go to the destination state s_j through the transition t^{nr}_{n+k} ("nr" means there is no rule); if there is any rule for the transition t_{n+k}, the token would be sent to the state s^f_{n+k} through the transition t^{hr}_{n+k} ("hr" means there is notification rule(s) for the transition t_{n+k}). s^f_{n+k} is a decision state which decides what notification rule for t_{n+k} should be fired. After the learning notification express delivery service sends a short message to the student via mobile phone, the token then goes to the destination state s_j automatically through the transition t^f_{n+k}.
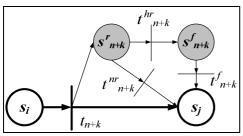
Fig. 2   Example of the learning notification process

To make teachers feel comfortable to use the service, Wu's research also designed a learning planner used for giving teachers a user friendly interface which allows teachers constructing their own teaching schedule easier. Learning planner consists two parts include the learning flow controller and feedback setting panel.

1. Learning flow controller:
   The learning flow controller takes responsible for the timing trigger of transitions. If the token

has only one choice to go to the next state, for example, if the token stands at s_1 in Fig. 3, the controller only needs to consider one timing for delivering token from s_1 to the transition t_5 at the check point c_1. If there are two or more choices for the token such like the state s_2, the controller needs to consider triggering transition t_6 or t_8 at check point c_2.

2. Feedback setting panel:
   Since the notification rules are stored in the Petri-net-based system just like Fig.2 shown, teachers should have privilege to decide and set the notification rules for each transition. A variable, f_{n+k}, is used to indicate whether the notification action should be activated or not.
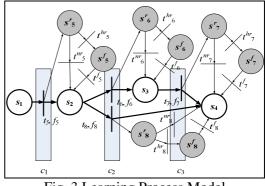
Fig. 3 Learning Process Model

Fig.3 is a learning process model and fits the example mentioned in Fig.1. The bold lines represent the main learning process; the additional states and transitions are used for the learning notification express delivery service. The symbols are:

s_1:   No Learning Activity.
s_2:   Execute Learning Activity.
s_3:   Redeem Activity.
s_4:   Learning Activity Finished.
t_5:   Activity Start.
t_6:   Activity Incomplete.
t_7:   Redeem Activity Complete.
t_8:   Activity Complete.
c_1:   Check point of t_1.
c_2:   Check point of both t_2 and t_4.
c_3:   Check point of t_3.
$f_5 \sim f_8$:   Notification action flags (correspondent with transitions $t_5 \sim t_8$).

Table 1 is a learning plan example according to Fig. 3. The first column is the parameters needed in the learning process model and the second column is an example. The first two parameters (title and content) are the learning plan descriptions. The learning flow controller uses the three check point settings inside

the bold table frame.   The rest parameters are notification action flags.   If teachers do not want the service delivers learning notification to students at a transition, they could un-check the correspondent notification action flag.

Table 1 Example of "Homework" learning activity

Parameters	Value
Title	Homework 1
Content	Finds out three types of notebook.
Start Time (c_1)	2006/01/10
End Time (c_2)	2006/01/13
Redeem Deadline (c_3)	2006/01/16
Activity Start Notification (f_5)	☑
Activity Incomplete Notification (f_6)	☑
Redeem Notification (f_7)	☐
Activity Complete on time Notification (f_8)	☐

3 System Design

Based on the previous research of feedback mechanism mentioned in Section 2, this research realizes the learning notification express delivery service.   This delivery service is used for providing information to students or their parents about their learning status, their next learning activities, and even reminder notes.
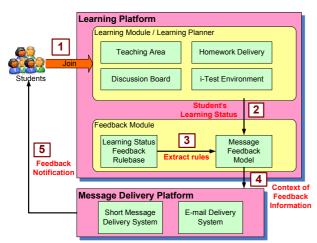

Fig. 4   The architecture and flowchart of the Learning Notification Express Delivery Service

Fig.4 shows the system architecture and flowchart of the Learning Notification Express Delivery Service.   Two major platforms are designed for this system, which are learning platform and message delivery platform. The learning platform provides various learning tools for students during different learning activities; learning platform also records students' activities; and also, the learning

platform will make decision about what kind of feedbacks it needs sending to a student according to his/her learning status.   The feedback will be sent via the message delivery platform; the delivery platform will send feedbacks with different ways such as short messages and/or emails according to the preferences of students and their parents.

For this purpose, the learning platform in the delivery service has two modules, Learning Module and Feedback Module.   Learning Module supports many e-learning activity tools, such as "Teaching Area" for students to read teaching materials; "Homework Delivery" for students to upload their homework; "Discussion Board" for students to discuss different issues in the lesson; and, "i-Test Environment" for students to do online tests.   All these learning activity tools are managed by the Learning Planner which is the main function of the Learning Module.   Teacher can use the Learning Planner to arrange a learning activity sequence and students can easily see what learning activities teachers planned for each course through the learning planner.

Feedback Module needs two important tools to decide when is the suitable time giving students feedback, the two tools are "Learning Status Feedback Rule-base" and "Message Feedback Model".   The "Learning Status Feedback Rule-base" grasps the student's status from the learning planner and finds out if there is any suitable feedback rule for the student.   If there is a suitable feedback rule, the corresponding feedback would be generated and sent to the "Message Feedback Model".   The model will create a personal message which is preparing for sending to the student by the message delivery platform.

The message delivery platform can send messages to various devices with different formats, for example, the platform can use short message delivery system to send text-format feedback to mobile phone and use email delivery system to dispatch rich-text emails.   With this platform, the constructed feedback messages from the learning platform can easily deliver to different kinds of devices based on the teacher's needs, student's capability (whether the student has email account/mobile phone or not), and parents' thoughts (sometimes short message will interrupt their regular jobs).

Fig. 4 also demonstrates a simple flowchart. At the first step, students follow the learning planner's instructions to do learning activities. During this time, the system will record student's personal learning status.   These data will be used by feedback mechanism in the next step.   At step 2,

"Message Feedback Model" gets needed information from Learning Planner in order to determine which feedback information that the student should receive. After that, "Message Feedback Model" tries to find out if there is any suitable feedback rule from "Learning Status Feedback Rule-base" (step 3).

With the retrieved rules, the "Message Feedback Model" produces a personal feedback message automatically and sends the constructed message to "Message Delivery Platform" (step 4). In the end, those feedback messages could be transmitted by sending text-format information to mobile phone or rich-text information in e-mail to students (step 5).

Fig.5 is a snapshot of the Learning Planner what a student will see after he/she logs into the system. The Learning Planner lists all learning activities of the lesson unit. Each learning activity has its deadline set by teachers in advance. Students can follow the schedule to do learning activities by themselves.

Fig. 5 The Students' View of Learning Activity in Learning Planner

When the deadline of each learning activity is coming, the "Message Feedback Model" constructs suitable message and asks Message Delivery Platform to send the message to the student or his/her parents. Fig. 6 is a photo of short message in cell phone sent by "Short Message Delivery System". This message send to parents to ask them reminding their kids the test few days later.

Fig.6   An example of the feedback message to parents by mobile phone.

4. Experiment and Evaluation

We designed an experiment to make sure that whether the feedback message could really improve the student's learning effect or not. The experiment involved two groups, experiment group and control group. The experiment course was fifth grade Math and it took seven weeks. There were 128 students in four classes participated the experiment. Each group had two classes.

The learning activity was on-line test. In the beginning of the class, teacher gave both of experiment and control group students the quiz schedule during the experiment period. Experiment group students would receive short message three days before the quiz, but the control group students wouldn't. Fig.7 illustrates the experiment process for both control group and experiment group.
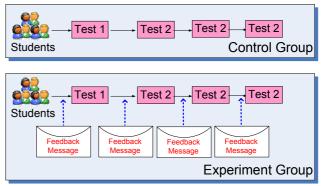

Fig.7   Experiment for both control and experiment groups

The misconception number can be seen as an index for getting the idea about the feedback effect. Take Table 2 as example, the first column shows the concepts covered in all online tests; the second and third columns record how many mistakes that a student make for the 1st and 2nd online tests in percentage; and, the last column calculates the difference between two online tests.

Table 2.   A student's with feedback the variation of mistaken concepts percentage.

Concepts Covered in All Tests	1st Test	2nd Test	1st Test – 2nd Test
Quadrilateral	0.26	0.06	0.20
Straight line	0.00	0.00	0.00
Line segment	0.00	0.25	-0.25
Relation of two lines	0.33	0.00	0.33
Square	0.00	0.00	0.00
Rectangle	0.25	0.00	0.25
Parallelogram	0.33	0.00	0.33
Trapezoid	0.33	0.00	0.33
Diamond	0.25	0.00	0.25
Average	0.19	0.03	0.16

For example, if a test sheet has 4 questions which testing students whether they understand the concept of Rectangle.   Student A has 1 incorrect answer in the domain of Rectangle in the 1st online test, hence, the "Rectangle" concept's "1st Test" column value is 0.25.   Furthermore, if student A has no incorrect answer to the Rectangle domain in the 2nd online test, then the correspondent column value is 0.00.   The difference for the Rectangle is 0.25, and the difference presents that student A's misconception in the Rectangle domain is decreasing.

By using the measurement described above, we applied T-test to see whether the learning efficiency of the experiment group students would higher than the control group students or not.   The results of the T-test are represented as Table 3.   The cell value equals to one means that the average learning effect of the "row" group is worse than the "column" group in column.   On the other hand, if the cell value equals to zero means that the average learning effect of the "row" group is better than the "column" group.

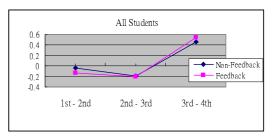Table 3.   T-test results of experiment and control groups

(a)		Control	Experiment
	Control	0	0
	Experiment	1	0

(a) 1st – 2nd test

(b)		Control	Experiment
	Control	0	1
	Experiment	0	0

(b) 2nd – 3rd test

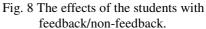| (c)		Control	Experiment
	Control	0	1
	Experiment	0	0

(c) 3rd – 4th test

From Table 3(a) we can find out that the average learning effect of experiment group students is not better than the control group students.
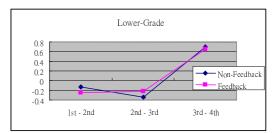
However, from Table 3(b) and 3(c) we find that the average learning effects of experiment group students are better than the control group students. The reason that the feedback effect does not show up might because students need time to adapt using the feedback service.
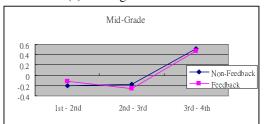
Another way to analyze the experiment data is to calculate the average difference between two tests.   Fig. 8 shows the average percentage of decreasing misconceptions (in y-axis) between 1st and 2nd test, 2nd and 3rd test, and 3rd and 4th test (in x-axis).   Though the experiment group has worse result when evaluating the difference between 1st test and 2nd test, their misconceptions are decreasing fast after the 2nd test.

Fig. 8 The effects of the students with feedback/non-feedback.

(a) lower-grade students

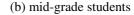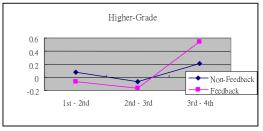(b) mid-grade students

(c) higher-grade students
Fig. 9 The effects of the students with feedback/non-feedback in different clusters.

Fig.9 separates both experiment and control groups into three clusters according students' grade in the last semester, the lower-grade students got C in the last semester; the mid-grade students got B; and, the higher-grade students got A. Fig .9 (a) and (b) show that the feedback mechanism may not have efficiency to the lower-grade and mid-grade students. However, the higher-grade students gain the advantages from the feedback mechanism after several quizzes.   That means this feedback mechanism is much useful for higher-grade students.

5. Conclusion

This paper implements a web-based system for supporting Learning Notification Express Delivery Service to students. The experiment results show that feedback information can help students if we provide a long-term feedback service. Moreover, the higher-grade students can get more advantages from the feedback service than the mid-grade and lower-grade students.

Though the experiment is not very evidently in the mid-grade and lower-grade students, we need some further researches to help us discussing this issue. First of all, the student characteristics should also put into the rule-base of the feedback mechanism. Furthermore, there might be a student type in which students do not like the feedback message. And of course, the feedback message could also be improved by giving not only reminder information but something about the domain of the learning activities.

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