A way of measuring learner's ongoing changes of interest and comprehension

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Abstract This study conducted to tried to find a way of on-line assessment of learner's interest and comprehension during interactive learning process. The result of experiment confirmed that learners' behavior patterns acquired from log data could be good predictors of learner's level of interest and comprehension in actual performance on KORI program. To predict learning outcome depending on the behaviors of individual learners, self-efficacy and mastery goal orientation were measured as individual differences. Then, participants were asked to use TA program KORI program at home for ten days and their response patterns were recorded through network. After using KORI, the levels of interest and comprehension were measured. As the result of multiple regression analysis, each learner's interest and comprehension were predicted depending on the combination of log data captured on real-time. This prediction process was done differently depending on learners' characteristics. Since equations which predict learners' interest and comprehension are different depending on learners' characteristics, differential interfaces should be provided depending upon changes in their level of interest and comprehension.

Key words: **Intelligence tutoring system; teachable agent; on-line assessment; interest; comprehension; and individual difference**

This research was supported as a Brain Neuroinformatics Research Program sponsored by both Minister of Commerce, Industry, and Energy and BK21 Grant funded by the Korean Government.

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1. Introduction

Intelligent tutoring system (ITS) has been widely used as part of an effort to enhance learning. In increasing cognitive skills and abilities, it is effective to provide systematic and well-informed instruction (Chen, Lee, & Chen, 2005). Yet, it hasn't been successful in enhancing motivation with previous ITS. Even though importance of motivation affecting persistence on learning and its outcome has been acknowledged, motivational aspect has been ignored in ITS for years. According to Deci and Ryan (1987), learners could be motivated and feel interest when they take an active role in autonomous environment. ITS, however, gave a fixed and passive role to learners. Receiving instructions from the computer is what learners do in traditional ITS. Therefore, its effects were limited in enhancing motivation to be involved in the program and learning.

Furthermore, in spite of its importance on learning process, individual differences have not been considered. Researchers found weaknesses of ITS in that it could not be applied for the entire user. ITS caused different effects on various types of users. In other words, ITS was useful to develop cognitive ability only for the motivated learners (Beal, Qu, & Lee, 2006). When users have interest and are motivated to learn, their later performance had increased. However, this is not the case for the unmotivated students. They are not interested in learning process and do not show considerable increase on performance. Also, some students find easy way to get better performance with not putting much effort and not focusing on learning itself (Walonoski, & Heffernan, 2006). Therefore, not only conducing active engagement of learners but also considering individual differences are highly required in order to design adaptive ITS.

To overcome the limitation of conventional ITS and to have positive effects on all of the learners, KORI (KORea university intelligent agent) was developed. Instead of assigning a role as a passive receiver, an active role was given to the learner. To achieve this goal, the concept of teachable agent was applied in KORI program. Teachable agent (TA) which is a new concept of intelligent agent was developed (Biswas, Schwatrz, Bransford, and TAG-V, 2001). Students teach the computer agent with the instructional method called 'learning by teaching' in TA. Teachable agent applied in KORI generally has two strong points.

First, as mentioned above, it offers learners active role as a teacher. Dynamic participation and deeper engagement is expected in this system. They don't follow a designed and planned computer program. Instead they set goals by themselves and plan the sequences of learning resulting in more thorough learning. KORI program is, therefore, distinguished from other traditional intelligent tutoring system in that the learners take responsibility on their learning processes and outcomes. In KORI program, the user became a teacher taking great responsibility and engagement, and learning could occur naturally in the process of teaching KORI.

Second, KORI program deals with individual differences in cognition. In face-to-face peer tutoring, when a tutor has less knowledge on the subject than a tutee, the tutor could easily feel anxious and lose competence on teaching and learning. However, teachable agent gives easier accessibility to get more information, so that individual differences were taken into account. In KORI program, the strength of TA was applied to overcome individual difference on diversity of knowledge level. That is, a mine of information was clearly arranged, so the user could find the information they need without putting a lot of effort. In addition, the information was able to access whenever the user required. Therefore, the user did not feel shame even if they have little knowledge, and they could learn from the provided information before teaching the agent.

It has been proven from various experiments that KORI, by applying TA is a powerful program to enhance not only interest and motivation of the subject but also cognitive ability and performance. That is, learning by teaching method was useful to enhance interest and comprehension (Lee et al., 2005). However, the positive effects of KORI could vary from learners to learners and if individual differences considered, the positive impacts that have on learners' interest and comprehension might be maximized. For instance, a student who has confidence might dislike easy activity, and providing challengeable task would help to increase interest more. Therefore, considering different prior knowledge level of learners is not enough to improve the positive effect of the program. Individual differences should be more considered to guarantee the positive result to all of the learners with diverse characteristics. Diverse needs of learners should be satisfied by taking learners' perspective (Nikolova, & Collis, 1998).

Thus, revised version of KORI was developed

considering individual differences in motivational aspects. Motivation theories such as goal orientations and self-efficacy provide good guidelines to predict their behaviors in learning situation (Yi & Hwang, 2003). Mastery orientated people's prior focus is mastering the task. They tend not to be afraid of failure, seek to learn new materials and show high persistence in learning (Dweck & Leggett, 1988). Thus, for this type of learners, letting them focus on the learning itself and providing abundant knowledge is recommend. When people have high self-efficacy, they have confidence on the tasks and anticipate challengeable tasks more (Bandura & Schunk, 1981). Hence, creating more successful experience in challengeable tasks might improve self-efficacy of the learner. *

However, certain activities can be valuable for some people, while others react negatively. For mastery oriented students, for example, additional resources are important to increase their interest. On the other hand, it might harm motivation of low self-efficacy students making them nervous. For them, showing the minimal information by increasing probability of success will help to enhance motivation. (In addition, although providing additional information may increase interest of mastery oriented students, but it might not be useful when they already have enough level of interest. For that reason, offering appropriate activities at a proper time is essential in designing an adaptive individualized program. In other words, TA should provide appropriate learning activities to each individual learner adaptively, reflecting ongoing changes of interest and comprehension during learning activities.

If interest and comprehension can be predicted based on real-time log behavior, appropriate activities to increase interest and comprehension can be given. To provide appropriate activities for each individual at a proper time, the way to predict the actual level of interest and comprehension was explored in this study.

2. Experiment

The experiment was conducted in order to predict user's interest and comprehension with the log data which was obtained when they use KORI program. Depending on individual differences such as self-efficacy and mastery goal orientation, it was expected to show different behavior patterns which indicate their level of interest and comprehension. Therefore, individual differences on self-efficacy and mastery goal orientation were assessed. In order to observe users' behaviors, log data was collected while they used KORI program. In addition, their actual level of interest and comprehension were assessed.

2.1 Method

2.1.1 Participants

The sample consisted of 87 fifth graders (48 males, 39 females) in elementary school.

2.1.2 Material

KORI (KOREa university Intelligent agent) was used in this study. KORI is an intelligent teachable agent which was designed to enhance user's motivation and interest to learn. It has a narrative structure to make the user engage in learning material. The user's autonomy and self-determination is also emphasized and immediate feedback is provided to enhance their motivation. As shown in figure 1, for example, users select a place to get specific rocks, and build a town with collected rocks which were given as reward of teaching KORI.

Figure 1: KORI program

The context of KORI is composed of 'rock and rock cycle'. Users are supposed to learn 'rock and rock cycle' using learning by teaching method. If they teach KORI well with a correct concepts and knowledge, they can collect different kinds of rocks. To build a wonderful town with collected rocks at the end, they are encouraged to learn more and teach well.

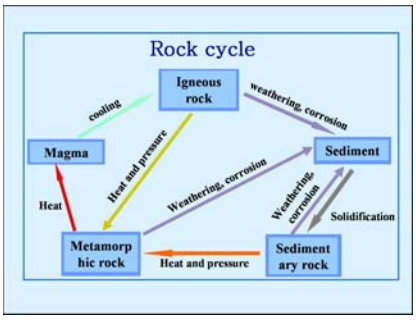

Figure 2: The context of 'rock and rock cycle'

2.1.3 Procedure

Before the experiment, self-efficacy and mastery goal orientation of all participants were measured for ten minutes. Then, participants were informed how to use KORI program for 20 minutes. After explanations, to make sure that they have understood fully how to use KORI, additional 20 minutes were given to explore KORI program by themselves. Participants were asked to use KORI program at least 20 minutes every day and were confirmed to use only at home.

During experiment period, they downloaded KORI program on the internet as instructed, and used it in free time at home. While users used KORI program, log data was collected in real-time. The experiment lasted for 10 days.

After the experiment, their level of interest was examined. In addition, comprehension on 'the rock and rock cycle' was evaluated.

2.1.4 Measures

For individual differences, self-efficacy and mastery orientation was assessed. Kim and Park's self-efficacy questionnaires (2003) were used. It consists of 10 statements, and they were adjusted for children. The reliability of self-efficacy measure was α =.87. Mastery orientation was measured using subscale of achievement goal orientation questionnaires (Park & Lee, 2005). It includes 7 statements and was adjusted for elementary school students. Its reliability was α =.72.

Learning outcome such as task interest and comprehension was evaluated as dependent variables. Task interest questionnaires contained 14 statements which taps interest of KORI program as well as contents of the 'rock and rock cycle' such as "The contents of rock and rock cycle were interesting." The reliability of interest measure was α =.89. Comprehension test was designed to ask about 'rock and rock cycle'. It includes 15 statements with multiple choice and short answer question. The reliability was α =.76.

Log data was collected through the network, whenever users used KORI program. It was obtained by each user and contained the information of time used and frequency of diverse behavior by stages during the whole period of the experiment. For analysis, log data up to third rotation were averaged.

2.1.5 Data Analysis

Participants were divided into 4 groups with two individual differences by median split. Those are high mastery goal & high self-efficacy (group A), high mastery goal & low self-efficacy (group B), low mastery goal & high self-efficacy (group C), and low mastery goal & low self-efficacy (group D). The median of mastery goal was M= 3.43, and the median of self-efficacy was M=3.50.

For multiple regressions, correlations between behaviors and interest and comprehension were explored by each group in advance. Then, the correlated behaviors with later outcomes were used as independent variables of multiple regressions. To control for multicollinearity, variance inflation factors (VIF) of the independent variables over 10 were excluded (Myers, 1990). SPSS/PC 12.0 program was used for the analysis.

2.2 Results

As the result of multiple regressions, various behaviors from different groups were found to be predictors of their interest and comprehension. Independent variables appeared in the order in which they were entered into the model.

As shown in table 1, in high mastery goal & high self-efficacy group (group A), the independent variables significantly explained 32% of the variance in interest (R^2=.32, F=6.07, p<.01). X_1 (standardized β = -.49, p<.05) made a unique contribution to the prediction of interest. To predict comprehension of group A, the independent variables explained 40% of the variance in comprehension (R^2=.40, F=5.47, p<.05) and especially X_3 (standardized β = -.39, p<.05) significantly made a unique contribution.

Table 1: predictors for interest and comprehension in high mastery goal & high self-efficacy group

DV	IV	Beta	t
interest	X_1	−.49	−2.51*
	X_2	−.12	−.600
comprehension	X_3	−.39	−2.44*
	X_4	.23	1.28
	X_5	.35	1.94

*p<.05

Note. DV: Dependent variable / IV: Independent variable / X_1: Frequency of reteaching at teaching stage / X_2: Frequency of responding correct answers at bonus stage / X_3: Duration of using full map at merchant stage / X_4: Frequency of putting in new concept of rocks at drawing stage / X_5: Frequency of logging in KORI program

In high mastery goal & low self-efficacy group (group B), as shown in table 2, 53% of the variance in interest were explained with the independent variables (R^2=.53, F=5.72, p<.05). In group B, the independent variables explained 68% of the variance in comprehension (R^2=.68, F=10.69, p<.05). X_9 made a significant contribution (standardized β = −.39, p<.05).

Table 2: predictors for interest and comprehension in high mastery goal & low self-efficacy group

DV	IV	Beta	t
interest	X_6	−.61	−2.01
	X_7	−.16	−.52
comprehension	X_8	.36	1.78
	X_9	−.60	−3.00*

*p<.05

Note. DV: Dependent variable / IV: Independent variable / X_6: Frequency of checking current rocks at traveling section / X_7: Frequency of checking current rocks at first trip-plan stage / X_8: Frequency of responding correct answers at merchant stage / X_9: Duration of staying at bonus stage

In high mastery goal & high self-efficacy group (group C), as shown in table 3, the independent variable significantly explained 35% of the variance in interest (R^2=.35, F=5.30, p<.05). X_{10} made a significant contribution (standardized β = .59, p<.05). In comprehension, the independent variable explained 37% of the variance (R^2=.37, F=5.80, p<.05). X_{11} (standardized β = .61, p<.05) significantly made a contribution.

Table 3: predictors for interest and comprehension in low mastery goal & high self-efficacy group

DV	IV	Beta	t
interest	X_{10}	.59	2.30*
comprehension	X_{11}	.61	2.41*

*p<.05

Note. DV: Dependent variable / IV: Independent variable / X_{10}: Duration of staying at first building stage / X_{11}: Frequency of traveling

In low mastery goal & low self-efficacy (group D), the independent variables significantly explained (R^2=.58, F=2.29, p<.05) 58% of the variance in interest (Table 4). In comprehension, the independent variables explained 54% of the variance (R^2=.54, F=6.41, p<.001). X_{24} (standardized β = .36, p<.05) and X_8 (standardized β = .40, p<.05) significantly contributed to the prediction of comprehension.

Table 4: predictors for interest and comprehension in low mastery goal & low self-efficacy group

DV	IV	Beta	t
interest	X_{12}	−.02	−.10
	X_{13}	−.34	−2.00
	X_{14}	−.04	−.11
	X_{15}	.38	1.77
	X_{10}	.12	.42
	X_{16}	.46	1.58
	X_{17}	−.02	−.05
	X_{18}	.07	.42
	X_{19}	.12	.36
	X_{20}	.32	1.45
	X_{21}	.06	.28
	X_{22}	−.40	−1.38
comprehension	X_{23}	.16	1.12
	X_{24}	.36	2.38*
	X_{25}	.21	1.39
	X_8	.40	2.61*
	X_{26}	.13	.92

*p<.05

Note. DV: Dependent variable / IV: Independent variable / X_8: Frequency of responding correct answers at merchant stage / X_{10}: Duration of staying at first building stage / X_{12}: Frequency of using program in inappropriate way at traveling section / X_{13}: Frequency of avoiding detailed explanation at

question stage / X_{14}: Frequency of revising concept of rocks at second drawing stage / X_{15}: Frequency of failing to change rocks at third conversion stage / X_{16}: Duration of staying at third building stage / X_{17}: Frequency of responding correct answers at third conversion stage / X_{18}: Duration of staying at trip-plan stage / X_{19}: Duration of staying at building stage / X_{20}: Frequency of the correct answers ratio at second conversion stage / X_{21}: Frequency of the correct answers ratio at third conversion stage / X_{22}: Frequency of revising concept and relation of rocks at second conversion stage / X_{23}: Duration of staying at first trip-plan stage / X_{24}: Frequency of using program in inappropriate way at first trip-plan stage / X_{25}: Duration of staying at question stage / X_{26}: Frequency of using program in inappropriate way on KORI program

Equations to predict interest and comprehension of each group were drawn. The equations of four groups are listed in table 5.

Table 5: equations to predict interest and comprehension

Group	Equation
high mastery goal & high self-efficacy (N=29)	Interest (Y) = $-.49X_1 - .12X_2 + 3.43$
	Comprehension (Y) = $-.39X_3 + .23X_4 + .35X_5 + 13.55$
high mastery goal & low self-efficacy (N=13)	Interest (Y) = $-.61X_6 - .16X_7 + 4.09$
	Comprehension (Y) = $.36X_8 - .60X_9 + 14.17$
low mastery goal & high self-efficacy (N=12)	Interest (Y) = $.59X_{10} + 2.50 = .35$
	Comprehension (Y) = $.61X_{11} + 12.57$
low mastery goal & low self-efficacy (N=33)	Interest (Y) = $-.02X_{12} - .34 X_{13} - .036X_{14} + .38X_{15} + .12X_{10} + .46X_{16} - .02X_{17} + .07X_{18} + .12 X_{19} + .32X_{20} + .06X_{21} - .40X_{22} + 2.56$
	Comprehension (Y) = $.16X_{23} + .36X_{24} + .21X_{25} + .40X_8 + .13X_{26} + .49$

3. Conclusion

This study was conducted to provide appropriate activities for each individual who has ongoing changes of interest and comprehension in learning process. Thus, the way to predict the actual level of interest and comprehension of learners was explored.

This study confirmed that learners' behavior patterns acquired from log data could be good predictors of interest and comprehension in actual performance on KORI program. That is to say, it is possible to provide different learners an each adequate learning program enhancing their interest and comprehension since ongoing changes of their learning outcomes are tracked down. For example, if people showed certain behaviors indicating low level of interest, interfaces can be adjusted in the way of increasing their interest. Moreover, even if both learners show low level of interest and comprehension, the interface should be offered differently depending on individual difference. That is, the interfaces for high self-efficacy people should be differed from those for low self-efficacy people. Consequently, it will bring great learning outcomes to all different users of KORI in both cognitive aspects and motivational aspects.

In this study, mastery goal orientation and self-efficacy were explored as one of the individual differences influencing on motivation and learning process. However, there are other important individual differences which should be considered in learning process. For example, metacognition might affect learning outcome. Metacognition is an essential skill to plan learning process and to understand learning material completely. When certain learners showed low level of performance and comprehension, metacognitive knowledge and skills should be developed by providing many challenging learning experiences (Ormrod, 1995).

Furthermore, additional researches are required to provide more helpful solutions to enhance learners' motivation (Wild, & Quinn, 1998). There are not enough researches on how motivation and interest develop. Especially there are little findings on what kind of activities and interfaces are effective to increase interest for certain kinds of individual characteristics. Only with abundant theoretical backgrounds, all the suggestions made in this research regarding enhancement of interest through TA can come into realization.

3.1 Acknowledgments

This research was supported as a Brain Neuroinformatics Research Program sponsored by Minister of Commerce, Industry and Energy and by the second stage BK21 Grant funded by the Korean Government.

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