Enhancement of Learning Experience Using Skill-Challenge Balancing Approach

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Abstract. This paper addresses the issue of content sequencing in computer-based learning (CBL). In doing so, it proposes a Skill-Challenge Balancing (SCB) approach as a way to enhance the CBL experience. The approach is based on the Flow Theory, allowing self-adjustment of the given levels of challenges in a given learning tasks so that the learner will consistently be adaptively able to engage in the CBL activity. An empirical study with 70 students suggested that the SCB-based learners were significantly better in their learning experience specifically in their focus of attention and intrinsic interests compared to the learners in the system without SCB. The results also revealed that SCB was fully utilised by the learners to regulate the levels of difficulty of the CBL tasks.

Keywords: Flow theory, learning experience, skill-challenge balancing, computer-based learning.

1 Introduction

Content sequencing is a common topic of research in the area of computer-based learning (CBL). The basic idea of content sequencing is to help learners to find an appropriate learning path which meets certain factors such as their prior knowledge, learning style and preferences [1]. The sequencing technique is mainly achieved using some computational methods and artificial intelligence (AI) techniques such as genetic algorithm [1], particle swam optimisation [2], rule-based [3], and neural network [4]. There is no doubt that the sequencing techniques are robust in organising learning contents; however, little is known about the effectiveness of the complex techniques in the real CBL setting. To be precise, the answer to the question '*do the techniques improve cognitive engagement in performing CBL tasks?*' is still elusive.

To address this issue, we performed an empirical study to understand the effectiveness of the content sequencing approach with regard to the learning experience [5, 6]. We assumed that the content sequencing approach would be able to partially optimise CBL experience, via balancing between the learner's skills or knowledge against the challenges given by the system.

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2 Learning Experience and Flow Theory

In the context of CBL environment, learning experience is an important factor that reflects the acceptance, adoption and future use of the systems [7]. CBL systems must be able to improve learners' performance and give them a personally satisfying experience so that the systems could sustain. A number of studies had already investigated the CBL experience, e.g., [8, 9]. Our approach in this study is to some extent different from the previous studies. This article uses the results of our previous studies [5, 6] in order to develop a pragmatic method to improve the CBL experience.

We adapted Csikszentmihalyi's *Flow Theory* [10, 11] as the basis to define CBL learning experience. It is also an underlying principle for developing the Skill-Challenge Balancing technique as described in Section 3. Basically, the theory suggests the flow condition; a mental state in which a person is totally absorbed in a particular activity. The flow condition gives a person a very rewarding experience and a feeling of enjoyment which is called '*optimal experience*'. Optimal experience is believed to be an important factor to improve human quality of life and achieve happiness. In the context CBL, optimal experience gives learners with enjoyable learning experience that subsequently fosters independent learning.

In spite of flow, both boredom and anxiety are two opposite mental states that could change the quality of learning experience. These three mental states are identified through assessment of one's current levels of skills against the given levels of challenges of an activity. Figure 1 shows four points of the mental states (A_1, A_2, A_3, and A_4) that one may experience when engaging in a learning activity. The *flow* state is achieved when there is a balance between one's skills and the given challenges. The states are represented by points A_1 and A_4 in Figure 1. When a person's levels of skills are not sufficient to satisfy the given levels of challenges, he or she is in the state of *anxiety* (i.e. A_3). If a person has a high level of skills, a low level of challenges given to him or her can cause *boredom* (i.e. A_4). In order to obtain *flow*, a balance between the given levels of challenges and one's skills is required.

Flow Theory emphasises that an equal skills and challenges is the key principle to achieve the optimal experience. For this reason, we exploited the theory to develop the *Skill-Challenge Balancing (SCB)* approach, which is a new method to improve the CBL experience.

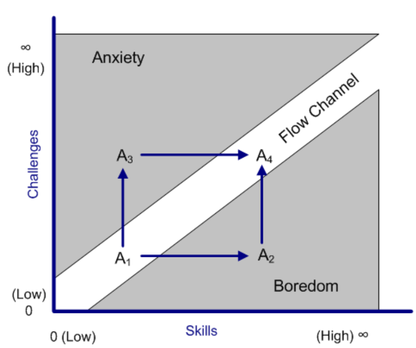

Fig. 1. Changes of mental states based on Flow Theory

3 Skill-Challenge Balancing Approach

The aim of the *Skill-Challenge Balancing* (SCB) approach is to improve interactions between learners and CBL systems so that learners obtain satisfying and engaging CBL experience. The SCB is developed based on one of the flow theory's assumptions that optimal experience could be achieved when the level of the given challenges matches the individual's level of skills. This paper attempts to answer *"how to incorporate the theory in the design of CBL systems"*

There are two approaches to serve this purpose: software-based [12-14] and hardware-based [15-17]. The hardware-based approach uses special devices or sensors for automatic detection of a person's affective states. Although the devices can accurately detect the affective states, they are very expensive and not yet available commercially. In contrast, the software-based approach seems to be more pragmatic as it is much easier, cheaper and feasible to be implemented using the existing computer infrastructure, thereby the underlying principle for our approach.

The main SCB concept is to allow a flexible adjustment of the given level of challenges. In CBL, the levels of challenges are characterised by the increasing level of difficulty of a learning content. In order to keep learners engaged, the given levels of challenges must always equivalent to learners' current level of knowledge. In doing so, the SCB technique allows learners to have self-assessment of their individual level of knowledge. Learners are given chances to evaluate whether the learning unit is too easy or too difficult for them. If a learner finds that the learning unit is too easy, he or she can choose to move forward to a higher level of difficulty of the learning unit. On the other hand, if the learner finds that the learning unit is too difficult, he or she can move backward to the lower level of difficulty of the learning unit.

Our approach introduces "*flow buttons*" in the CBL *user interface* to support the self-assessment capability. The buttons comprise of two types; the "*anxiety button"* comes along with the tutorial questions and the "*boredom button"* appears with the explanation of the concept. The tutorial questions are the tool to measure learner's current knowledge. The decision to move forward to a higher level is depending on the learner's answers in the tutorial session. The correct answers will direct the learner to a higher level of learning. In the case that the wrong answer is given, the learner will be presented with the explanation associated to the question.

The "*boredom button*" accompanies the tutorial questions with the purpose to avoid novice learners from lost in their learning path. As the difficulty level of learning is increasing along with the tutorial questions, the system forces the learners to answer the tutorial in order to move to a higher level so that their current levels of knowledge are accurate. The "*anxiety button*" appears along with the tutorial questions to allow learners to move backward to a lower level of learning. Hence, they will be able to browse the explanation for the question. Figure 2 shows the learning process with the present of the "*flow button*".

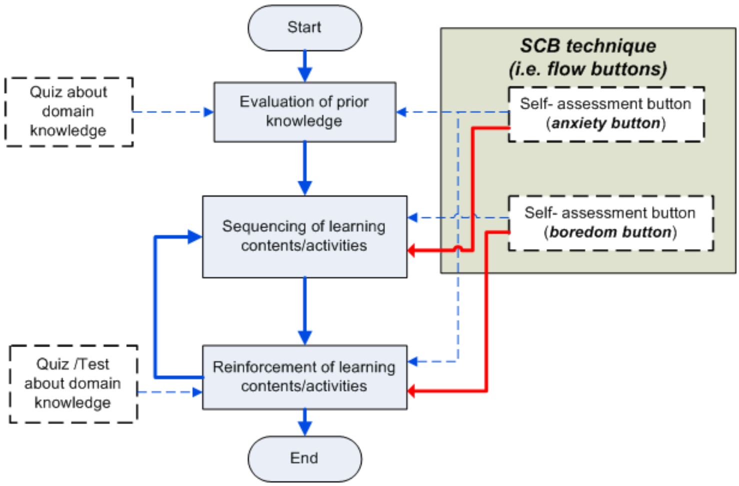

Fig. 2. SCB technique learning process

A prototype has been developed to demonstrate how the SCB technique would work with a realistic learning situation. In doing so, we reused most of the software components of the current version of IT-Tutor system [5, 6] including the user interface layout, the databases, and the functions. The prototype was developed within the .NET platform and set to be accessible through the Internet.

The implementation of "*flow buttons*" has been simplified to avoid confusion among learners. In doing so, more understandable words were used and printed on the buttons. In the case of the "*anxiety button*", the authors use the text "*Click here if you do not know the answer*". For the "*boredom button*", the text "*Click here if you think the section is too easy*" is used. The buttons in the red dotted line in Figure 3 and Figure 4 show the screen shot examples containing the "*anxiety button*" and the "*boredom button*", respectively. The interaction of these buttons with the domain knowledge repository is accomplished by a set of pre-programmed rules using the following algorithm:

```
Present the <tutorial questions>
If <the anxiety button> is pressed then
      Present the associated learning contents
      If <the boredom button > is pressed then
        Test <learner's current knowledge>
        If <learner's current knowledge> is <insufficient> then
             Give feedback to learner
                Present the sequence of learning contents
             Test <learner's current knowledge>
             If <learner's current knowledge> is <sufficient> then
                       Give feedback to learners
                 Proceed to the next level of <tutorial questions>
                 Test <learner's current knowledge>
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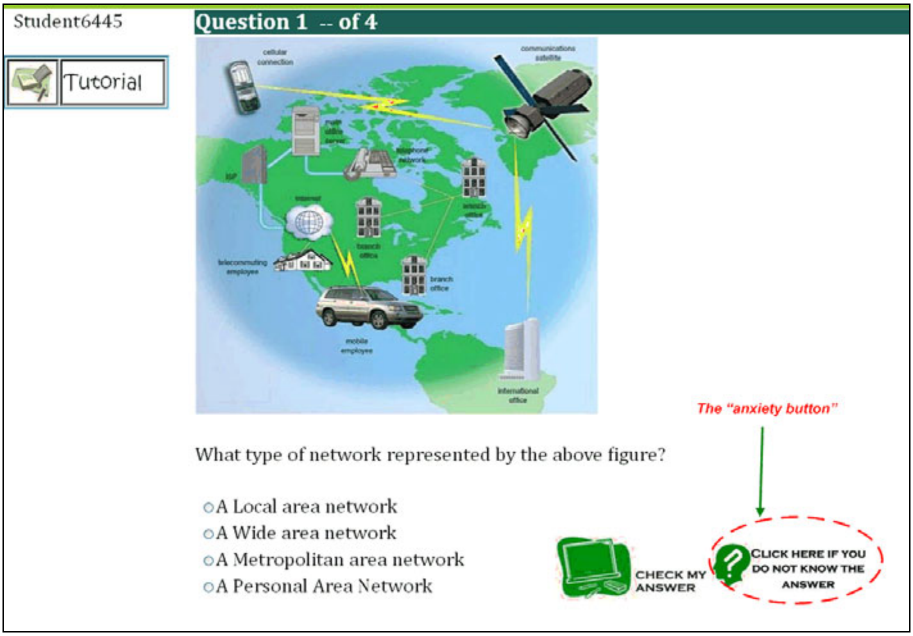

Fig. 3. The "*anxiety button*" in the IT-Tutor interface

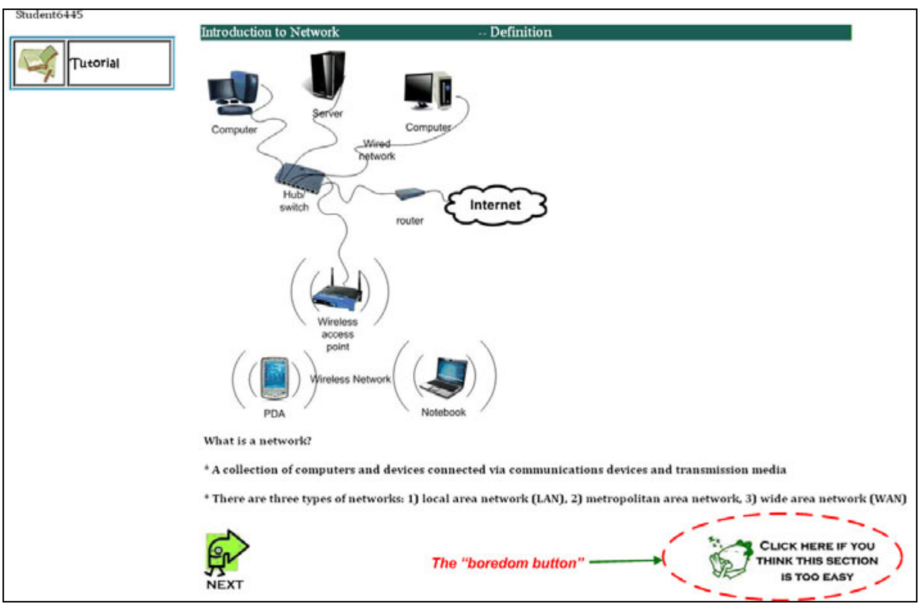

Fig. 4. The "*boredom button*" in the IT-Tutor interface

4 Evaluation of Skill-Challenge Balancing Approach

4.1 Method

Subjects

The subjects were recruited among students from two universities: Massey University (New Zealand) and Northern University of Malaysia through advertisements in the learning management systems of the corresponding universities for some selected courses. Ninety-two students participated on a voluntary basis. However, only seventy of them completed the given tasks. Among them were eighteen males and fifty-two females. 85% of the participants were students of Northern University of Malaysia with 80% of them were undergraduate students. The participants were randomly assigned into one of two groups (i.e. the experimental group and the control group). This experimental study was conducted between March and April 2011.

Apparatus

Two types of materials were used in this study: CBL systems and a set of questionnaire. The CBL systems were comprised of two types: IT-Tutor with SCB and IT-Tutor without SCB (i.e. the older version of the system as reported in [5, 6]). IT-Tutor with SCB was used by the participants of the experimental group, while the control group used IT-Tutor without SCB.

The tutorial session in both types of CBL systems comprised of four questions. As the SCB technique used a couple of "*flow buttons*" that allowed the learners to flexibly move between questions and explanations, the stages of the tutorial in this version of the CBL system was not transparent to the learners. On the other hand, the two stages of tutorial were clearly shown in IT-Tutor without SCB. From the two stages of the tutorial session, Stage 1 was used to evaluate learner's prior knowledge to generate a learning path for the learners, while Stage 2 of the tutorial served as a reinforcement stage.

A learning experience questionnaire was adopted from Park *et al.*[18]. It comprised of four components: demographic information (10 items), learning experience (12 items), and usability (2 items). For the usability questionnaire, it was adopted from Chiu *et al.* [19]. The learners were asked to rate their learning experience and usability questionnaire using 5-point Likert Scale (i.e. 1 represents strongly disagree and 5 represents strongly agree).

Experimental Design

A one-way between-subjects design was used in this study. The independent variable was the two *types of CBL systems* (i.e. IT-Tutor with SCB and IT-Tutor without SCB). The dependent variables were comprised of the *learning experience and usability*. For the case of IT-Tutor with SCB, we analysed the *SCB usage* in order to understand whether or not the "*flow buttons*" were effectively used by the learners.

Procedure

This study was conducted in an unsupervised online mode. All materials were pre-programmed in a form of a web application. The participants were given a URL (an Internet address) to access the materials. Firstly, they were given the research information sheet. As they consented to participate in the research, the system had randomly assigned them into one of two groups of the CBL systems. Then, they were redirected to the corresponding CBL systems. The learners were required to undergo a virtual tutorial session in the corresponding CBL systems and follow the given instructions as they were interacting with the system. As soon as the participants completed the tutorial session, they were given the questionnaire. All participants performed the tasks at their own paces and their own convenience. In order to retain the reliability of the study, the participant will be logged off from the system when they were inactive[1] for five minutes.

4.2 Results and Discussions

The demographic information analysis showed that the average age of the participants was 25.20 years with approximately 85% of them were aged 17 to 30. About 75% of them had more than 3 years experience in using the computer and at least 60% of them had used other CBL systems before. Apart from that, about 64% of the participants classified themselves as beginners, while the rest had learned about the course before. None of the participants classified themselves as experts in the area of the subject of this study (i.e. Computer Networks).

Learning Experience & Usability

The learning experience information was derived from the questionnaire. It was measured in four dimensions: control, attention focus, curiosity, and intrinsic interests. On the other hand, usability measured how useful the corresponding CBL systems in improving the learners' performance and the systems suitability with the learners' learning styles.

A series of *Kolmogorov-Smirnov tests* suggested that the data were not normally distributed. Hence, simpler non-parametric tests were used to analyse the data. The learning experience and usability data were relatively high in their internal consistency, and Cronbach's Alpha coefficient (0.828) confirmed this. The means and mean ranks for each dimension of the learning experience including usability were calculated and presented in Table 1.

Table 1 shows that the experimental group learners (i.e. IT-Tutor with SCB) rated higher in all dimensions of the learning experience and usability compared to that of the counterpart group. For IT-Tutor with SCB, intrinsic interests received the highest ratings (*3.90*), followed by usability (*3.87*), and curiosity (*3.68*). In contrast, attention focused (*3.25*) had received the lowest ratings among learners in this group. For the

[1] Inactive is the situation in which no interaction has occurred (e.g. no clicking buttons, no moving mouse, etc.)

Table 1. Means and mean ranks for the learning experience dimensions and usability

Dimensions of experience	IT-Tutor with SCB (n=35)		IT-Tutor without SCB (n=35)		Significant level
	Mean	Mean rank	Mean	Mean rank	
Control (CO)	3.42	39.07	3.13	31.93	(z=-1.498, p=0.136) n.s.
Attention Focus (AF)	3.25	40.36	2.86	30.64	(z=-2.041, p=0.041) p<0.05
Curiosity (CU)	3.68	37.66	3.52	33.34	(z=-0.902, p=0.371) n.s.
Intrinsic Interests (II)	3.90	40.34	3.58	30.66	(z=-2.020, p=0.043) p<0.05
Average experience	3.56	41.70	3.27	29.30	(z=-2.557, p=0.010) p<0.05
Usability	3.87	39.34	3.60	31.66	(z=-1.613, p=0.108) n.s.

other group (i.e. IT-Tutor without SCB), usability (*3.60*) had received the highest ratings, followed by intrinsic interests (*3.58*). The ratings for attention focus in the control group were also the lowest in the counterpart group.

In order to understand whether or not the SCB technique was effective in improving the learning experience, a series of *Mann-Whitney U* tests had been performed. The test results suggested that attention focus, intrinsic interests, and the overall learning experience for the IT-Tutor with SCB were significantly higher than the opposite group. Although the IT-Tutor with SCB ratings were higher for control, curiosity and usability compared to the counterpart, the differences were not statistically significant. Hence, it can be said that, the SCB technique improved learners' overall learning experience specifically from the context of their attention focus and intrinsic interests.

"*Flow buttons*" usage

The log data analysis showed that 77% (26 out of 35) students from the experimental group used the "*anxiety button*" with 34 hits in Stage 2 and 9 hits in Stage 1. For the case of the "*boredom button*", 34% of the students used this facility with majority accesses came from Stage 2 (i.e. 17 hits). The bar chart in Fig. 5 shows the hits of the buttons in the two stages of the tutorial. From the graph, it clearly shows that the "*anxiety button*" has been used extensively by the learners in comparison to the "*boredom button*". This could be justified by the demographic backgrounds of the participants which comprised of novice and intermediate learners.

The results suggest that the "*anxiety button*" allowed the learners to adjust the difficulty levels of the tutorial by moving backward to the lower one which consequently giving them a better learning experience. On the other hand, the "*boredom button*" helped learners to move to a higher level of learning to prevent them from becoming bored due to the familiar learning content. The analysis on the usage data had suggested that both buttons (i.e. the boredom button and the anxiety button) were needed by learners in order for them to adjust their own learning path flexibly.

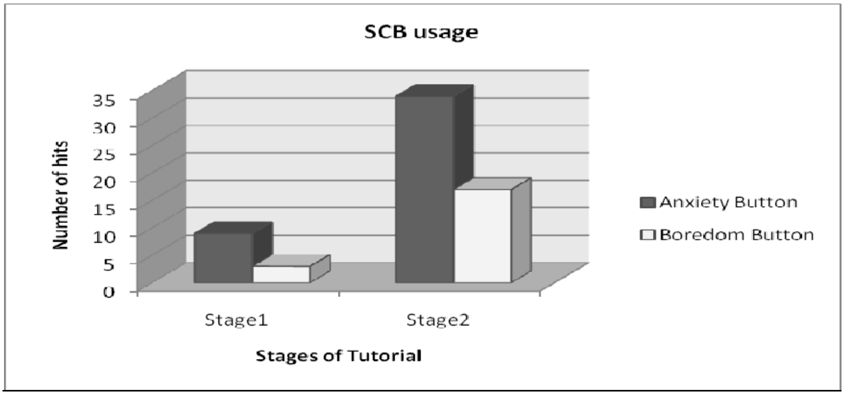

Fig. 5. The "*flow buttons*" usage according to the two stages of tutorial

5 Conclusion and Future Works

We have described in Section 3 and 4 of this paper about the SCB design and evaluation. In general, the SCB approach for sequencing learning content seemed to improve the overall learning experience in comparison to the older version of the content sequencing system. Given that no expert learners were recruited, the effect of the SCB is still not fully discovered. It is our plan in the near future to replicate the research by recruiting expert learners so that the effectiveness of SCB in managing learners with different backgrounds is known. The self-adjustment of levels of challenges seems to be an ideal approach to learners regardless of their prior knowledge in a particular domain. Through this way, it helps learners to engage in the learning tasks constantly which consequently giving them a pleasant learning experience.

References

1. Chen, C.M.: Intelligent Web-Based Learning System with Personalized Learning Path Guidance. Computers & Education 51(2), 787–814 (2008)
2. de Marcos, L., Martinez, J.J., Gutierrez, J.A., Barchino, R., Gutierrez, J.M.: A New Sequencing Method in Web-Based Education. In: IEEE Congress on Evolutionary Computation (CEC 2009), pp. 3219–3225 (2009)
3. Chi, Y.L.: Ontology-Based Curriculum Content Sequencing System with Semantic Rules. Expert Systems with Applications 36(4), 7838–7847 (2009)
4. Idris, N., Yusof, N., Saad, P.: Adaptive Course Sequencing for Personalization of Learning Path Using Neural Network. International Journal of Advanced Soft Computing Applications 1(1), 49–61 (2009)
5. Katuk, N., Ryu, H.: Finding an Optimal Learning Path in Dynamic Curriculum Sequencing: An Account of the Flow Learning Experience. In: 2010 International Conference on Computer Applications & Industrial Electronics (ICCAIE 2010), pp. 227–232. IEEE Computer Society, New York (2010)

6. Katuk, N., Ryu, H.: Does a Longer Usage Mean Flow Experience? An Evaluation of Learning Experience with Curriculum Sequencing Systems (CSS). In: Gupta, G.S., Bailey, D., Demidenko, S., Osseiran, A., Renovell, M. (eds.) Sixth IEEE International Symposium on Electronic Design, Test and Application, pp. 13–18. IEEE Computer Society, New York (2011)
7. Sun, P.C., Tsai, R.J., Finger, G., Chen, Y.Y., Yeh, D.: What Drives a Successful E-Learning? An Empirical Investigation of the Critical Factors Influencing Learner Satisfaction. Computers & Education 50(4), 1183–1202 (2008)
8. Deepwell, F., Malik, S.: On Campus, but out of Class: An Investigation into Students' Experiences of Learning Technologies in Their Self-Directed Study. Research in Learning Technology 16(1), 5–14 (2008)
9. Engelbrecht, E.: Adapting to Changing Expectations: Post-Graduate Students' Experience of an E-Learning Tax Program. Computers & Education 45(2), 217–229 (2005)
10. Csikszentmihalyi, M.: Beyond Boredom and Anxiety. Jossey-Bass Publishers, San Francisco (1975)
11. Csikszentmihalyi, M.: Flow: The Psychology of Optimal Experience. Harper & Row Publishers, New York (1990)
12. Leontidis, M., Halatsis, C., Grigoriadou, M.: Mentoring Affectively the Student to Enhance His Learning. In: Aedo, I., Chen, N.S., Kinshuk, Sampson, D., Zaitseva, L. (eds.) 9th IEEE International Conference on Advanced Learning Technologies (ICALT 2009), pp. 455–459. IEEE Computer Society, New York (2009)
13. Sabine, A.M.: A Learner, Is a Learner, Is a User, Is a Customer: QOS-Based Experience-Aware Adaptation. In: 16th ACM International Conference on Multimedia, pp. 1035–1038. ACM, Vancouver (2008)
14. Ryoo, W., Jung, H., Yoo, M., Hwang, S.: Development of Motivational E-Learning Environment Based on Flow Theory. In: The World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education 2008, pp. 1208–1211 (2008)
15. Woolf, B., Arroyo, I., Cooper, D., Burleson, W., Muldner, K.: Affective Tutors: Automatic Detection of and Response to Student Emotion. In: Nkambou, R., Bourdeau, J., Mizoguchi, R. (eds.) Advances in Intelligent Tutoring Systems. SCI, vol. 308, pp. 207–227. Springer, Heidelberg (2010)
16. Muldner, K., Burleson, W., VanLehn, K.: "Yes!": Using Tutor and Sensor Data to Predict Moments of Delight During Instructional Activities. In: De Bra, P., Kobsa, A., Chin, D., Muldner, K., Burleson, W., VanLehn, K. (eds.) UMAP 2010. LNCS, vol. 6075, pp. 159–170. Springer, Heidelberg (2010)
17. Kaklauskas, A., Krutinis, M., Seniut, M.: Biometric Mouse Intelligent System for Student's Emotional and Examination Process Analysis. In: Aedo, I., Chen, N.S., Kinshuk, Sampson, D., Zaitseva, L. (eds.) 9th IEEE International Conference on Advanced Learning Technologies (ICALT 2009), pp. 189–193. IEEE Computer Society, New York (2009)
18. Park, J., Parsons, D., Ryu, H.: To Flow and Not to Freeze: Applying Flow Experience to Mobile Learning. IEEE Transactions on Learning Technologies 3(1), 56–67 (2010)
19. Chiu, C.M., Hsu, M.H., Sun, S.Y., Lin, T.C., Sun, P.C.: Usability, Quality, Value and E-Learning Continuance Decisions. Computers & Education 45(4), 399–416 (2005)