Flow and Learning Emotions in Computer Education: An Empirical Survey

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Abstract

It is important to keep learners' feeling positive during learning to enhance learning performance. According to flow theory,challenge-skill balance is a precondition for flow experience: Learnersfeel anxietywhen the challenge of learning is higher than their ability, feel boredom when the challenge of learning is lower than learners' ability, and engage in flow status when the challenge of learning matches the learners' ability. However, the current empirical study reveals that emotions related to enjoyment may appear when the learners' skill is equal to or higher than the learning challenge. Nevertheless, boredom emotion may appear when learners perceive the courses are difficult but unimportant. These empirical survey results revealed the necessary of rethinking the appearance of boredom and enjoyment emotions in computer education.

Keywords : Flow theory, Positive and Negative Emotion, Learning, Challenge-skill balance, Computer Education

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1. Introduction

Learners exhibit a variety of learning emotions during and after completing their learning lessons. They may feel enjoyment, boredom, anxiety, frustration, and other emotion during learning. Learners may be distracted since the learning course are not fit their skill. Positive emotions during courses may enrich learning motivations, which negative ones may weaken learning motivations. It is important for educators to find ways to provide learners positive emotions and keep learners away from negative emotions during learning.

1.1 Flow Theory

Flow refers to an optimal experience resulting in intense engagement, distorted sense of time, and heightened motivation [Chen, 2006, Czikszentmihalyi, 1990]. Csikszentmihalyi proposed the Flow theory to subjectively explore the well-being of people during engagement in an activity and to explore the generation of positive emotions during engaging in activities. People fully engage in what they are doing and experience enjoyment when they are in the flow state [Hoffman and Novak, 2009].

People in the flow state completely focus and have a feeling of control, passion and fulfilment during the activity. Flow theory includes the three channel model to discriminate three affective states of flow, anxiety and boredom during activities people involved in. The flow state occurs when the challenge and skill are balanced. If the perceived challenge and perceived skill are equivalent or similar, will a flow state appears. However, if the challenge level of activity is beyond the individual's skill, anxiety feeling generates; in contrast, if the individual's skill is beyond the challenge level, a state of boredom generates.

1.2 Challenge-Skill Balance

Flow theory argues that the flow state occurs when challenge-skill balance exists: Achieving the challenge-skill balance is one of the preconditions for flow experience [Csikszentmihalyi, 1975; Csikszentmihalyi and Larson, 1987; Czikszentmihalyi, 1990]. If people's skill cannot meet the challenge, the overwhelming activity generates anxiety; on the other hand, if the challenge decreases and ones'skill exceeds the challenge, they might come to a state of boredom. Only if the perceived challenge match the perceived skill, a flow state may appear.

The concept of challenge-skill balance and flow theory are widely used in the field of learning research. For example, Hwang et al. [2012] designed an effective learning system to promote students' flow experiences during web-based problem-solving activities. Pearce et al. [2005] used flow to explore learning activities in an online learning environment. Ho and Kuo [2010] indicated that flow experience has a positive effect on learning outcomes.

1.3 Emotion and Challenge-Skill Balance

Challenge-skill balance is essential to attract learners' attention according to the flow theory. When learners perceive a challenge-skill balance

in learning materials, they are in the flow state. The flow state will generate positive emotions. However, according to flow theory, if they perceive the learning materials as too difficult, learners may feel anxiety; in contrast, if the learning materials are too easy, they may feel boredom.

Nevertheless, in the real educational practice, the boredom emotion may appear when learners perceive learning materials as more difficult than their ability; this does not match the prediction of the flow theory. Task importance may be a moderator variable needed to be considered when exploring the relationship between the challenge-skill balance and learning emotion. If the learning content is difficult but unimportant, learners may feel boredom rather than anxiety. In this case, learners do not feel anxiety even they cannot understand the learning contents since they perceive the learning task as unimportant. To our knowledge, however, no previous study has focused on the moderating effect of task importance on the influence of the challenge-skill balance on learning emotion of boredom and anxiety.

In addition, flow theory argues that the boredom emotion may also appear when learners perceive learning materials as less difficult than their ability. However, in the real educational practice, learners may get a sense of achievement when the challenge of the learning material is slightly lower than the learners' ability. Thus, the forecast of flow theory has some limitation.

1.4 Research Purpose

The current study aims to investigate whether the perceived difficulty level of learning materials and perceived task importance can lead to different learning emotions, which were correlated to learning performance. We explored the associations between challenge-skill balance, task importance, and learning emotions in computer education.

2. Methods

The research aims to determine the influence factors of learners' positive and negative emotions during learning activities. We explore the conditions required for the appearance of enjoyment, anxiety, boredom, frustration and correlation between learning emotion and learning outcome. The independent variable, challenge-skill balance and task value were an important antecedent to predict learning emotion. The dependent variables, learning performance was the consequences of learning emotion.

2.1 Participants

The study recruited 110 participants from two Taiwanese university campuses, including 89.0% male and 11.0% female, ranging in age from 20 to 25 years. Subjects were all undergraduate students majored in computer science and enrolled in the courses of algorithm and computer programming. The gender ratio of the study was similar to that of the departments: according to the student enrollment data, 89.1% of the students in the department were male. The average age of respondents was 20.23 years with the standard deviation of 1.95. All of them joined the

study voluntarily and were informed of their right to quit the survey at any time. The study recruited participants from the classes of algorithm and computer science since that the learning challenge increase along with the stage of semester.

2.2 Procedure

The study asked participants to fill out the questionnaires on the challenge-skill balance, flow experience, task value, and learning emotions about the class. In order to investigate the change of learning emotion in semester, we carried out a longitudinal study compose of two questionnaire surveys for the same participants at the first half of the semester and the week next to the middle term exam.

2.3 Measures

The current study collected participants' emotion response by questionnaires, which comprised of four main parts, including flow experience, challenge-skill balance, learning emotion and task value. Participants were asked to present their challenge-skill balance perception of the computer-based instruction learning using a 7-point scale from -3 (too easy) to 3 (too difficult). The positive or negative scores were regarded as an unbalance state, and the neutral score (0 point) was seen as a challenge-skill balance state.

To measure learners' flow experience dimensions of enjoyment, telepresence, focused attention, and time distortion, the study adopted the scales used by Shin [2006] and some previous flow research [Ghani, 1995; Novak et al., 1998; Skadberg and Kimmel, 2004; Steuer, 1992; Yager et al., 1997]. Since the measurement scale statement of "engagement" dimension in Shin [2006]'s study was inappropriate for the present study, the current study adopted "involvement" dimension, which based on Novak et al. [1998]'s conceptual model of flow, as a replacement for engagement dimension in Shin [2006]. We adopted involvement dimension that was measured by Saxena et al. [2004]. All of the items were measured on a 7-point Likert scale, from 1 (Strongly Disagree) to 7 (Strongly Agree).

The study adoptedsix items from the Motivated Strategies for Learning Questionnaire (MSLQ) [García and Pintrich, 1995; Pintrich, 1991; Pintrich et al., 1993] to measure task value (learning importance). The MSLQ is usually used to measure students' motivation for studying and asks students to describe how important, interesting, and useful a task is to them.

The current study used Achievement Emotions Questionnaire (AEQ) to measure learning emotions. The original AEQ consists of nine emotions; enjoyment, hope, pride, anger, anxiety, shame, hopelessness, and boredom [Pekrun et al., 2011]. The present research focused on examining four learning emotions; enjoyment, anxiety, boredom, and frustration. The four emotions were selected since they are frequently experienced in achievement settings [Csikszentmihalyi and Larson, 1987; Pekrun et al., 2011].

We adapted the AEQ learning emotion scale developed by Pekrun et al. [2011] and Lichtenfeld et al. [2012] to measure enjoyment, anxiety, and boredom. For frustration, we used the measure-

〈Table 1〉 Reliabilities and Validity

	AVE	Alpha	1	2	3	4	5
Enjoyment	.80	.93	**.89**				
Telepresence	.79	.86	.70**	**.89**			
Focused Attention	.86	.83	.47**	.57**	**.93**		
Involvement	.74	.87	.73**	.64**	.41**	**.86**	
Time Distortion	.52	.92	.43**	.48**	.33**	.49**	**.72**

Note: ** $p < 0.05$; values in bold are square root of AVE.

ment scale developed by Artino [2009].

Both the measurement items of flow and task value were measured on a 7-point Likert scale from 1 (Strongly Disagree) to 7 (Strongly Agree). All of the measurement items of emotion were measured by 7-point semantic scale.

2.4 Reliabilities and Validity

To verify the reliabilities of the measurement scale, the current study calculated Cronbach's alphas. The Cronbachs' alpha test results revealed that reliability coefficients were all exceeded 0.70, which were well within the acceptable range. The Cronbach's alphas of enjoyment, telepresence, focused attention, involvement, time distortion were .93, .86, .83, .87, .92, respectively.

To assessed convergent validity, the current study examined the average variance extracted (AVE) of each dimension. The results showed that AVE values of all measurement scales in the current study were well above the value of 0.5 suggested by Fornell and Larcker [1981], which confirmed the soundness of convergent validity for the measurement scales. The AVE values of enjoyment, telepresence, focused attention, involvement, time distortion were .80, .79, .86, .74, .52, which represent the variable possess a good convergent validity. Discriminant validity refers to the extent to which evaluations of different constructs are unique from each other [Bagozzi, 1981]. The discriminant validity was examined through the rule that the square root of AVE value must be greater than other variables correlation coefficients. The <Table 1> revealed that the square root of AVE in each measurement scale is greater than correlation coefficients, indicating that the discriminant validity has been accepted.

3. Data Analysis

To explore the influence of challenge-skill balance on learning emotions, we divided the participants into three groups of hard, balance (middle), and easy. If participants felt that the level of learning challenge was higher than their skill, they were placed into the hard level of difficulty group; if their perceived challenge level was equal to their ability, they were placed into the balance group; if their perceived challenge level was lower than their ability, they were placed into the easy level of difficulty group.

Flow and emotion status of the three groups were compared through a series of one-way

〈Table 2〉 Emotion, Flow and Level of Difficulty

		Difficulty Level			ANOVA analysis
		Easy (N = 23)	Balance (N = 40)	Hard (N = 47)	
Enjoyment	Mean S.D	5.55 0.76	5.53 0.87	4.70 1.04	F = 11.191 P = .00*
Anxiety	Mean S.D.	2.39 0.74	2.88 1.00	4.40 1.05	F = 43.038 P = .00**
Boredom	Mean S.D.	2.23 0.73	2.39 0.91	3.12 1.07	F = 9.380 P = .00**
Frustration	Mean S.D.	2.04 0.68	2.36 0.95	3.39 0.96	F = 22.787 P = .00**
Flow	Mean S.D.	4.72 0.63	4.90 0.82	4.20 0.79	F = 9.411 P = .00**

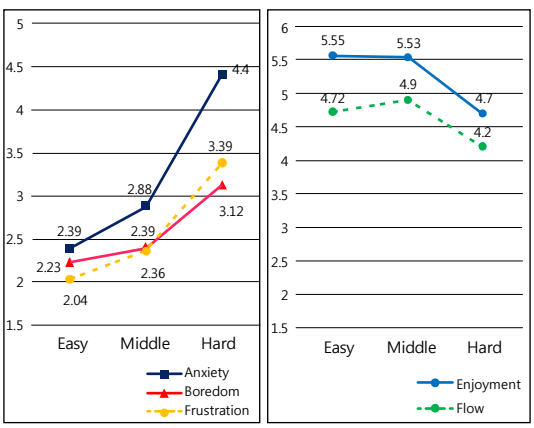
* $p < 0.05$; ** $p < 0.01$.

ANOVA analysis. <Table 2> reveals that enjoyment, anxiety and frustration scores were significantly different between the easy, balance and hard level of difficulty groups. When participants regarded the learning materials as easy and balance, the subjects' average enjoyment level was 5.55 (SD = 0.76) on the 7-point scale. The average score of enjoyment was 5.53 (SD = 0.87) when the participants regarded the material as balance and the average score of enjoyment was 4.70 (SD = 1.04) when the participants regarded the material as hard. Participants felt enjoyment when they perceived that learning was easy. The average scores of anxiety on the seven point scales were 2.39 (SD = 0.74) for participants who felt that the learning was easy, 2.88 (SD = 1.00) for those who felt it was balance and 4.40 (SD = 1.05) for those who felt it was hard. The average score of boredom was 2.23 (SD = 0.73) for participants who regarded the learning materials as easy, 2.39 (SD = 0.91) for those who regarded the learning materials as balanceand 3.12 (SD = 1.07) for those who regarded the learning materials as hard. The average score of frustration was 2.04 (SD = 0.73) for participants who regarded the learning materials as easy, 2.36 (SD = 0.95) for those who regarded the learning materials as balance and 3.39 (SD = 0.96) for those who regarded the learning materials as hard. The more difficult the perception of the lesson, the more anxiety, frustration, and boredom the participants felt.

The average scores of flow on the seven point scales were 4.72 (SD = 0.63) for participants who felt that the learning was easy, 4.90 (SD = 0.82) for those who felt it was balance, and 4.20 (SD = 0.79) for those who felt it was hard. The results confirmed that learners who perceived challenge-skill balance might achieve higher flow experience. When learners regarded the learning materials as too easy or too hard, they may achieve lower level of flow experience.

The <Figure 1> reveals that enjoyment, anxiety, boredom, frustration and flow scores were significantly different among the three levels of difficulty groups. The less difficult the percep-

tion of the lesson, the more enjoyment the participants felt. The more difficult the perception of the lesson, the more anxiety, frustration, and boredom the participants felt. Among all the emotion, anxiety was the emotion which was affected most by level of difficulty. In addition, <Figure 1> also reveals that the participants reported who report challenge-skill balance also reported higher flow experience than participants who reported the learning material was too easy or too hard.



(a) Flow and Positive Emotion (b) Negative Emotion

<Figure 1> Emotion and Level of Difficulty

To reveal the impact of learning task value on learning emotion, the study divided the participants into two groups of high and low importance perception based on their task value score. Since a seven point Likert type scale was used to measure task value, we used a mean score of 4 as the cut off point for high and low importance perception. The score 4 was classified as low importance group.

<Table 3> reveals that participants in the high importance group showed a significantly higher level of enjoyment (Mean = 5.38, SD = 0.91) than those in the low importance group (Mean = 4.44, SD = 1.01). The average score of flow was 4.77 (SD = 0.76) in the high importance group, and 3.84 (SD = 0.68) in the low importance group. Furthermore, the low importance group showed a higher level of boredom (Mean = 3.46, SD = 1.14) than the high importance group (Mean = 2.45, SD = 0.88). Participants who regarded the learning as highly important experienced enjoyment during the learning; and participants who regarded the learning as of low importance felt boredom. There was no significant difference in

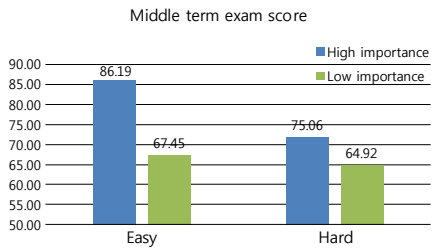
<Table 3> Emotion and Task Value Importance Perception

		Importance		t-test results
		Low (N = 24)	High (N = 86)	
Enjoyment	Mean S.D	4.44 1.01	5.38 0.91	t = 4.350 p = .00**
Anxiety	Mean S.D.	3.88 1.20	3.30 1.30	t = -1.937 p = .06
Boredom	Mean S.D.	3.46 1.14	2.45 0.88	t = -4.653 p = .00**
Frustration	Mean S.D.	3.18 1.06	2.61 1.04	t = -2.346 p = .02*
Flow	Mean S.D.	3.84 0.68	4.77 0.76	t = 5.42 p = .00**

*p < 0.05.

anxiety levels between the high and low importance perception groups. Task value is a significant determinant of enjoyment, flow and boredom. However, anxiety was not significantly influenced by task value perception.

<Figure 2> reveals the learning performance of the fourgroups(easy/hard challenge x high/low importance). The learning performance with high importance in easy group (Mean = 86.19; SD = 13.77) was higher than hard group (Mean = 67.45; SD = 21.92). Likewise, the learning performance with low importance in easy group (Mean = 72.06; SD = 21.40) was higher than hard group (Mean = 64.92; SD = 20.56). <Table 4> reveals that the scores of learning performance were significantly different with different level of challenge and importance. Subjects' learning performance decreased along with the level of learning materials, and increased along with the level of importance. The higher importance the lesson, the more performance the subjects obtained.



〈Figure 2〉 Performance between Different Level of Challenge and Importance Groups

4. Discussion and Conclusion

4.1 Discussion

The study explore the happen of positive and negative emotionsduring learning activities. The results indicated that easy level learning course will lead to positive learning emotion. The empirical survey results support the argument that positive learning emotion has a positive effect on learning outcomes. Learners who regarded the learning materials as hard would appear negative learning emotion like anxiety, boredom and frustration. Learners would appear anxiety and frustration when they perceived hard difficulty level of learning materials and high importance level to the learning material. The current study found that boredom emotion may occur when the learning material is perceived as difficult but unimportant. Moreover, learners with negative emotion would have low performance. Thus, the empirical survey results support the argument that low performance learners feel a higher level of anxiety, boredom, and frustration than others.

The current study advocated that boredom may appear when the learners perceived the courses are difficult but unimportant. When the course is difficult, learners may feel boredom as well as anxiety. If learners regard the learning

〈Table 4〉 Performance of Different Level of Challenge and Importance

	Challenge		Importance		Two-way ANOVA		
	Easy (n = 63)	Hard (n = 47)	Low (n = 24)	High (n = 86)	Challenge	Importance	Challengex Importance
Performance Mean	78.74	67.22	66.56	79.40	F = 10.23	F = 8.85	F = 10.86
S.D.	2.73	2.87	3.79	2.04	P = .00**	P = .00**	P = .00**

*$p < 0.05$; **$p < 0.01$.

as unimportant, they may feel boredom when they perceivedthe learning content is difficult. In this situation, there may be a trend for learners to discontinue their learning, since they cannot complete the learning contents and feel that the learning content is unimportant. However, if learners regard the course as important, they will feel anxiety when they perceived the course is difficult. In this situation, learners may try, but fail, to complete the learning content. Anxiety and frustration may appear in this situation. High performance would strengthen the level of learners' positive emotion. On the contrary, low performance would strengthen learners' negative emotion and let learners perceive the course as unimportant. Based on the results of the empirical survey, we suggest that instruction development should avoid developing learning material that is beyond the learners' ability, especially when some learners regard the course as unimportant.

4.2 Theoretical Contribution

The current research contributes to the extant literature and practice in several ways. First, the current research confirms that challenge-skill balance and importance perception are two essential antecedents to appear positive and negative emotion. Besides, the research found that boredom may occur when the learning material is difficult but perceived as unimportant, which contradicts the forecast of the flow theory. Flow theory is widely used in learning to discuss the impact of flow experience on learning outcomes. It forecasts that anxiety will occur when the learning challenge is beyond the learners' skill. Empirical survey results of the present study confirms this argument. However, flow theory forecasts that boredom will occur when the learning is too easy. According to observations in educational practice, some learners may feel boredom rather than anxiety when they perceive learning materials as too difficult for their ability. Boredom did not only appear when the challenge level was lower than the skill level, but also when the challenge level was higher than the learners' skill level and the importance of the lesson is perceived as low. The result is inconsistent with the thoughts of flow theory.

4.3 Research Limitations

In light of our findings, certain limitations of the current study should be considered. First, the current study found that boredom emotion may occur when the learning material are perceived as difficult but as unimportant. However, the present research does not oppose the possibility that boredom will occur when the learning content is too easy as flow theory forecast. The courses we selected in the current study may be not easy enough to let learners appear boredom. Future studies can focus on the area of boredom (personal skill is beyond the challenge). Therefore, researchers who are interested in learning emotion can design an adaptive material for learners. If learners can receive an appropriate difficulty level of learning content, their positive emotion and learning outcomes may also increase obviously.

Second, the learning environment in current study was the courses of algorithm and com-

puter programming which were taught by different teacher. Nevertheless, it is probable that lots of factors like instructional factors and the standard of score are also influence learners' emotion.

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