Flow in computer-human environment

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Abstract
Flow or optimal experience is a concept connected with intrinsic motivation which has been explored in the past 30 years. Many researches showed correlation between *flow*, on one side, and positive experiences and well-being on the other side. The more time students spend in the state of *flow*, the better quality of their experiences: they experience a higher level of concentration, creativity and positive emotions (Nakamura & Csikszentmihalyi, 2002). The aim of this study was to explore whether students of "Faculty of Electrical Engineering and Computing" (FEEC), Zagreb, Croatia, experience flow while engaged in computer programming and related study fields, and which variables contribute to experiencing flow. The sample consisted of 142 students. The research was conducted via online questionnaire and paper-pencil testing in March and April of 2011. Results show that students experience flow while programming (M=5,1; on the scale of 8). Proportion of variance explained of flow was 39% ($F=8,621$; $df=92$; $p<0,01$). Variables which contribute to flow were: grade acquired in programming subjects at the university ($\beta=0,23$; $p<0,05$), number of programming languages one is familiar with and can use ($\beta=0,20$; $p<0,05$) and positive affect ($\beta=0,47$; $p<0,01$).

Keywords
flow, students, human-computer environment, computer

Introduction

The theory of optimal experience or *flow*, developed by Mihaly Csikszentmihalyi in 1975, defines this experience as an '*optimal, extremely enjoyable state in which people are so involved in the activity that nothing else seems to matter;…that people will do it even at great cost, for the sheer sake of doing it*' (Csikszentmihalyi, 1990, p. 4). There are various exisiting definitions of flow (see Novak, Hoffman & Yung, 1998, p. 10-11) but the description given by Csikszentmihalyi (1975) is something that is widely accepted by the reseraches. He summarized perceptions of flow experiences into eight dimensions: (1) clear goals and immediate feedback; (2) personal skills well suited to given challenges; (3) merging of action and awareness; (4) concentration on the task at hand; (5) a sense of potential control; (6) a loss of self-consciousness; (7) an altered perception of time; (8) autotelic experience.

Flow has been researched in many various fields of study but Csikszentmihalyi did not apply the characteristics of an optimal experience to the computer-mediated environment (CME) or human-computer interaction (HCI) research field (Mistry & Agrawal, 2004). He refrains from discussing the possible applications of an optimal experience within cyberspace environments with the exception of several brief interviews, popular papers and short statements (Smyslova & Voiskounsky, 2009).

There are two descriptions of flow in CME or HCI studies: flow is a '*mental mode represented by the combination of some characteristics that individuals experience*' (Shin, 2006) and '*flow is a function of 'skill' and 'challenge*'' (Csikszentmihalyi, 1990). Kivikangas (2006), among others, showed that most of the researches in HCI field have used different operationalizations of flow in their studies and that no model has been generally accepted. There are many inconsistencies and discrepancies, as authors tried to fit the flow model as a psychological state into a unique CME (Finneran & Zhang, 2005). According to Shin (2006), despite of all the discrepant views on flow there are two points on which researches agree upon: (1) *the level of an individual's flow experience is determined by the function of one's skill and challenge* and (2) *the flow experience will work in a positive way for participants in CME in carrying out the tasks concerned*. Shin (2006) showed that online learners experience flow by testing 525 undergraduate students who participated in virtual classes: *(1) students' perceptions of 'skill' and 'challenge' specific to each course are critical in determining the level of flow, (2) flow is a significant predictor of course satisfaction and (3) individual differences such as 'gender' and 'having a clear goal' can make a significant difference in the level of flow reached during a virtual course.*' But, in spite of all the problems in the research of flow experience within a CME, it has been shown that CME improves quality of work by increasing positive affect, exploratory behavior, computer use, communication and learning (Finneran & Zhang, 2005; Kivikangas, 2006). Lakhani & Wolf (2005) in their study, on the 684 IT software developers, found that improving programming skills and intellectual stimulation induced by code writing are top motivators. Luthiger and Jungwirth (2007) were able to show on open source developers that joy experienced while programming plays an important role in work motivation and that deadlines do not affect their intrinsic motivation while working on a software project.

Some researches have shown that students who experience flow while being engaged in some activity show higher degree of psychological well-being (Clarke and Haworth, 1994; according to Chen, Wigand & Nilan, 2000) and if they spent more time in the flow state they are more cheerful, sociable and happy (Massimini and Carli,1988; according to Chen et al., 2000). Csikszentmihalyi and colleagues (1993; according to Nakamura & Csikszentmihalyi, 2002) found in a longitudinal ESM study that ambitious and talented high school students after a period of four years had more frequent flow experiences and experiences less anxiety then their peers while engaged in school-related activities. For them, the activities for which they had a talent were the source of flow. Students were intrinsically motivated and their optimal experience was more pleasing and rewarding than the result itself, which can be defined as an *autotelic* state (Csikszentmihalyi, 1990). Autotelic students had more well-defined future goals and reported more positive cognitive and affective states (Adlai-Gail, 1994; according to Nakamura & Csikszentmihalyi, 2002).

According to Csikszentmihalyi (1990) when people are in the flow state and completely devoted to their activity their focus of awareness is absorbed in the activity itself; '*they control their psychic energy, and everything they do adds order to their consciousness*'. Frequent experiences of flow contribute to greater life satisfaction, creativity and quality of life.

Hypotheses
The aim of this study was to determine whether students of “Faculty of electrical engineering and computing” (FEEC) experience flow while engaged in programming and related studies, how intense their experience of flow is and how frequently they experience it.

1st Hypothesis: FEEC students experience flow while programming.
a) They experience it frequently.
b) Their experience of flow is intense.

2nd Hypothesis: FEEC students who have:
a) better skills and knowledge in computer programming,
b) greater subjective well-being, and
c) better living conditions should experience flow more frequently.

3rd Hypothesis: The University does not offer enough interesting, challenging and encouraging subjects that would lead to flow experience, and students experience flow more often while applying their computing science knowledge outside University.

Method

Participants
The study was conducted on a sample of 142 students of „Faculty of Electrical Engineering and Computing“ (FEEC) in Zagreb, Croatia.

Instruments
Several questionnaires have been applied in the reserach: Flow Experience Questionnaire (Csikszentmihalyi & Csikszentmihalyi, 1988), Life satisfaction scale (Diener, Emmons, Larsen & Griffin., 1985) and PANAS (Watson, Clark & Tellegen, 1988). The Flow Experience Questionnaire was developed by Csikszentmihalyi and Csikszentmihalyi (1988). It consists of two parts: the first part consists of quotations given by people who had flow experiences and the second part of twelve statements which participants had to rate on an 8-point Lickert type scale.

Subjective well-being was measured by SWLS and PANAS. The Satisfaction with Life Scale (SWLS) is a global measure of life satisfaction developed by Diener et al. (1985). It consists of 5-items that are completed by the individual whose life satisfaction is being measured. PANAS (Positive and Negative Affect Schedule) was created by Watson et al. (1988). It consists of 2x10-item mood scales measuring positive and negative affect where participants were asked to assess their life in general.

Level of skill and knowledge in computer programming was measured by: the very first grade the student received at the university in general, first grade in computer programming, average grade in general and the number of programming languages the student is familiar with and can use.

Students were asked to assess on 5-point Lickert type scale in which activities (reading university-related literature, writing seminars, engaging in acitivies outside university) related to computer science-informatics they experience flow. Life conditions were measured with 5 items according to which students had to assess their life conditions during their university life on a 5-point Lickert type scale (eg. economic security).

Procedure

Majority of the data was collected by the online questionnaire and the rest was collected by paper-pencil testing in March and April of 2011. Participants were informed that the research was about flow experience while programming and being engaged in university-related activities. The questionnaire was anonymous.

Results

First, we determined whether students studying at the FEEC experience flow while engaged in computer programming and how often. Results show that students experience flow moderately often (M=2,63; of the 5-grade Lickert-type scale) and with above average intensity (M=5,1; on the scale of 8).

To determine which variables contribute to the higer flow experience while programming, regression analysis was conducted. The variables which we have been interested in were: the grades the student received at the university, number of programming languages the student is familiar with and can use, life conditions, positive and negative affect and life satisfaction. Proportion of variance explained was 39% and it is statistically significant (F=8,621; df=92; $p<0,01$). As it can be seen from *Table 2* the significant predictors of flow in computer programming were: grade acquired in programming subjects at the university ($\beta=0,23$; $p<0,05$), number of programming languages one is familiar with and can use ($\beta=0,20$; $p<0,05$) and positive affect ($\beta=0,47$; $p<0,01$).

Table 1. *Results of regression analysis*

R	R^2	Adjusted R^2	Std. Error of the Estimate	F	Significance
,671	,451	,399	,776	8,621	,001

Table 2. *Standardized coefficients in the regression analysis*

	Standardized Coefficients (β)	t-test	Significance
The very first grade the student received at the university in general.	,017	,151	,880
First grade in computer programming.	,234	2,028	,046
Average grade in general.	,046	,492	,624
Number of programming languages the student is familiar with and can use.	,195	2,315	,023
Life conditions.	-,044	-,503	,617
Negative affect.	-,164	-1,593	,115
Positive affect.	,474	5,121	,000
Life satisfaction.	,030	,271	,787

Table 3. *Mean values in flow inducing activities*

	Mean	Std. Deviation
Reading the technical and scientific literature related to computer science/informatics.	2,28	1,190
Seminar work related to computer science/informatics.	2,16	1,144
Programming	3,21	1,381
Solving problems or tasks related to a computer science/informatics.	3,00	1,326
Activities related to computer science/informatics, but outside of studies.	3,18	1,489

In Table 3 it is shown that students during their studies experienced flow most often "*programming in a computer language*" (M=3,18). They experienced flow the least often while engaged in "*seminar work related to computer science/informatics.*" (M=2,16; of the 5-grade Lickert-type scale).

Discussion and conclusion

Results show that indeed FEEC students experience flow while computer programming moderately often and (M=2,63) with above average intensity (M=5,1). It was expected so because at the FEEC the majority of subjects revolve around programming and students should have knowledge and skills well suited to given challenge which is one of the conditions for getting into the flow Csikszentmihalyi (1975). Also activity of programming offers clear goals, immediate feedback and a sense of potential control which can lead to a loss of self-consciousness, an altered perception of time and autotelic experience, namely flow.

Proportion of variance explained of flow in regression analysis was 39% and it is statistically significant ($F=8{,}621$; $df=92$; $p<0{,}01$). The significant predictors of flow in computer programming were the very first grade acquired in programming subjects at the university ($\beta=0{,}23$; $p<0{,}05$) and the number of programming languages that student is familiar with and can use ($\beta=0{,}20$; $p<0{,}05$) which are indicators of student's knowledge and skills in this particular area. Grades at University in general were not significant predictors of flow because they can refer to other things apart from skills and knowledge in programming. In accordance with research of Clarke and Haworth (1994; according to Chen et al., 2000) it was expected that students who experience flow during their activities show higher degree of psychological well-being. This hypothesis was only partially confirmed. Positive affect was significant predictor of flow ($\beta=0{,}47$; $p<0{,}01$) but negative affect and life satisfaction were not. It was assumed that better living conditions would contribute to the more frequent flow experiences, but this hypothesis was not confirmed. This is congruent with Csikszentmihalyi's (1975) definition of flow. Flow experience depends on factors regarding the task that is being executed, person's awareness and motivation, but not on life conditions.

During study students most often experienced flow while "*programming"* (M=3,21) and the least often while engaged in "*seminar work related to computer science/informatics*" (M=2,16). This is also in line with construct of flow, because tasks that offer clear goals and immediate feedback (programming) should induce higher flow than tasks with delayed feedback (writing seminars). Third hypothesis, that students experience flow more often while applying their computing science knowledge outside University, was not confirmed. Students rated this item with second highest arithmetic mean (M=3,18). So, it can be concluded that programming is highly self-rewarding experience and that it induces flow regardless of external or internal motivation.

It can be summarised that FEEC students experience flow more often while programming than while engaging in other activities related to their studies in the fields of computer science/ informatics. Most researches done in the field of flow in CME focused on inducing flow with online or web activities, whereas flow in computer programming has not been thoroughly researched. Charateristics of programming are well suited for inducing flow state because it offers clear goals and immediate feedback.

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