Happy Girls Engaging with Technology: Assessing Emotions and Engagement Related to Programming Activities

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Abstract. The advent of programming languages for students (i.e., Scratch) combined with accessible programmable hardware platforms (i.e., Arduino) is becoming an emerging practice for computer science education (CSE). Robots and interactive installations are some of the most widespread artifacts for increasing students' adoption in CSE. But what kind of emotions motivate students to participate in such creative development activities? In this paper we present the results of an empirical investigation regarding the key emotions and their impact on a creative learning context. In our empirical evaluation, a group of researchers and artists designed, implemented, and evaluated three workshop programs. The workshops were based on the Reggio Emilia education principles, open source software Scratch and Arduino and were conducted in creative centers. We designed a survey, based on the main Emotional factors identified from the literature as important on the technology context. Responses from 37 twelve-year-old girls were used to examine the effect of Enjoyment, Happiness and Anxiety on students' intention to participate on similar creative development activities. Results confirmed the positive effects of Happiness and the negative effect of Anxiety. Moreover, the results indicated that students' Enjoyment has no relation with students' intention to re-participate in an activity. The overall outcomes are expected to contribute to design practices and promote the acceptance of creative development activities

Keywords: Creativity, Scratch, Programming, Girls in programming, Students' intentions, Emotions, Engagement, Workshop program, Reggio Emilia principles.

1 Introduction

Despite the economic crisis, demand for IT-professionals persists. Currently, several efforts to broaden participation in Computer Science (CS) and introduce computational literacy to young students [6] [22] [33] are in progress. School education plays an important role in raising young students' interest in IT, and particularly in CS subjects. Another notable aspect is the low number of female students in CS subjects.

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Women more often than men choose disciplines like linguistics, cultural studies, and arts. In the last decades, attention has been drawn to the imbalance between the males and females in computing; and many initiatives have been taken to that direction [5] [23] [29]. School girls typically show less interest in CS topics; something that later deters them from studying and attaining a CS career [31].

Studies conducted by the (1) Association for Computing Machinery (ACM) and the Computer Science Teachers Association (CSTA) [1], and (2) ACM ITiCSE Working Group Informatics in Secondary Education [17] revealed that CS education faces problems regarding lack of exposure and motives, which are essential for the students. Although students use computers for many tasks both at home and at school, the majority of them never quite understand what computer science is and how it relates to algorithmic thinking and problem solving. Their exposure to computers in school most likely consists of text editors and media presentation tools. Few upper secondary education schools have a mandatory (or even a selective) computer science course and even fewer lower secondary education schools offer a CS course, at a time that is considered crucial for students to think about careers choices and plan future decisions.

The lack of exposure to CS in schools leads to fewer students choosing computer science as a career. To increase the interest, engagement and participation in CS in general, and for females in particular, numerous approaches and projects have been initiated; such as the CS Unplugged [6], Alice [7], Scratch [22] and Greenfoot [16]. Building upon previous research motivating and engaging students with CS in terms of creativity [2] [3], our approach introduces a program which is based on creative activities as a means to facilitate a particular process for teaching youth how to program.

Based on the recent developments of computer science education (CSE) [8] [4], many tools, activities and environments that support CS learning have been developed and were successfully deployed [3] [5] [14]. Although many of these activities are focusing on female students (e.g., female-only events), a possible reason for the lack of success of these intervention strategies is that their evaluation is apparently not usually carried out [9].

Our main research goal is to determine whether female students' (hereinafter students) emotions revealed during the activity can provide a means to increase their intention to adopt a similar activity in the future. Using a quantitative approach, we gained insight on students' emotions towards the activity and then we examined any potential relation of students' emotions and their intention to participate on any similar events in the future. In our line of research, we measure and understand students' emotions regarding creative development activities, in order to be able to:

- Investigate what emotions motivate or distract students to adopt creative programming activities.

The clarification of students' emotions during these activities is expected to contribute to the understanding of their intentions to pursue creative development activities in the future.

2 Related Work

2.1 Creativity in Computer Science Education

In the last decades, various attempts in introducing creativity in CS teaching have been made. One of the earliest is that of Niguidula and van Dam [25]. Perhaps some of the most successful efforts to date are those of using media computation as a context [15] and utilizing Alice to introduce non-majors to computing [7]. These approaches have since been expanded into introductory CS courses (e.g., CS1) with documented success [5]. Other notable efforts in the area include: a course in Introduction to Interactive Multimedia at The College of New Jersey and the Artbotics project which also uses robotics to engage students in creating creative artifacts [34]. On the same direction, the Computational Thinking course at Colby College taught by Bruce Maxwell uses Python and Turtle Graphics for 2D graphics as a medium of creativity, expression, communication and experimentation. Despite its appeal, the concept of generative art and creative computing are relatively underutilized in creating introductory computing curricula.

Numerous projects are focused on creativity and design using computational techniques (e.g., VVVV, PD, Scratch, Processing, Panda3D, Arduino, Wiring). Most of these projects build on the context of robotics, interactive installations and creativity. Their uses in formal computing education are mostly localized to the development groups and their institutions or their immediate communities. However, they represent an exciting direction for bringing computing to a much larger community of students and practitioners.

As we aforementioned, there are many tools to support creativity and idea generation. In our study, we chose to use Scratch (scratch.mit.edu), as the main cornerstone of our study, enabling students to create their own physical characters. Scratch is a media-rich programming language that allows youth to design and share programs in form of stories, movies and games. Students engaging with Scratch use building block command structures; in addition programmable objects can be any imported two-dimensional graphic image, digitally or physically made. This makes it particularly amenable to an array of young creative students who want to build their own software and engage in the participatory culture [19]. With 1.3 million registered members and over 2.8 million projects shared to date, the Scratch website is one of the most vibrant online communities. Scratch can also be used in small group formats (e.g., pair programming).

2.2 Students Emotions

Different emotions arise during the learning procedure and affect students' behavior. As a general categorization, these emotions might either be positive or negative. Previous studies (e.g., [24] [26] [32]) have showed that emotions and feelings in general affect people's intentions and future decisions. Koo and Ju [21] found that pleasure and arousal that derive from atmospherics affect positively computer use. Besides the more generalized positive and negative emotions, it is essential to examine the specific types-categories of emotions and how they affect students while they are learning through different processes.

Students' emotional reactions are very important for the learning process. Hedonic motivations have been found to affect learners' experience and their future decisions and achievements [3] [28]. The different emotions that arise on students during a learning activity can affect students' behavior. However, there is limited research on the different emotional aspects that occur during learning and how these aspects influence the learner. It has been argued that emotions are comprised of different constructs, however, it is generally agreed that in technology education, happiness and anxiety can provide useful insights and are representative of positive and negative emotions [20]. Happiness is defined as to which extend the student feels satisfied, excited and curious, whereas anxiety refers to which extent the student feels anxious, helpless, nervous and insecure; during the learning activity.

Among the various feelings that arise during the learning process, enjoyment is considered of high importance, as it can usually affect students' future behavior and decisions [3] [28]. Enjoyment is generally defined as the degree to which the activity is perceived to be personally enjoyable. The enjoyment that a student feels when studying, sometimes affects positively his attitude towards learning [32].

Previous studies point out the importance of anxiety while using technology [20].Specifically, low levels of anxiety lead to more positive attitudes. Moreover, anxiety has a negative effect on students' intention to use many forms of technology (e.g., mobile applications) [18]. In the context of technology enhanced learning (TEL), previous studies have found that higher levels of happiness and lower levels of anxiety may lead to increased TEL use [20].

Our study is based on prior findings regarding the importance of students' emotions and feelings [3] [27] [28]. In particular, we selected to examine the relation of enjoyment, happiness and anxiety on students' intention to participate on creative development activities. The main reason of this selection was the central role of enjoyment during the creative activity and the representative nature of happiness and anxiety on positive and negative emotions respectively.

2.3 Our Research Hypotheses and Approach

The aim of this study is to assess students' enjoyment, happiness and anxiety during a creative development activity and test the effect of these factors on students' intention to participate in future similar activities.

We formulate the three following research hypotheses:

H1. Students' Enjoyment during the activity is positively related with their intention to participate on future similar activities.

H2. Students' Happiness during the activity is positively related with their intention to participate on future similar activities.

H3. Students' Anxiety during the activity is negatively related with their intention to participate on future similar activities.

In particular, our research is intended to fill the gap on the topic of students' emotions on CSE and in particular on creative development activities. We conducted field studies, collecting empirical data and providing insights that enable scholars and educators to efficiently design and develop programs based on creative and open source activities. Our research follows a three-step process (Figure 1). In the three consecutive steps, we proceed with the sampling, data collection and data analysis. After the workshop and the data collection and analysis, we were able to provide insights regarding the impact of students' emotions on the creative activities adoption from young students. In the following section, the methodology of our research will be presented in more detail.

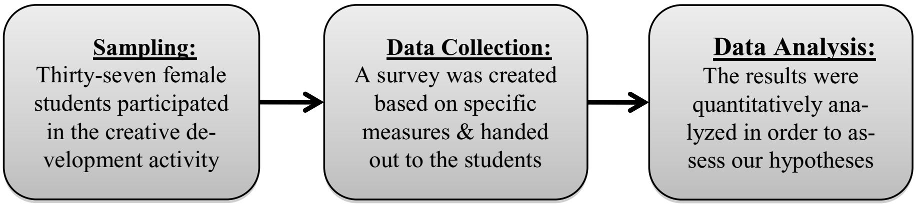

Fig. 1. Overview of the research process

3 Methodology

3.1 Procedures and Participants

In order to introduce students with creativity in CS we organized a series of workshops. The workshops took place at creative centers of University and ReMida centers. ReMIda is a center which collects and offers a variety of materials for use in creative and educational projects. The center is a cooperation between the municipality, the education project Reggio Children, the municipal waste company (recycling) and the local business community. Students' worked according to Reggio Emilia education principles [11]. The main idea is that the initiative for creative actions should spring from the student itself. The centers we used are creative places with a lot of appealing objects where students start to work without being activated by adults. The adults act as assistants.

The creative development program was composed of three workshops. The first and the second workshop lasts two days and the third lasts one day. Each workshop was formed up by 12, 10 and 15 girls respectively, students worked on dyads (with one exception) and each dyad had one computer. In the first and the second workshop 12-year-old girls (last class of primary school) participated, whereas in the third workshop 17- year-old girls participated; however all workshops followed the same schedule.

During the workshop students worked with Scratch for Arduino (S4A); which is a special version that allows the use of actuators (motors and lights) and not only sensors. In particular, the workshop program consisted of four steps:

Creative Session 1: Create physical characters (Figure 2a)

Tutorial: S4A tutorial, learn how to control Arduino, sensors, and motors

Creative Session 2: Make Scratch programs which animate the physical characters with S4A and Arduino boards (Figure 2b, 2c)

Presentation: When students have completed their artworks, they gave them names and presented them to the other teams

At the end of the workshop, a final discussion was held. Students' artworks of the workshop program have been collected and presented in an official exhibition in the university. Figure 2d presents a concrete example of the artworks.

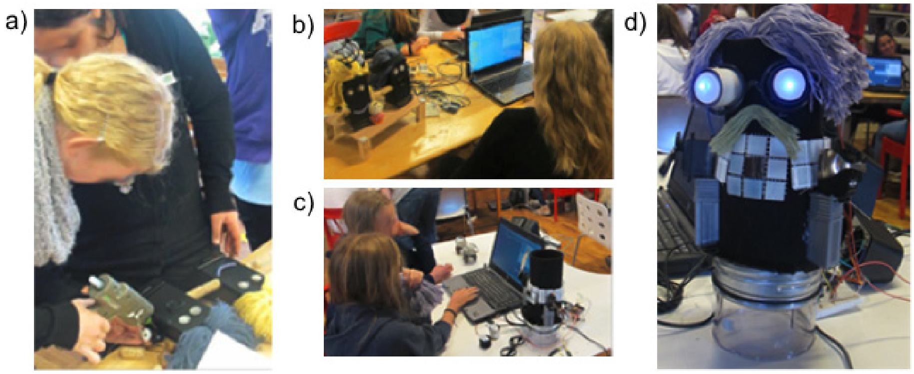

Fig. 1. a) Physical activity; b-c) giving life on the physical characters by programming; c) Example of interactive artworks

3.2 Data Collection

The questionnaire handed out to the students was divided into two parts. The first included questions on the demographics of the sample (age and gender) and the second part included measures of the various factors regarding students' intentions and emotions. Table 1 lists the questionnaire factors with their items, their operational definition, and the source from the literature review. In all cases, 7-point Likert scales were used to measure the variables.

Table 1. The factors used on the survey, their operational definitions, their items and the source

Constructs	Definition	Items (Questions)	Source Adopted
Intention to Participate	The degree of students' intention to participate in a similar activity.	I intend to participate in similar activities in the future (ItP1)	[13]
		My general intention to participate in similar activities in the future is very high (ItP2)	
		I will regularly participate similar activities in the future (ItP3)	
		I will think about participating similar activities (ItP4)	

Table 1. (*continued*)

Enjoyment	The degree to which the activity is perceived to be personally enjoyable.		Attending the activity was enjoyable (ENJ1)	[32]
			Attending the activity was exciting (ENJ2)	
			I was feeling good in the activity (EN3J)	
Happiness	The degree to which a person felt happy during the activity.	In general during the activity I felt:	Satisfied (HAP1)	[19]
			Excited (HAP2)	
			Curious (HAP3)	
Anxiety	The degree to which a person felt anxious during the activity		Insecure (ANX1)	[19]
			Helpless (ANX2)	

4 Data Analysis and Results

Fornell and Larcker [12] proposed three procedures to assess the convergent validity of any measure in a study: a) Composite reliability of each construct, b) Item reliability of the measure and c) The Average Variance Extracted (AVE).

First, we carried out an analysis of composite reliability and dimensionality to check the validity of the scale used in the questionnaire. Regarding the reliability of the scales, Cronbach`s α indicators was applied [12] and inter-item correlations statistics for the items of the variable. As Table 3 demonstrates, the result of the test revealed acceptable indices of internal consistency in all the factors.

In the next stage, we proceeded to evaluating the reliability of the measures. The reliability of an item was assessed by measuring its factor loading onto the underlying construct. Fornell and Larcker [12] recommended a factor loading of 0.5 to be good indicator of validity at the item level. The factor analysis identified four distinct factors (Table 2):

1. Intention to Participate (ItP)
2. Enjoyment (ENJ)
3. Happiness (HAP)
4. Anxious (ANX)

The third step for assessing the convergent validity is the average variance extracted (AVE); AVE measures the overall amount of variance that is attributed to the construct in relation to the amount of variance attributable to measurement error. Convergent validity is found to be adequate when the average variance extracted is equal or exceeds 0.50 [30].

Table 2. Summary of measurement scales

Factors	Item	Mean	S.D	CR	Load	AVE
Intention to Participate (ItP)	ItP1	4.37	1.37	0.849	0.849	0.74
	ItP2	4.43	1.27		0.873	
	ItP3	3.47	1.54		0.898	
	ItP4	4.49	1.48		0.817	
Enjoyment (ENJ)	ENJ1	6.56	0.73	0.867	0.843	0.79
	ENJ2	6.25	1.08		0.910	
	ENJ3	6.06	0.92		0.913	
Happiness (HAP)	HAP1	6.22	0.80	0.717	0.710	0.60
	HAP2	5.31	1.24		0.793	
	HAP3	5.78	1.20		0.813	
Anxious (ANX)	ANX1	2.33	0.93	0.702	0.936	0.59
	ANX2	1.69	0.89		0.555	

SD, Standard Deviation; CR, Cronbach α; AVE, Average Variance Extracted.

Even though these factors arise from an orthogonal rotation and are separable in terms of item loadings, they are correlated (Table 3). Pearson's correlation coefficient between the factors was used, which is about quantifying the strength of the relationship between the variables. Pearson's test suggests all the factors are related relatively strong (Table 3).

Table 3. Pearson's correlation coefficient between factors (n = 86)

Factors	ItP	ENJ	HAP	ANX
ItP	1	0.204	0.511*	-0.467*
ENJ		1	0.519*	-0.500*
HAP			1	-0.501*
ANX				1

* Correlation is significant at the 0.01 level.

To examine the research questions regarding the effect of the Emotion factors on students' ItP we divided ENJ, HAP and ANX on low and high categories using median split approach. And then we used Analysis of Variances (ANOVA) including students' ItP as dependent variables and the three confidence factors (ENJ, HAP, ANX) as independent variable. All statistical analyses reported in this research were conducted in a significance level of 0.05. As we can see from the outcomes in Table 4, Enjoyment has indicated insignificant influence and Happiness and Anxiety have indicated significant influence on students' intention to participate on similar activities in the future, as such H1 hypotheses was rejected and H2 and H3 were supported.

Table 4. Hypotheses testing using Analysis of Variances (ANOVA)

Dependent Variable	Mean (S.D.)		F	Results
	Low	High		
Intention to Participate (ItP)	Enjoyment (ENJ)			
	4.02 (1.12)	4.42 (1.29)	0.89	H1 (Rejected)
	Happiness (HAP)			
	3.54 (0.67)	4.93 (1.26)	**16.25***	H2 (Accepted)
	Anxiety (ANX)			
	4.89 (1.39)	3.83 (0.90)	**-7. 05***	H3 (Accepted)

* Correlation is significant at the 0.01 level.

Observing Figure 3, we can easily notice the positive influence of Happiness, the negative influence of Anxiety and the neutrality of Enjoyment.

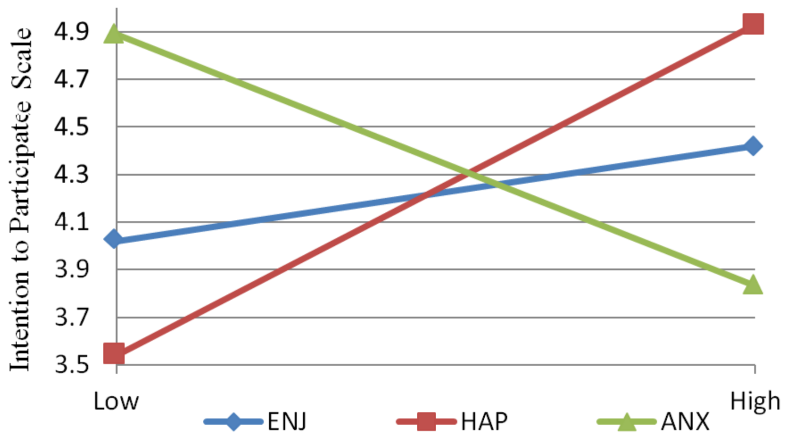

Fig. 2. The effect of enjoyment, happiness and anxiety in students' intention to participate to the programming activity

5 Discussion and Conclusions

In order to attract more students to the CS and IT disciplines, creative development activities have been designed and successfully applied in the last years [2, 5, 8]. In addition, recent studies have reported the crucial role of students' emotions and feelings on their behavior [3, 24]. To this end, a vital issue on that direction is: how emotions can increase students' intention to participate on creative development activities?

In the current paper we attempt to provide insights on the direction of using creative development activities to attract and engage students within the CS. The first step was to design and deploy a series of creative development activities. In particular, students engaged in programming languages (i.e., Scratch) and programmable hardware platforms (i.e. Arduino), which enabled them to engage in the world of creativity with digital enriched artifacts, like robots and interactive installations. In the next step, we used the empirical data obtained from students' experience with the activity in order to evaluate the effect of the key emotions on their intention to adopt on similar future activities.

Specifically in this study, three hypotheses (H1–H3) which help in understanding the role of emotions, and their contribution on creative development activities adoption from students were presented. The findings indicate that happiness has a positive effect, anxious has negative effect and enjoyment has no effect (neutral) on students' intention to participate on similar activities in the future. As such, by increasing students' happiness and decreasing anxiety we will be able to increase participation on creative development activities.

Based on the above findings, practices for increasing happiness (e.g., using humor in instructing, eliminate what students normally do not like, giving them positive feedback) must be performed by activities designers and instructors. Along with increasing students' happiness, practices to decrease their anxiety during the activity are highly recommended. For example, instructors must set attainable goals, praise about students' developing skills and use scenarios for increasing collaboration.

As with any empirical study, there are some limitations. First, in this study the respondents were students, in the frames of Norwegian educational system; this may limit the extent of the generalization of the findings. Secondly, the data are based on self-reported method, other methods such as depth interviews and observations could provide a complimentary picture of the findings through data triangulation. Thirdly, there are numerous emotions (e.g., sadness, anger) affecting students' behavior and intentions, but this study focused on Enjoyment, Happiness and Anxiety, as they are considered the most representative and important from the literature. Last, there is an age difference on the participants of one workshop, this was made because we wanted to see if there is a difference on that group on the under investigation effects. However, the distribution of the responses was the same and there was no moderation effect. Therefore, we decided that there is no reason to distinguish the responses obtained from that group.

In the next step of this ongoing project we will continue our research with qualitative methods, and aim to improve and optimize the workshop experience for our young participants. As such, future studies with larger sample from different classes and educational systems using wide variety of measures (i.e., observations, interviews) would valuably contribute on the understanding and improving the creative development activities and the role of students' emotions.

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