Stimulating Intrinsic Motivation for Science learning by using digital tools during scientific multi–maker event

Konstantina Kotsari¹, Zacharoula Smyrnaiou¹, Menelaos Sotiriou²

¹ School of Philosophy, Pedagogy & Psychology, National & Kapodistrian University of Athens
² Science View

Abstract: Intrinsic motivation is the form of motivation comes from within. Children are naturally curious and interested in learning, exploring, and mastering challenges. This study proposes that engaging with interactive science activities with the use of digital tools; will increase the intrinsic motivation of the student. We analyzed data from 51 students of a science learning activity during a multi-maker scientific event that was held in a primary school in Athens, Greece. We used the component of intrinsic motivation from SMQ-II questionnaire for science learning. By giving to students to fill in an ex-ante and an ex-post questionnaire, we tried to assess the impact of this activity to the students, by discussing three main dimensions of intrinsic motivation: relevance to everyday life, interest and curiosity.

Keywords: Intrinsic Motivation, Science Education, Digital Tools, Scientific Event

Introduction

According to social-cognitive theory, we are more motivated to learn if we believe we can achieve the desired result (Bandura, 1986), whereas if we have low self-efficacy, we are afraid of difficult tasks because we have negative expectations and do not believe in our ability to manage the task (Glynn et al., 2009). Therefore, it is not surprising that, for example, Pajares (2002) postulates self-efficacy as a very strong predictor of academic achievement. Furthermore, self-efficacy beliefs are also held responsible for influencing adolescents’ career decisions (Bandura et al., 2001).

According to Rothstein et al. (1994), science motivation components and personality traits are considered to influence scholastic success, whereas science achievement is regarded as dependent on science motivation.

Children’s everyday activities provide opportunities for the development of talent interests and cognitive skills (Goldschmidt & Bogner, 2015). Simpkins et al. (2006) support that middle childhood may be a particularly influential time for activities because this is when behavioral habits critical for health and competence are solidified and when skills, which form the basis for personal identities and self-esteem, are being learned (Erikson, 1982).

According to Glynn et al. (2011) motivation in science learning is defined as ‘an internal state that arouses, directs and sustains science learning behavior’ (p. 2). Motivation plays an important role in learning science. Except from promoting academic success, motivation provokes more help-seeking behaviors and commitment. Besides, it is very important for teachers to detect the reasons about the student’s lack of motivation and provide them assistance in self-assessment goal setting (Pajares, 2002).

At this level, intrinsic motivation is the drive we feel when we do something because it is inherently interesting or enjoyable (Ryan & Deci, 2000). A reward for performing an intrinsically motivated activity is the activity itself. Consequently, intrinsic
motivation is regarded as an important factor influencing children’s attitudes towards science learning because it stimulates their curiosity, interest, value and pleasure. A reward for performing an intrinsically motivated activity is the activity itself. Fostering intrinsic motivation with interactive applications can increase the enjoyment that people experience when using technology, but can also translate into more invested effort (Birck et al., 2016).

For understanding intrinsic motivation the aspect of autonomy, self-determination and self-efficacy is essential. Self-determination theory (Ryan et al., 2006) is a well-grounded theoretical framework that allows us to explain the intrinsic motivation that people have to be engaged with various activities due to having their basic psychological needs satisfied through this interaction. In an educational context, this self-determination refers to the control a student perceives he has over his learning. The feeling of autonomy leads to positive impact on academic performance (Black & Deci, 2000) and is therefore interesting for research on science motivation with students.

Furthermore, researchers have found that individual differences in self-beliefs and task beliefs emerge over the elementary school years and then are continually refined in response to performance feedback and identity formation processes through adolescence. Thus, participation in out-of-school activities during the elementary school years when self-beliefs and task beliefs are emerging may be particularly important.

Researchers have shown that children’s participation in organized and informal activities during middle childhood has implications for both their beliefs in these domains (e.g., importance, self-concept of ability) and emerging cognitive abilities (Gauvain, 1999). In fact, research suggests that math and science out-of-school activities are positively associated with youths’ interest in science and self-concept of abilities in these domains. Although these studies provide preliminary evidence that children’s participation in out-of-school activities is associated with concurrent beliefs, few studies have examined the longitudinal associations between out-of-school choices and subsequent beliefs.

**Description of the Activity**

In the multi-maker scientific event - which was held in Athens in the context of European Maker Week1 - 51 students of 5th and 6th Grades were engaged with digital activities about the history of space and the black holes. The event is based on the pedagogical and assessment framework which was developed by the European Project CREATIONS (http://creations-project.eu/). In this session, there were 3 researchers and 3 school teachers who facilitated students during the activities. This is session lasted 2 didactic hours in a special modulated classroom of a public school.

The first phase was based on the detection of universe with a digital telescope2 which is composed of stellar photos and telescopes image of space that someone can zoom in and see the details of all objects of the sky. They could also read the user's position and show the sky as he sees it. Finally, students were able to watch pictures from

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1 EMW: http://europeanmakerweek.eu/
2 WorldWide Telescope: http://www.worldwidetelescope.org/webclient/
telescopes and robots that have landed to planets. Students were separated into groups of 3. Each group had a pc with internet available.

After this first inquiry phase, researchers gave to students 2 worksheets with texts about the history of universe and ‘black holes’. Students had to read the text, discuss the context and try to answer the questions. Afterward they tried to discuss their answers to the plenary while the researchers were the facilitators of the discussion without intervene with the right answers.

The final phase of this activity is the creation of digital comics through open access software, available for free on line. Researchers had already created accounts for the students’ groups at “Toondoo”3. The final phase of this activity was the presentation of all these team work to the plenary. Students had the opportunity to communicate their comics through school’s web page (Figure 1).

![Figure 1: Students engaging with the digital tools](image)

**Methodology**

In this study we tried to detect internal motivation for science learning of 51 among 11 – 12 year old students of a public primary school in Athens, Greece. Before the implementation of the 4 interactive phases of the activity, students filled in an ex-ante questionnaire based on the 1st component of the most updated Science Motivation Questionnaire (SMQ – II). For the purposes of this research we isolated 5 relevant questions that consists the 1st component (intrinsic motivation) about science learning (relevance, interest, meaningfulness, curiosity, enjoyable).

According to Lovelace & Brickman (2013), the search for appropriate tools to measure science motivation is supported by various researchers. In this study we used the most updated questionnaire for Science Motivation (SMQ-II; Glynn et al. 2009; Glynn et al., 2011), a multi-component construct provided the frame for assessing science motivation combining important motivational factors, like intrinsic motivation in combination with personal relevance (Glynn et al., 2009). This model was grounded on the social-cognitive theory of human learning (Bandura, 1986).

After engaging with the phases of the activity, students filled a special ex-post questionnaire, in order to detect the impact of these interactions. The questionnaire had 2 main categories: a. insights that concern the activity (interest, collaboration, tools) and b. insights that concern motivation for science learning. For the purposes of

this study, we choose to analyze the second category which includes 3 relevant questions about motivation in learning science using technology, the connection of science with their everyday life and the interest for science learning.

**Results Analysis**

In this study, we tried to compare the results of specific questions that concern components of intrinsic motivation before and after the implementation of the activity. We used a Likert-type scale in order to specify their level of agreement or disagreement on a symmetric agree-disagree scale for a series of statements (Trochim, 2006). Thus, the range captures the intensity of their feelings for 3 basic dimensions science learning: relevance to their lives, interest and curiosity.

In the table below (Table 1), we analyze the frequencies of the answers of the first component of SQM II Questionnaire that refers to Intrinsic Motivation. The answers are numeric and they represent the following statements: 0 = always, 1 = rarely, 2 = sometimes, 3 = always.

<table>
<thead>
<tr>
<th>Learning science makes my life more meaningful</th>
<th>I am curious about discoveries in science</th>
<th>I enjoy learning science</th>
<th>The science I learn is relevant to my life</th>
<th>Learning science is interesting</th>
</tr>
</thead>
<tbody>
<tr>
<td>N Valid</td>
<td>51</td>
<td>51</td>
<td>51</td>
<td>51</td>
</tr>
<tr>
<td>N Missing</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Mean</td>
<td>2.41</td>
<td>2.84</td>
<td>2.78</td>
<td>2.29</td>
</tr>
<tr>
<td>Std. Error of Mean</td>
<td>.190</td>
<td>.184</td>
<td>.201</td>
<td>.162</td>
</tr>
<tr>
<td>Median</td>
<td>2.00</td>
<td>3.00</td>
<td>3.00</td>
<td>2.00</td>
</tr>
<tr>
<td>Mode</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Std. Deviation</td>
<td>1.359</td>
<td>1.317</td>
<td>1.433</td>
<td>1.154</td>
</tr>
<tr>
<td>Variance</td>
<td>1.847</td>
<td>1.735</td>
<td>2.053</td>
<td>1.332</td>
</tr>
<tr>
<td>Skewness</td>
<td>.354</td>
<td>-.847</td>
<td>-1.006</td>
<td>-.123</td>
</tr>
<tr>
<td>Std. Error of Skewness</td>
<td>.333</td>
<td>.333</td>
<td>.333</td>
<td>.333</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>-1.022</td>
<td>-.455</td>
<td>-.289</td>
<td>-.764</td>
</tr>
<tr>
<td>Std. Error of Kurtosis</td>
<td>.656</td>
<td>.656</td>
<td>.656</td>
<td>.656</td>
</tr>
<tr>
<td>Range</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Minimum</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Maximum</td>
<td>25</td>
<td>1,00</td>
<td>2.00</td>
<td>2.00</td>
</tr>
<tr>
<td>Percentiles</td>
<td>50</td>
<td>2,00</td>
<td>3,00</td>
<td>3.00</td>
</tr>
<tr>
<td>75</td>
<td>4,00</td>
<td>4,00</td>
<td>4.00</td>
<td>3.00</td>
</tr>
</tbody>
</table>

Table 1: Descriptive Statistics SMQ II – Frequencies Output of SPSS 20.0
Firstly, we see that “Missing” answer of the sample is only 1, so there is no problem with the validity. As far as the mean in concerned, the sample tends to be between sometimes and always to the first 4 answers, while they tend to the answer “sometimes” Mean = 2.29 – 2.84) in the last question which concerns the interest for science learning (Mean = 3.27). It deems that “Means” of the answers about curiosity, enjoyment and interest are less than the “Medians” of the observations, so we have negative symmetry, while the answers can be gathered to the right of the distribution.

Standard deviation is the square root of the variance. It measures the spread of a set of observations. The larger the standard deviation is, the more spread out the observations are. In this study, it is positive that we have values of the St. Deviation from 1.154 to 1.433.

Skewness measures the degree and direction of asymmetry. A symmetric distribution such as a normal distribution has a skewness of 0. Here, due to the negative values, we have a negative symmetry of the distribution. Kurtosis is a measure of the heaviness of the tails of a distribution. The negative values of all answers make the distribution platycurtic. Kurtosis and Skewness move into the closed space -2. 2 therefore although the distribution presents distortions, they are not so strong as to say that the distribution is not normal.

After the statistic analysis of the first component of SMQ II, in Figure 2, we present the lines of relevance of the three dimension of the ex-ante questionnaire. In this questionnaire we focused on the 3 dimensions of relevance to everyday life, interest and curiosity. From this diagram, it is remarkable to say that while students assume that science is interesting and they are curious about the scientific discoveries, they feel that science is irrelevant to their lives.

![Figure 2: Ex-ante questionnaire results](image-url)
For this reason, after the activity, we tried to compare the results of the ex-ante and the ex-post questionnaires on the matter of possible relevance to their lives; we see that there are great differences before and after the implementation of the activity (Figure 3).

![Comparison ex-ante Vs ex-post questionnaires about science learning and relevance to life](image)

**Figure 3**: Comparison ex-ante Vs ex-post questionnaires about science learning and relevance to life

**Discussion**

Fostering intrinsic motivation with interactive applications can increase the enjoyment that people experience when engaging with interactive activities. The goal of our work was to determine whether the use of various activities with the use of digital tools could increase intrinsic motivation. We first show that students believe that science as they learn it in school is not relevant to their lives. After the activities, students answer to a similar question to the post-ante questionnaire showing that, eventually, science has great relevance to their lives. It is very important to mention, that in both questionnaires students showed great interest and curiosity about state-of-the-art discoveries of science, especially space cutting-edge activities.

We believe that these findings are very important, but they are extremely restricted and focused to the needs of this pilot study. For that reason further research is needed in order to stimulate intrinsic motivation of students about science learning, through activities which could be instrumental in addressing societal challenges, building capacities and developing innovative ways of connecting science to society. In this way science will be more attractive to young people and open to society, stimulating the relevance of everyday life to cutting edge science discoveries (Horizon, 2020).

**Acknowledgment**

4 Science With And For Society – European Commission
References


