PROMOTION OF INTRINSIC MOTIVATION OF NEW GENERATION LEARNERS FOR LEARNING PHYSICS BY DIGITAL PHYSICS LABS

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Abstract. *The article deals with the role of digital Physics experiments in the promotion of intrinsic motivation of secondary school age learners for learning Physics. The methodological basis of research is inquiry-based learning. The article focuses on the second level of inquiry-based learning referred to as structured inquiry. The study is based on the sociological approach, with the emphasis on the new generation (Generation Z) and their exclusive relationship to technology. The research problem is formulated as a question: how does digital Physics laboratory promote intrinsic motivation of the new generation learners? Learners' intrinsic motivation is analysed on the basis of Self-Determination Theory. Despite this theory, motivation is based on three basic needs: a need for autonomy, a need for competency and a need for social relatedness. The article examines how digital Physics labs provide basic psychological needs for autonomy, competency and social relatedness of eighth-form learners.*

Keywords: *intrinsic motivation for learning Physics; inquiry-based learning; digital Physics labs.*

Introduction

Science is an important component of our European cultural heritage; it is particularly important in today's creative society.'Yet in recent times fewer young people seem to be interested in science and technical subjects. Why is this?' (Osborne & Dillon, 2008, p.5). The subject of Physics is an integral part of science. The problem of the attractiveness of the subject of Physics is very wide, it is analysed from different aspects: the individualization of learning (Zacharia & Olympiou, 2010), collaborative learning (Nedic, Machotka & Nafalski, 2003), formation of the concepts of Physics (Bajpai, 2013).

Motivation for learning Physics is rarely examined from the sociological aspect which is based on the theory of generation. According to the sociological classification, persons born in 1977-1994 belong to Generation Y, whereas the ones born in 1995-2012 belong to Generation Z (McCrindle & Wolfinger, 2010). Currently, learners of Generation Z attend basic school. Is motivation for learning Physics of new generation exceptional? Are new generation learners less interested in Physics than Gen Y learners? The problem of motivation for learning Physics was also important for the learners of Generation Y: 'A German learner at lower and upper secondary level regards Physics as very difficult to learn, very abstract and dominated by male learners. As a result, Physics at school continuously loses importance' (Fisher & Horstendal, 1997,

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p.411). According to H.R. Fisher and M. Horstendal, a very abstract content of Physics is one of the reasons for reducing the Y-generation learners' interest in Physics.

The new Generation Z learns using new technologies that can facilitate the absorption of the complex content. The relationship of Generation Z with technologies has been precisely defined by A. Cross-Bystrom (2010): 'Generation Z *is* technology'. The statement presupposes a very close relationship with technologies since the generation itself is equaled to technologies. Learners of this generation have lived in the world closely intertwined with technologies since early childhood (Cross-Bystrom, 2010). Californian psychologist L. D. Rosen (2012) raises a question about what teachers know about young people who spend entire hours at the computer in different social networks. L. D. Rosen's question can be restated as follows: what do teachers know about the motivation of learners of Generation Z to study natural sciences and how is it affected by e-learning? (Peciuliauskiene, 2014).

It is assumed that two approaches could be distinguished while analyzing the role of new technology to study Physics: generalised approach (the aspect of generations) and a specific approach (specific experiments: virtual, digital, real) of using technologies in a specified place and time. However, the analysis of the employment of virtual learning platforms in specific conditions merely reveals the effect of specific technologies on the learning process and motivation to study Physics (Ince, Kirbaslar & Yolcu et al., 2014).

Not only new learning technologies (digital, virtual) provide new insights into the motivation for learning Physics, but also the conception of motivation, and its theoretically defined levels. The motivation for learning Physics can be analysed from the extrinsic and intrinsic aspects. J. Brophy (2008) suggests shifting from focusing on intrinsic motivation to focusing on how to motivate learners to learn, i.e. to find learning activities meaningful and worthwhile even though they do not necessarily feel pleasurable per se for the learners. A. Loukomies et al. (2013) support J. Brophy (2008) by claiming that their conclusions are in agreement with J. Brophy's (2008) and provide further evidence that, irrespectively of the context or country, learners learn science with regard to what they view as meaningful and worthwhile activities.

This situation necessitates for a deeper look into the problem of motivation for learning Physics − by the aspect of intrinsic motivation. The discussed situation highlights *the scientific problem* which is formulated as a question: What is the intrinsic motivation of the new generation learners for learning Physics and how is it determined by the experimental activity based on digital technologies?

The object of the research is the intrinsic motivation of learners for learning Physics.

*The aim of the research*isto reveal the impact of digital Physics labs on the intrinsic motivation of basic school learners for learning Physics.

*The objectives of the research*are as follows:

1. What is the impact of digital Physics labs on the intrinsic motivation of basic school learners?
2. What psychological learner needs determined by Self-Determination Theory are assured by digital Physics labs?
3. How is the motivation of new generation learners for learning Physics related to basic psychological needs determined by Self-Determination Theory, i.e. a need for autonomy, a need for competency and a need for social interaction?

Theoretical background

When searching for an answer to the question what factors determine the positive approach to the studies of natural sciences, first at all, we have to answer the question what motivation is. The conceptualisation of motivation is a big challenge. Motivation is a theoretical construct used to explain behaviour. Theories of human motivation have evolved from the emphasis on reactive responses to pressures (external reinforcement contingencies or internally felt needs) to an emphasis on intrinsically motivated, self-determined actions (Pardee, 1990).

There is a close relationship between extrinsic and intrinsic motivation which is explained by theOrganismic Integration Theory (OIT). According to OIT, the regulation of behaviour may be autonomous (self-determined) or controlled, depending on the degree of internalisation. Intrinsically motivated individuals engage in certain activities freely, led by the feelings of interest and enjoyment (Ryan & Deci, 2002). Intrinsic motivation arises from a desire to learn a topic due to its inherent interests, self-fulfillment, enjoyment and achievement of mastery of the subject (Ryan & Deci, 2009). Intrinsic motivation is very important at school as "schools are not day camps or recreational centers" (Brophy, 2004, p.12). Intrinsic motivation contributes to the achievement, especially when people are self-employed. This actuality raises the question how to encourage intrinsic motivation.

People's healthy tendencies toward growth and integrity can be explained by Self-Determination Theory (SDT) constructed by Edward L. Deci and Richard M. Ryan (2002). The main idea of SDT is that humans are active and growth-oriented, seeking for the actualisation of their potentialities and fulfilling their basic psychological needs. These needs include *autonomy, competency and social relatedness*. They move the lives of learners in desired and specific directions rather than being passive subjects. A person's motivation in a particular situation is a result of the interaction between immediate social context and the individual's need system that seeks fulfilment (Ryan & Deci 2002; Vansteenkiste & Ryan, 2013).

Individuals with different motivation orientations develop motivation towards science learning through being engaged in activities that may fulfil their basic psychological needs, but different aspects of the activity appeal differently to different learners (Loukomies et al., 2013). Autonomy-supportive teacher behaviour can be effective in fostering intrinsic motivation in learners (Reeve & Jang, 2006). Autonomy-supportive teacher behaviour can be supported by different levels of inquiry-based learning. H. Banchi & R. Bell (2008) identified four levels of inquiry-based learning:confirmation inquiry, structured inquiry, guided inquiry and open enquiry. The lowest level of inquiry (confirmative inquiry) corresponds to activities where learners know the possible outcomes of a project, and where a detailed description of activities and problems are provided. The second level of inquiry (structured inquiry) is reached in projects when learners are provided with a problem and the method for its solution. The third level (coordinated inquiry) is characterized by the fact that learners know the problem but have to find out how to solve it by themselves. The highest level (open inquiry) is reached when learners identify a problem, methods for its solution, and explanations for the cross-curricular phenomena themselves. Low autonomy is acquired by confirmation inquiry, a higher autonomy is gained by structured inquiry and guided inquiry, whereas the highest autonomy is obtained by open enquiry. The article deals with the application of the structured inquiry in Physics labs with digital devices which provide the autonomy of experimental activity.

Methodology

The research methodology is based on constructivist theory of education, which acknowledges structured inquiry as an efficient educational technology promoting a positive attitude towards the subjects of natural sciences and helping to apply the acquired knowledge in different situations, developing higher-level thinking abilities as well as promoting active learning processes that are based on knowledge and experience. Moreover, realist education philosophy stating that the reality of natural sciences is objective and cognisable is considered.

The instrument of quantitative research. Intrinsic Motivation Inventory (IMI), a valid and reliable instrument, was used to explore intrinsic motivation. E. McAuley, T. Duncan, and V.V. Tammen (1987) carried out a study to examine the validity of the IMI and found strong support for its validity. IMI is a multidimensional measurement device intended to assess participants' subjective experience related to a target activity in laboratory experiments (Ryan, 1982). This instrument allows assessing intrinsic motivation and self-regulation of learners. There are seven subscales in this instrument: the subscale of participants interest/enjoyment, perceived competency, effort, value/usefulness, felt pressure and tension, perceived choice (or autonomy of activity) and relatedness. The first subscale (*interest/enjoyment*) is the main subscale of IMI and assesses the intrinsic motivation of learners. On the basis of this subscale, overall questionnaire is called Intrinsic Motivation Inventory. According to the Self-Determination Theory, the second subscale *feeling of competency*, the fifth subscale *perceived choice* and the seventh subscale *interpersonal interactions*are important for intrinsic motivation. The results of subscales are represented by the interval scale, which ranges from 1 to 100 points.

The sample and sampling of quantitative research. The research sample is reliable and representative (probability cluster sample). The sample included eighth-form learners of Lithuania. The research clusters were the largest cities of Lithuania. Classes were selected on the basis of probability cluster sample and all learners of a selected class were tested.

The research sample was reliable as it involved 385 learners. The total population was 25000 eighth-form learners (EMIS – Education Management Information System). The confidence interval being 5%, confidentiality level is 95%. Hence, the research sample should have included 379 respondents. Therefore, the probability (confidentiality level) is 95% that the obtained data can shift only by 5% from the population parameters (confidence interval). Eighth-form learners were tested using IMI questionnaire after digital Physics lab accomplished with digital devices.

Method of research. The learners accomplished a Physics lab using digital laboratory software Xplorer GLX. It is a tool of storage, presentation and analysis of the data of experimental measurements that operates with PASPORT sensors.

The learners were working in groups: on average three persons per group. In terms of inquiry-based levels, the lab conformed to the second level (structured inquiry). Before the accomplishment of the lab, the learners were introduced to the aim and procedure of the work, but they were not familiar with the result. After the accomplishment of the lab, the learners filled in IMI questionnaire that was meant to determine intrinsic learning motivation and its determinant factors.

Results

The study focused on the promotion of learners' intrinsic motivation to study Physics by digital Physics labs. We used IMI questionnaire which consisted of seven groups of questions – subscales (Table 1). From the viewpoint of Self-determination Theory, the following subscales are important: feeling of competency, perceived choice and interpersonal interactions. There are two scales of IMI that are related to personal effort and felt pressure and tension (Table 1) and one subscale related to value/usefulness.

A 100 point interval measurement scale was used to explore the intrinsic motivation of learners; therefore, parametrical data were obtained. On this basis, the mean, median and standard deviation were calculated for every subscale (interest/enjoyment; feeling of competency, effort; felt pressure and tension, perceived choice, value/usefulness, interpersonal interactions), as well as skewness coefficients of every subscale were drawn (Table 1).

Table 1. Key tendencies of learners' intrinsic motivation and its determinant factors

	1. Interest/ enjoyment	2. Feeling of competency	3. Effort	4. Felt pressure and tension	5. Perceived choice (autonomy)	6. Value/ usefulness	7. Interpersonal interactions
Mean	59,74	62,73	64,91	52,48	59,71	76,67	52,00
Median	60,00	63,00	64,00	52,00	60,00	80,00	55,00
Std. Deviation	11,590	14,272	13,941	12,814	13,032	23,392	19,632
Skewness	0,074	-0,443	-0,370	0,217	0,162	-0,905	-1,064
Std. Error of Skewness	0,295	0,295	0,295	0,295	0,295	0,295	0,295
Minimum	37	30	24	20	31	20	0
Maximum	80	90	100	92	91	100	90

The first subscale (interest/enjoyment) is the most significant one in IMI (Table 1) as it reveals learners' intrinsic motivation for learning Physics. Its mean is 59,74 points out of the total of 100 points. The research data demonstrate that the data of the subscale is distributed according to the normal distribution and is marked by positive skewness (Interest/enjoyment). The mean of the first subscale (interest/enjoyment) is closest to the mean of the fifth subscale (perceived choice or autonomy) (59,71). Distribution of the fifth subscale is also marked by a weak positive skewness and it approximates the normal distribution.

It should be stated that the assessment of the satisfaction of the basic psychological needs (autonomy, competency and interpersonal interaction) differs while conducting digital labs in Physics. Digital Physics labs mostly satisfy learners' need for the competency feeling: the mean of the second subscale is 62,73. Therefore, digital Physics labs provide preconditions for a learner to feel competent: "I think I am pretty good at this activity"; "I think I did pretty well at this activity, compared to other learners". It appeared that a need for interpersonal interaction is satisfied least of all by digital Physics labs. The mean of the seventh subscale equals to 52,00. The discrepancy between the second and seventh subscales equals to 10,73 (Table 1).

The research data reveal (Table 1) that while conducting digital Physics labs learners do not experience extensive emotional pressure and tension (the mean is 52,48). Nevertheless, accomplishment of digital Physics labs demands some effort (the mean is 64,91). According to IMI questionnaire, it is impossible to determine what demands more effort: the content of Physics lab or its digital means. Therefore, it is impossible to draw a conclusion that learners of the new generation consider digital Physics labs as demanding effort.

The study also attempted at exploring whether the means of the subscales differed statistically significantly from the point of view of Self-Determination Theory (Table 2). ANOVA data block was used to identify statistical significance of the differences in means. This statistical criterion is applied for more than two dependent samples when the data are parametrical.

Sphericity Assumed (p = 0,000) showed means that differed statistically significantly. Significant statistical differences of the means of the second (feeling of competency), fifth (perceived choice or autonomy) and seventh (interpersonal interactions) subscales were explored (Table 2).

Table 2. Results of ANOVA Bonferoni data block test. Pairwise Comparisons between main factor of Self-Determination theory: 2 - feeling of competency; 5 – perceived choice or autonomy; 7 – interpersonal interactions

(I) factor1	(J) factor1	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a]	
					Lower Bound	Upper Bound
2	5	3,015	2,204	0,528	-2,400	8,431
	7	10,727*	2,718	0,001	4,047	17,408
5	2	-3,015	2,204	0,528	-8,431	2,400
	7	7,712*	2,611	0,013	1,297	14,128
7	2	-10,727*	2,718	0,001	-17,408	-4,047
	5	-7,712*	2,611	0,013	-14,128	-1,297

Based on estimated marginal means
*a. Adjustment for multiple comparisons: Bonferroni. *The mean difference is significant at the ,05 level.*

The results of ANOVA Bonferoni test in the table of Pairwise Comparisons demonstrated statistically significant differences of the means of the seventh (interpersonal interactions) subscale from the second (feeling of competency) and fifth (perceived choice or autonomy) subscales (Table 2). The statistically significant difference occurred due to the fact that the mean of the seventh (interpersonal interactions) subscale was lower than those of the second and fifth subscales (Table 1). It was determined that the need of the learners of new generation for social interaction was less important in experimental activity in comparison to the feeling of competency (p = 0,001) or the feeling of autonomy of activity (p = 0,013) (Table2).

Correlation between the data of different subscales was also explored (Table 3). As it was mentioned earlier in the article, humans are actively seeking for the actualization of their potentialities fulfilling their basic psychological needs: needs for autonomy, competency and social relatedness. Therefore, it was important to determine how the data of the first (interest/enjoyment) subscale correlated with the data of the second (feeling competency), fifth (perceived choice) and seventh (interpersonal interactions) subscales.

The strongest statistically significant correlation was determined between learners' intrinsic motivation for learning Physics and the feeling of competency (the first and second subscales) ($r = 0{,}462^{**}$, $p = 0{,}01$). Hence, digital labs in Physics gave learners' the feeling of competency and promoted positive motivation for learning Physics.

Table 3. Promotion of the learners' intrinsic motivation for learning Physics through experimental activity: Pearson correlation coefficients between IMI questionnaire subscales

	Interest/ enjoyment	Feeling of competency	Effort	Felt pressure and tension	Perceived Choice	Value/ usefulness	Interpersonal interactions
Interest/ enjoyment	1	0,462**	-0,195	0,019	0,235*	0,445**	0,187
Feeling of competency		1	0,373**	0,072	0,143	0,377**	0,181
Effort			1	0,123	0,422**	0,339**	0,288*
Felt pressure and tension				1	0,264*	-0,092	0,280*
Perceived Choice					1	-0,025	0,206
Value/ usefulness						1	-0,125
Interpersonal interactions							1
**. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed).							

A statistically significant correlation was determined between learners' intrinsic motivation for learning Physics and the feeling of autonomy while accomplishing a Physics lab (the first and fifth subscales) ($r = 0{,}235^{*}$, $p = 0{,}01$). This correlation is significant in assessing the reliability of the questionnaire for motivation. In fact, to be confident in one's assessment of intrinsic motivation, one needs to find that the free-choice behaviour and the self-reports of interest/enjoyment are significantly correlated (Ryan, Koestner and Deci, 1991). A statistically insignificant correlation was determined between intrinsic motivation for learning Physics (the first subscale) and interpersonal interaction (the seventh subscale) ($r = 0{,}187$, $p = 0{,}05$).

Correlational analysis demonstrated (Table 3) that digital labs in Physics created the feelings of activity value and usefulness and established strong and statistically significant correlation with intrinsic motivation for learning Physics ($r = 0{,}445^{**}$, $p = 0{,}01$). The data on the value/usefulness of experimental activity was marked by strong and statistically significant correlations with the data of the subscale of feeling of competency ($r = 0{,}377^{**}$, $p = 0{,}01$) and with the one of effort ($r = 0{,}339^{**}$, $p = 0{,}01$). Value/usefulness of experimental activity enhanced the feeling of competency of the learners of Generation Z; however, it demanded more effort. Three statistically significant correlations that were determined in the subscale of value/usefulness suggested that the learners of Generation Z were characterized by a pragmatic approach to experimental activity.

According to R.M. Ryan, R. Koestner and E.L. Deci (1991), when participants were ego involved, they engaged in pressured persistence during a free choice period and this behaviour did not correlate with the self-reports of interest/enjoyment. Conclusions of R.M. Ryan, R. Koestner and E.L. Deci (1991) were drawn with reference to the studies of intrinsic motivation of preceding generations (Generation X or Generation Y). The research of new generation learners' intrinsic motivation for learning Physics that was based on the promotion of motivation for learning demonstrated (Table 3) that the learners were ego involved because the data of the fourth subscale (felt pressure and tension) did not statistically significantly correlate with the data of the first subscale (interest/enjoyment).

Discussion

The research involved the analysis of the results of Physics labs that are attributed to structured inquiry in terms of the Inquiry Theory. While accomplishing structured inquiry labs, the learners could communicate in groups and search for an unknown outcome of the lab. Despite the inquiry theory, learners had to be engaged in the learning process and encouraged to share and discuss ideas with peers. The inquiry learners needed to design experiments, decide upon appropriate data to collect, as well as to tabulate their findings (Wolf & Fraser, 2008). Stephen J. Wolf & Barry J. Fraser (2008) analysed how eighth-form learners explored activity of static electricity and determined that learners in the inquiry classes worked more closely and offered advice and suggestions. According to the sociological characteristics of generations, the research participants in S. J. Wolf & B. J. Fraser's (2008) study belonged to Generation Y. Hence, social interaction was important for learners of Generation Y while accomplishing labs in static electricity. Our research also involved learners' social interaction (as a component of Self-Determination Theory). It appeared that the respondents attributed the least amount of points to the need for real social interaction while accomplishing digital labs in Physics (Table 1). The data of our research presuppose that learners of the new generation (Z) are less inclined to communicate in the real environment, i.e. in a group of learners accomplishing a lab. A component of their real social interaction does not statistically correlate with the intrinsic motivation for learning Physics (Table 3).

A. Loukomies et al. (2013) maintain that, in terms of inquiry strategy, it is important to employ not only learners' prior knowledge but also the basic psychological needs they want to fulfil. The current research embodied the design of the enhanced intrinsic motivation by supporting learners' innate psychological needs. The conducted research reveals that basic psychological needs (for autonomy, competency and social relatedness) are significant for the intrinsic motivation of new generation learners for studying Physics. The most expressed among them is a need for competency recognition (Table 1).

We agree with A. Loukomies et al. (2013) that "different learners value aspects intended to enhance motivation differently; and therefore, various motivational features make it easier to affect different learners with one sequence" (p. 2536). A well designed activity that encompasses support for new generation learners' basic psychological needs and especially for support perceived competencyis a reasonable way of enhancing new generation learners' intrinsic motivation towards digital Physics labs.

Conclusion

1. Digital labs in Physics are most often accomplished at school. Their impact on the intrinsic motivation of new generation (Z) learners, or the so-called learners of technology generation, is significant; however, it is not essential. According to IMI questionnaire, the mean of learners' intrinsic motivation for learning Physics is 59,74 points out of the total of 100 points. Basic school learners are convinced about the value, practical applicability and benefit for the future of digital labs in Physics. The mean of the subscale of value/usefulness is 76,67 out of the total of 100 and is higher than that of other subscales (of IMI). Awareness of the value of experimental activity is an important factor of a new generation learner's intrinsic motivation for learning Physics.
2. The peculiarities of the intrinsic motivation of new generation learners for experimental activity are revealed on the basis of Self-Determination Theory. According to this theory, intrinsic motivation for learning occurs when basic psychological needs (for autonomy, competency and social relatedness) are satisfied. Digital labs in Physics provide highest satisfaction of new generation learners' need for competency, and the lowest satisfaction for the need of interpersonal interactions (the difference is statistically significant: $p = 0{,}001$). Moreover, digital labs in Physics

provide better satisfaction of the need for autonomy as compared to the need of interpersonal interactions (the difference is statistically significant: p = 0,0013).

3. Correlational analysis of the main components of Self-Determination Theory reveals that the strongest and statistically significant correlation is manifested between learners' intrinsic motivation for learning Physics and their feeling of competency ($r = 0{,}462^{**}$, when $p = 0{,}01$), as well as between intrinsic motivation for learning Physics and the feeling of autonomy while accomplishing a lab (the first and fifth subscales) ($r = 0{,}235^{*}$, when $p = 0{,}01$). The correlation between learners' intrinsic motivation for learning Physics and their feeling of competency is stronger than the correlation between motivation to learn Physics and the feeling of autonomy while accomplishing a digital lab.

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