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THE INFLUENCE OF BASIC PSYCHOLOGICAL NEEDS ON SECONDARY SCHOOL STUDENTS' INTRINSIC MOTIVATION AT RRI ACTIVITY

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Abstract. *The article deals with the role of responsible research and innovation (RRI) at science education in promoting intrinsic motivation of secondary school learners from Lithuania. RRI deals with uncertain areas of knowledge and gives students an opportunity for responsibility and self-expression to come to informed decisions about science innovations and their impact. The theoretical background of learners' intrinsic motivation was analysed on the basis of Self-Determination Theory (STD). STD highlights three basic psychological needs of learners: the need for autonomy, the need for competence and the need for relatedness.*
The research problem is formulated as a question: how do basic psychological needs influence intrinsic motivation of secondary school learners at RRI activity? Intrinsic motivation inventory was used to assess the secondary school students' intrinsic motivation related to RRI activity. The collected data were analysed using simple regression. The findings confirm that the need for competence and the need for relatedness are important internal factors in promotion of intrinsic motivation of secondary school learners at RRI activity.
Keywords: *responsible research and innovation; intrinsic motivation; inquiry-based learning.*

Introduction

The motivation for learning science is relevant for education policy-makers and for researchers (Byman et al., 2012; Loukomies et al., 2013; Osborne, 2007). The concept of motivation is a complex construct. The Latin root of the word 'motivation' means 'to move', in this sense the study of motivation is the study of action (Eccles & Wigfield, 2002). "To be motivated means *to be moved* to do something" (Rayan & Deci, 2000, p. 54).

Theories of human motivation have evolved from the emphasis on reactive responses to action to an emphasis on self-determined actions (Pardee, 1990). Self-Determination Theory (SDT) posits that humans are active fulfilling their basic psychological needs: autonomy, competency and social relatedness (Deci & Ryan, 2002). SDT claims that intrinsic motivation is fostered in environments if they "provide people [with the] opportunity to satisfy their basic psychological needs for competence, relatedness and autonomy" (Deci, Vallerand, Pelletier, & Ryan, 1991, p. 329). SDT describes motivation as a continuum from amotivation

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to intrinsic motivation (Ryan & Deci, 2002). Intrinsically motivated behaviour is characterised by interest and engagement. According Byman et al. (2012), it occurs spontaneously and people become involved in the activity by feelings of interest and enjoyment.

The problem of the motivation for learning science at school is related to inquiry based science learning (IBSL): formulating problems, solving dilemma problems, critiquing experiments and distinguishing alternatives, debating with peers using evidence and representations, and forming coherent arguments (Minner, et al., 2010). Inquiry can be considered as a teaching approach that places school students in situations very similar to what scientists experience during their work. Inquiry allows students to construct their own knowledge and to share the findings and ideas for critical view of others.

Various educational projects are implemented in educational practice that promotes motivation for learning science of school students on the basis of the IBSL. ENGAGE project is one of them. The ENGAGE project is part of the EU Science in society agenda to promote more Responsible Research and Innovation (RRI). Stahl (2013) states that “RRI is a higher-level responsibility or meta-responsibility that aims to shape, maintain, develop, coordinate and align existing and novel research and innovation-related processes, actors and responsibilities with a view to ensuring desirable and acceptable research outcomes” (Stahl, 2013, p. 708). The European Commission has highlighted the importance of RRI in Science Education through its Science in Society programs (FP7 and Horizon 2020).

RRI is an inclusive approach to ensure that societal actors understand risks and benefits of innovations because “Research has traditionally been seen as an extension of human knowledge and thus as a moral and public good” (Stahl, 2013, p. 708). On the one hand, the impact of scientific innovation is uncertain and requires knowledge and skills for reflecting on social and ethical implications. On the other hand, it stimulates the interest of learners in the results of innovation implementation, and leads to the dilemma solution. It is important to investigate how RRI influences school students' motivation for learning science.

The discussed situation highlights the scientific problem, which is formulated as a question: how do basic psychological needs influence intrinsic motivation of secondary school learners at RRI activity?

The object of the research is intrinsic motivation of secondary school learners for learning science.

The aim of the research is to disclose the influence of basic psychological needs for motivation of school students for learning science at RRI activity.

The influence of basic psychological needs for motivation of learning science was disclosed by testing three hypotheses on the basis of a simple linear regression:

1. There is a positive and significant relationship between students' need for competence and motivation for learning science at RRI activity.
2. There is a positive and significant relationship between students' need for autonomy and motivation for learning science at RRI activity.
3. There is a positive and significant relationship between students' need for relatedness and motivation for learning science at RRI activity.

Methodology

The research methodology. The study is focused on IBSL teaching methods which include scientific inquiry, discovery, and problem-based learning (National Research Council, 2007). These methodological approaches feature the teacher in the role of a facilitator and stress that students will only engage in learning processes if they are interested and willing to do so, thus stressing the importance of motivational variables as individual prerequisites for successful learning processes (Andre & Windschitl, 2003). The research methodology emphasises collaborative group work and relatedness, construction of argumentation through communication, as well as the development of competencies and self-regulation

Method of research. The data presented in the current study is part of the 7BP ENGAGE project implemented in Lithuania (2014-2017). ENGAGE focused on cutting edge science topics bringing up complex ethical, economic, and social questions. This project was based on dilemma approach which lead students towards the dilemma question. ENGAGE dilemma approach consisted of 5 E's inquiry cycle: Engage (motivation of students), Explore (searching concepts and facts into evidence), Explain (claim, and evidence and reasoning), Elaborate (claim, and evidence and reasoning), and Evaluate (debate which explained problem-based solutions) (Bybee, 2002). Dilemma based learning in science education was implemented by carrying out mini-project in school student groups (four students in one group). Mini-projects encompassed formal (two lessons) and informal education. In the first lesson of mini-projects, students learned new content, looked at scientific evidence, performed an experiment, and discussed the conclusions of the experiment (Engage, Explore, Explain). Explain and Elaborate cycle took place in informal education. Students gathered information from different sources, weighed up benefits and drawbacks and applied what they knew. In the second lesson (Evaluation cycle), students discussed a dilemma solution and analysed the benefits, risks and its possible sequences. According to Ocada (2016), by the end of these cycles, students are equipped with both scientific concepts and principles that they need to respond to the original problem.

The instrument of the quantitative research. Intrinsic Motivation Inventory (IMI) (Ryan, 1982) was used to assess the students' basic psychological needs (competence, autonomy, relatedness) after the mini-projects.

Primary data collection was done using questionnaire instrument based on Likert Scale. The students were asked to respond as well as to provide a statement that expressed the answer to the questions. The transformation from Likert scale toward interval scale was done using MSI (Method of Successive Interval). The results of each subscale in our research are represented by the interval scale, which ranges from 1 to 100 points.

The sample and sampling of the quantitative research. The research sample (the confidence interval being 5 %, and the confidence level being 95 %) was reliable as it involved 400 school students. The total population was 25000 eighth form school students (EMIS – Education Management Information System). Therefore, the probability (confidence level) is 95 %, so the obtained data can shift only by 5 % from the population parameters (confidence interval). The research clusters were the largest cities of Lithuania. The classes were selected on the basis of probability cluster sampling and all the learners of the selected classes were tested.

Results

This research aimed to measure the influence of basic psychological needs (competence, autonomy, and relatedness) on school students' motivation for learning science at RRI activity. For this purpose, simple linear regression was chosen. Simple linear regression allows summarizing and studying relationships between two continuous (quantitative) variables.

When performing a regression analysis, it is important to make sure that the data meet the condition of normality. The normality test of Kolmogorov-Smirnov was used in this study (Table 1). This test was conducted to determine if the data were normally distributed. The significance level of Kolmogorov-Smirnov sig> 0.05 test shows normal distribution of the data. The results of Kolmogorov-Smirnov test show that the data of students' motivation for learning science ($p=0.061 > 0.05$), the data of need for competence ($p= 0.115 > 0.05$), the data of the need for autonomy ($p= 0.225 > 0.05$), and the data of the need for relatedness ($p= 0.055 > 0.05$) were normally distributed (Table 1).

Table 1 ***Results of the One-Sample Kolmogorov-Smirnov Normality Test***

	Motivation for learning science	Need for competence	Need for autonomy	Need for relatedness
Mean	68,281	70.37	57.214	57.594
Std. Deviation	9.022	11.746	9.742	10.248
Skewness	-0.039	0.260	0.274	0.587
Kurtosis	0.0642	0.255	0.365	-0.641
Kolmogorov-Smirnov Z	1.855	1.488	1.412	1.991
Asymp. Sig. (2-tailed)	0.061	0.115	0.225	0.055

A simple linear regression was calculated to test the first hypothesis and predict the students' motivation for learning science based on their need for competence (Table 2). There was a strong positive linear relationship between the two, which was confirmed by Pearson's correlation coefficient (r) of 0.612.

Table 2 ***Simple linear regression analysis: motivation for learning science and basic psychological needs***

Dependent variables	B	SE B	β	t	p
1. Need for competence	0.565	0.037	0.612	15.469	0.000
2. Need for autonomy	0.012	0.014	0.015	0.298	0.766
3. Need for relatedness	0.218	0.032	0.273	3.508	0.001

A significant regression equation was found (F (1.399) =239.302, $p<0.001$), with R^2 of 0.375. The coefficient of determination (R^2) indicates that 37.5 % of the variation in motivation for learning science can be explained by the model containing only confidence in competence. This coefficient is quite high, so the predictions from the regression equation are fairly reliable. It also means that 62.5 % of the variation is still unexplained, so adding other independent variables could improve the fit of the model. The coefficient of students' motivation for learning science was 0.562 and the constant number was 28.494. Based on these data, the regression line equation can be written as follows:

Motivation for learning science (y) = 28.494 + 0.565 (Need for competence) (x) (1)

The equation (1) shows that if the students' need for competence increases by 1 unit, then students' motivation for learning science will increase by 0.565 units. Therefore, it could be concluded that the independent variable (Need for competence) affects the dependent variable (Motivation for learning science). In other words, the students' need for competence has a positive influence on their motivation for learning science.

A simple linear regression was carried out to investigate the relationship between the school students' need for autonomy and motivation for learning science. There was a weak positive linear relationship between the motivation for learning science and the need for autonomy 0.015.

The simple linear regression showed a statistically insignificant relationship between motivation for learning science and need for autonomy at RRI activity ($p=0.766 > 0.05$). The slope coefficient for confidence in autonomy was 0.012 (Table 2). It means that the dependent variable (motivation for learning science) increases by 0.012 units if every unit in the need for autonomy increases by 1 unit. The R^2 value was 0.099, so only 9.9 % of the variation in motivation for learning science can be explained by the model containing only confidence in autonomy at RRI activity. This coefficient is quite low, so predictions from the regression equation are not fairly reliable.

The third hypothesis test was carried out using the simple linear regression analysis (Table 2). The correlation value between the need for relatedness and motivation for learning science was calculated to be 0.199. This shows that R_{x1y} correlation coefficient is positive; thus, students' confidence in relatedness affects their motivation for learning science.

A significant regression equation was found ($F(1,399) = 12.307$, $p<0.001$), with R^2 of 0.275. The coefficient (R^2) indicates that 27.5 % of the variation in motivation for learning science can be explained by the model containing only the need for relatedness. The students' motivation for learning science coefficient was 0.218 and the constant number was 55.754. It means that the regression line equation can be written as follows:

Motivation for learning science (y) = 55.754 + 0.218 (Need for relatedness) (x) (2)

The linear regression analysis (2) revealed that if the students' need for relatedness increases by 1 unit, their motivation for learning science will increase by 0.218 units. Thus, it can be concluded that the independent variable (Need for relatedness) has a positive influence on the dependent variable (motivation for learning science).

The linear regression analysis revealed a different influence of basic psychological needs on motivation for learning science (equation 1; equation 2) at RRI activity. The most significant linear regression model was found analysing the school students' need for competence and motivation for learning science at RRI activity ($R^2 = 0.375$). The statistically insignificant regression model was detected analysing the students' need for autonomy and motivation for learning science ($R^2 = 0.099$).

The results of this study indicate that unstandardised beta (B) coefficients are different for the need of competence, autonomy and relatedness (Table 2). The unstandardised beta (B) value represents the independent variable and the dependent variable. The independent variable 'need for competence' best represents the motivation for learning science at RRI activity (Table 2).

Standardised beta coefficients (β) were calculated for the purpose of the study. They allow seeing which independent variable has the strongest relationship with the dependent variable (works similarly to a correlation coefficient). The standardised beta coefficients (β) are higher analysing students' need for competence and motivation for learning science (Table 2). It means that the need for competence has the strongest relationship with motivation for learning science (Table 2).

Discussion

Scholars have shown that intrinsic motivation has positive effects on learning (Deci, 1975; Deci & Ryan, 1985). In the present study, the conceptualisation of motivation is based on the Self-Determination Theory (SDT), which highlights three basic psychological needs: the need for competence, the need for autonomy, and the need for relatedness.

The objective of this study was to determine the influence of basic psychological needs (competence, autonomy and relatedness) on motivation for learning science at RRI activity. During the mini-projects in the science classroom, the need for competence was fulfilled by evidence-based learning about new technologies and scientific achievements, the need for relatedness – by collaboration when carrying out mini-projects of students with the teacher and scientists, while the need for autonomy – by freedom of choice of the way of cognitive activity.

The conducted research reveals that the need for competence is significant for the motivation of learning science at RRI activity (Table 2). Evidence-based learning about new technologies and scientific achievements was used at RRI activity. Hence, evidence-based learning gives preconditions for revealing the competence of students. Teachers can challenge students' intrinsic motivation by engaging students in the discourse on RRI issues. The results of the conducted research comply with the opinion of Jurik, Gröschner, and Seidel (2014). The scholars noticed that deep-reasoning questions in science classrooms, socio-scientific problems and ethical dilemma solutions give a possibility for the promotion of students' competences (Jurik, Gröschner, & Seidel, 2014).

We had one insignificant model, as shown with the variable 'need for autonomy' (Table 2). It was an unexpected result. The different categories of autonomy were taken into account to explain this result: organizational, procedural and cognitive (Stefanou et al., 2004). Procedural autonomy provides an opportunity for choice and use of classroom materials and equipment, organizational autonomy means that students make decisions about the layout of the classroom activities, whereas cognitive autonomy means that teachers let students become initiators of their own learning. In our research, high cognitive autonomy (students may find multiple solutions to problems, receive considerable support in re-evaluating their errors) support in the mini-projects was noted. The research conducted by other scientists has also revealed contrast with their hypotheses related to cognitive autonomy. "Students in the low cognitive autonomy-supportive conditions learned significantly more, perceived significantly more choice, and rated instruction as more positive than did students in the high cognitive autonomy supportive conditions. Results are framed in the context of achieving reform in science teaching" (Furtak & Kunter, 2012, p. 284). It is advisable to carry out research in order to examine the role of different categories (organizational, procedural) of school students' autonomy of the motivation for learning science at RRI activity.

Many science reform advocates have promoted the idea that science classrooms should be designed to replicate the scientific community (Shumov, 2013). It is actual in promoting "scientific thinking in a community of scientists" (Nolen, 2003, p. 349). Teams of school students were working to solve complex dilemma problems at RRI activity at the ENGAGE project. The students' need for social relatedness at ENGAGE project was also supported through formal discussions in the classroom and informal discussions with peers, as well as between students and scientists.

An effective dialogue between scientists and non-scientists requires two factors: a trusting relationship for mutual exchange of information and know-how for collaborative decision-making processes (Okada, 2016). Scholars noticed that learners actively employ a variety of skills and motivations in their collaborative efforts (Lotrecchiano et al., 2016). Working actively with a dilemma of RRI may enable students to get to know each other better and even to make friends (Loukomies et al., 2013). Our results of linear regression about the influence of the need for relatedness on motivation for learning science corresponds to the results of the quantitative research of other scholars: "more time needs to be <…> [allowed to] students to participate in inquiry, reflection, and discussion of the results and their meaning. This might increase students' perception that they are doing and learning science" (Shumov, 2013, p.249). The data of our research confirmed the idea that relatedness is one of the factors that promotes intrinsic motivation of school students for learning science.

Our research had some limitation. "However, it is unrealistic to imagine that all physics learning can be intrinsically motivated" (Byman, Lavonen, Juuti, & Meisalo, 2012, p.380). There is a very thin line between intrinsic motivation and integrated regulation. Integrated regulation resembles intrinsic motivation in that both are self-determined. However, they are not the same. Intrinsic motivation is characterised by interest in the studying activity itself, whereas integrated regulation is characterised by the personal importance of the activity to a valued outcome (Byman, Lavonen, Juuti, & Meisalo, 2012). Integrated regulation is supposed to have positive effects on learning similar to those of intrinsic motivation. Other studies should be conducted in order to determine the influence of basic psychological needs on the highest level of extrinsic motivation (integrated regulation).

Conclusions

One of the results of this study is that linear regression analysis reveals a group of basic psychological needs related to intrinsic motivation for learning science at RRI activity. SDT describes the importance of basic psychological needs for learning motivation (needs for competence, autonomy and relatedness). This study has taken into account the new learning context (RRI activity) and revealed the influence of students' basic psychological needs on motivation for learning science.

Another result gained from this study is that the need for competence and the need for social relatedness (student and teacher; student and scientist) statistically significantly influence the students' motivation for learning science at RRI activity. The two basic psychological needs have a different power on the motivation for learning science. The need for competence is significant for the engagement in science and on how they evaluate information related to socio-scientific problems, as well as how they find the dilemma solving solution. The results of the simple linear regression confirm the SDT statement that relatedness is one of the psychological needs that promotes motivation for learning at RRI activity.

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