School Students' Intrinsic Motivation for Learning Science in RRI Activity: the Influence of Perceived Competence and Relatedness

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Abstract: The article deals with the influences of perceived competence and relatedness on school students' intrinsic motivation for learning science (IMLS) in responsible research and innovation (RRI) activity. RRI activity in the science classroom discloses the positive and negative impact of research and innovation discoveries for the society. The evaluation of the negative and positive sides of the research and innovation involves school students in discussion and gives a possibility to feel competent and related with others. 5E model is used in this research. It encompasses formal and informal science education. The purpose of the study is to explore the influence of perceived competence and relatedness on school students' intrinsic motivation for learning science in RRI activity.

The data presented in the current study are a part of the 7BP ENGAGE project, implemented in Lithuania (2014-2017). The participants chosen for this study were 8th-10th grade school students from different schools of Lithuania. Multiple regression analysis was used to test if the two basic psychological needs (perceived competence and relatedness) significantly predicted students' intrinsic motivation for learning science.

Our research revealed that school students' motivation for learning science was simultaneously influenced by perceived competence and relatedness in RRI activity. We established a statistically significant relation between the students' motivation for learning science and their perceived competence and relatedness. Perceived competence influenced the school students' motivation for learning science more than perceived relatedness in RRI.

Keywords: *responsible research and innovation; intrinsic motivation; competence; relatedness.*

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1. Introduction

The 21st century is characterised by the rapid development of science and technologies. However, the research shows that a minority of school students have positive attitudes to science (Archer et al., 2010; Lyons, 2006; Osborne & Collins, 2001; Van Breukelen et al., 2016). In the first decade of the 21st century, Osborne and Dillon raised the question: “Why is this?” (Osborne & Dillon, 2008, p. 5). Seeking to answer the question “Why is this?” no less relevant to answer the question “What is the motivation for learning science?” The answer to this question is not easier than the answer to the question “Why is this?” because “There is no single, widely accepted theory to explain all of human motivation in learning” (Leong et al., 2018, p. 2245).

Different motivational theories analyse the phenomenon of learner motivation: theories focusing on expectancy, focusing on reasons of activity, theories analysing expectancy and value concepts, as well as theories focusing on motivation and cognition (Eccles & Wigfield, 2002). In this study, we analyse the phenomenon of motivation for learning science employing the Basic Needs Sub-theory of Self-Determination Theory (SDT), which focuses on the reasons of motivation. According to this Sub-theory, learners have three basic needs that give the basis for self-motivation: to feel competent, autonomous, and related to others (Deci & Ryan, 2012). Self-motivation is inherent to intrinsic motivation (Savin- Baden, 2016). According to SDT, the level of intrinsic motivation is attained when the main psychological needs are satisfied: the need for competence (seeking to control the outcome and experience mastery), the need for autonomy (acting in harmony with one's integrated self), and the need for relatedness (connection with others and experience caring for others) (Ryan, 1995; Ryan & Deci, 2000; Ryan & Deci, 2017).

According SDT, intrinsic motivation for learning science (IMLS) occurs when students learn science without any external rewards for students' inherent satisfaction. Our approach to exploring school students' IMLS is aimed at reinforcing the relationship between science and society, supporting students' connection with others, reinforcing experience of caring for other members of the society (Savin- Baden, 2016). Science classrooms should be promoting “scientific thinking in a community of scientists” because it engages students more deeply in science and moves away from learning of isolated facts (Nolen, 2003, p. 349).

A responsible research and innovation (RRI) expresses a new view towards the relationship of science, society and technology (Owen et al.,

2012). There is a perception that technological advances provide the basis for a better society. But there is another side of technological progress. According to Okada (2016), innovations in science and technology should give the maximal benefits and the minimal harmful impact (Okada, 2016). Von Schomberg (2011, p. 9) states that RRI is "... a transparent, interactive process by which societal actors and innovators become mutually responsive to each other with a view on the (ethical) acceptability, sustainability and societal desirability of the innovation process". School students should have access to the latest information about progress of science and technologies not only provided by the teacher, but also through direct contact with professionals (Loukomies et al., 2013). The partnerships between schools and industrial organisations are important for students' engagement in science and technology. RRI requires a dialogue between all societal actors (youth and scientists) seeking to "better align the results of research with societal needs" (Okada, 2016, p. 11). However, such dialogue is often lacking (Leeuwis & Arts, 2010). Scholars state that science and relatedness are still separate areas and many opportunities for synergy are yet unused (Van der Sanden & de Vries, 2016).

The synergy between relatedness and science should be ensured because through the relationships and interactions with others, students can receive a positive encouragement and feedback on the performance because "science is no longer an individual search for knowledge" process (Okada, 2016, p. 11). Such feedback helps students to feel more competent. Perceived competence is one of the key needs for intrinsic motivation of learners (Deci & Ryan, 2012). RRI in the science classroom allows increasing perceived competence of learners starting with small goals and increasing upwards to a higher level of self-perception in their competence to control the environment affected by innovation.

RRI implementation in life is related to solving a dilemma and requires an ability of students to use scientific knowledge and principles that they have learnt in a science lesson in their decision-making processes. In a dilemma situation, students have to make a difficult choice between two or more equal alternatives, analysing the benefits, risks and possible sequences of innovation (Okada, 2016). Students at an early age must be equipped "to understand socio-scientific issues, applying science knowledge, ethical values and inquiry skills to form evidence-based opinions" (Okada, 2016, p. 9). This situation in a science lesson requires perceived competence and relatedness of students.

The above-said highlights the **problem of the research**: how do perceived competence and relatedness engage school students in learning

science in RRI? **The purpose of the study is** to explore the influence of perceived competence and relatedness on school students' intrinsic motivation for learning science in RRI activity.

In particular, the study represents an attempt to answer two **research questions:**

1. What is the relationship between school students' perceived competence, relatedness, and intrinsic motivation for learning science in RRI activity?
2. How strongly do school students' perceived competence and relatedness with others influence intrinsic motivation for learning science in RRI activity?

2. Theoretical Background

Seeking to understand the meaning of the concept 'responsible research and innovation', the concept 'responsible development' needs to be clarified. The term 'responsible development' is the term of the 21st century. This term appeared and was first used in the US Act on nanotechnology development in 2003. In Europe, the term 'responsible development' was first used by the Netherlands Organization for Scientific Research (NWO) in 2009 (Stahl, 2013). The emergence of the concept 'responsible development' was due to the fact that technological progress highlighted not only positive, but also negative results of science and technology development. Numerous technical accidents and cataclysms required a broader societal reflection on the risk of the implementation of innovations in the life of society (Stahl, 2013). Originally, the concept of responsible development mostly aimed at avoiding negative outcomes of technological progress (Stahl, 2013; Canvas, 2015)

Science and technological progress is based on research and innovations. "An *innovation* is an idea, practice, or project that is perceived as new by an individual or other unit of adoption" (Rogers, 2003, p. 12). Sahin (2006) clarifies the concept of an innovation construct by stating that the idea may not be new. It may also be a newly discovered old idea "but individuals perceive it as new" (Sahin, 2006, p.14). The implementation of an innovation is defined as a social process, which encompasses not only science and technology, but peoples' beliefs and values (Leeuwis & Aarts, 2010). The safe outcomes of science and innovations depend on a responsible research. Stahl (2013) defines RRI "as a higher-level responsibility or meta-responsibility that aims to shape, maintain, develop, coordinate and align existing and novel research and innovation-related processes" (Stahl, 2013, p. 40). It means that RRI has a broader remit than

‘responsible development’. Responsible development focuses on risks and technologies, whereas RRI moves towards innovation policy (Davis & Laas, 2014, p. 963). The European Commission has facilitated the implementation of RRI ideas in science education by Science in Society programmes (FP7 and Horizon 2020) (Sutcliffe, 2011).

The first steps of learning how to answer the key RRI questions in a responsible way should be taken at school. Science teachers need to help students understand the importance of RRI and need to explain “how to use the outcomes of science and technology in a responsible way” (Van der Sanden & de Vries, 2016, p. 4). The key RRI questions in science education should be about the reasons; outcomes, benefit, and value of innovations (Owen, 2015). Bayram-Jacobs (2015) states that science education needs to renew it self and work along with the developments in science and technology.

Teaching methods which strengthen school students' intrinsic motivation in RRI activity are more relevant than ever. Scholars reveal that the task of educators is more than inform students about science and technology innovations (Anderson, 2002; Bayram-Jacobs, 2015; Bayram-Jacobs et al., 2019). Griffiths (2004) and Healey (2005) reveal four group teaching methods which may be applicable in RRI activity. Research-tutored learning and research-based learning is mostly applicable in RRI. They both deal with a paradigm shift: from teacher-centred to student-centred learning. According to Shin & Myeong-Hee (2018), student motivation is crucial in student-centred learning.

RRI learning model has many features of inquiry-based science learning (IBSL): formulating dilemma problems, planning of research, researching hypothesis, searching for new information, creating models, discussing with others students using concrete arguments, forming evidence (Linn, Davis & Bell, 2004; Minner et al., 2010). Scholars describe three distinct meanings of the term of IBSL: scientific inquiry; inquiry learning, and inquiry teaching (Anderson, 2002; Minner et al., 2010). By participating in a scientific inquiry, students are able to analyse how scientists work, how they solve dilemmas, and how they make important subjects decisions for the current society (Constantinou & Tsivitanidou, 2018). RRI activity corresponds to scientific inquiry when students construct their own knowledge ‘doing science’ Scholars posit that student can report enjoying science by ‘doing science’ in the classroom, but they may still choose not to be science scientists, i.e. ‘being a scientist’ (Archer et al., 2010). RRI activity in the science classroom fosters identity of a science researcher and helps to

move from ‘doing science’ to ‘being a scientist’ (Sherborne et al., 2014; Ocada, Young & Sanders, 2015).

According Self-Determination Theory (SDT), the shift from ‘doing science’ to ‘being a scientist’ corresponds to the shift from the introjected regulation behaviour to integrated regulation behaviour (Ryan & Deci, 2000). The more students internalise the reasons for an action and assimilate them themselves, the more their extrinsically motivated actions become self-determined or intrinsically motivated (Ryan & Deci, 2000). RRI activity motivates students by maintaining an optimal level of stimulation and, by revealing their competences seeking to ensure positive results of research and innovation (Sutcliffe, 2011). RRI activity in science lessons require competences, relatedness with others and autonomy by solving a dilemma (Bayram-Jacobs, 2015; Okada, 2016; Okada & Sherborne, 2018). According to SDT, the need for competency means that students desire to feel efficacious when solving RRI problems, to have arguments on a statement about the effectiveness of the implementation of science and technology innovations in the life of society, as well as to have arguments how to achieve acceptable and even desirable outcomes of innovations (Okada et al., 2015). The need for autonomy at RRI activity is expressed by a desire to be self-initiating and to have a sense of acting with a sense of full volition. The need for relatedness deals with a desire to be connected to other people (Ryan & Deci, 2002). The need for relatedness at RRI activity manifests itself by a desire to feel connected with others and to be accepted by others (Okada et al., 2015; Sherborne et al., 2014).

3. Research Methodology

3.1. The research method

The data presented in the current study are a part of the 7BP ENGAGE project implemented in Lithuania (2014-2017). ENGAGE started from the conception of RRI and solved the problem how to deal with science and technology innovations in science lessons. RRI corresponds to the inductive approaches of learning science giving space for argumentation, observation, evaluation of results, and societal consequences of scientific and technologic innovations on the societies (Rocard, 2007). ENGAGE shifts the emphasis from Research-led; Research-oriented methods towards transmitting Research-tutored; Research-based methods.

ENGAGE project consisted of three phases: Adopt, Adapt, and Transform. Lithuanian science teachers participated in all the three phases of

the project. This study describes the data obtained during the third stage – Transform.

Lithuanian science teachers who participated in the project ENGAGE at the Transform phase organized mini-projects of school students on 5E model Engage, Explore, Explain, Extend, Evaluate) (Table 1). Mini-projects encompassed formal (two lessons) and informal education (Table 1). 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). The Explain and Elaborate cycles took place in informal education. In the second lesson (Evaluation cycle), students discussed a dilemma solution and analysed the benefits, risks and its possible consequences (Table 1). The topics of mini-projects were different: Giant viruses; Solar roadways; What does the fox say? Grow your own body? EBOLA: trial of the vaccine? BIG BAG BAN? Eco-phone; Exterminate, and others. The teachers were free to choose the topic of the mini project. After six mini projects school students completed the intrinsic motivation (IMI – intrinsic motivation instrument) questionnaire in order to self-evaluate intrinsic motivation, perceived competence and relatedness.

The content of RRI (Table 1) was used from the ENGAGE project: a slide presentation with new lesson content, guidelines for lesson, information about science news, and video links with scientists. The materials of ENGAGE aimed at making students: raise hypotheses, solve dilemmas, gather arguments for evidence, conduct research, as well as discuss with peers, teachers and scientists. For example, in the first lesson “Animal Testing”, school students applied their knowledge about of the gas exchange system in the body to explain the reasons of asthma (Table 1). Students looked into scientific and ethical arguments to decide whether animals can be used for testing of new asthma drugs and performed experiments. In the informal activity, students extended this activity by collecting additional information from peers, teachers and scientists for evidence of the use of animals for testing a new asthma drug. In the second lesson of mini-projects, students presented the results of the informal activity. During a discussion, they provided scientific and ethical evidence against animal testing.

Table 1. Mini project model at Transform stage

Stage of activity	Purpose	Content Animal Testing	Activity form
Engage	Interest	Introduction of a problem. Students can propose the problem based on images/video clip, discussion of initial ideas/class vote.	Formal in a classroom
Explore	Understanding	Reminder of science knowledge and introducing the RRI process. Engaging activity (game) where students experience the process and understand the principles involved, introduction of <i>thinking guide</i> - breaking RRI skill into chunks.	
Explain	Process	Use process they have learnt in Explore to discuss the problem set up in Engage. Apply science content, use of <i>thinking guide</i> , use of <i>argumentation tool</i> (claim/evidence/debate).	
Extend	Practice	Use the RRI skill to consider another problem in a different, but similar, context. Opportunity to discuss how RRI skill applies to other contexts.	Informal outside a classroom
Evaluate	Evaluate learning	Assess understanding of RRI skill and science knowledge Present a justified answer to the RRI problem.	Formal in a classroom

3.2. The sample and sampling of the quantitative research

The participants chosen for this study were 8th-10th grade school students from different schools of Lithuania. The representativeness of the sample was assured by cluster sampling in the research. The reliability of the sample was assured by selecting a suitable sample size. The sample size was calculated by selecting 5% confidence interval, and 95% the confidence level. The total population was 75000 school students. In this regard, the

sample size was deducted. The research sample involved 400 school students.

3.3. The instrument of quantitative research

Intrinsic Motivation Inventory (IMI) (Ryan, 1982) was used to assess the school students' intrinsic motivation for learning science in RRI activity. The data were analysed on the basis of the three subscales in this study: participants' interest/enjoyment (first subscale), perceived competency (PC) (second subscale), and perceived relatedness (PR) (seventh subscale).

From the test results of the validity of the students' motivation for learning science variable it appeared that perceived competence variable and relatedness variable using Pearson's Product Moment Correlation with value ($df = n-2$) $df = 400-2 = 398$ at the 5% significance level is $r_{table} = 0.113$. All the items of the statement for intrinsic motivation for learning science variable r -value count greater than the r_{table} ; it was concluded that all item statements are valid (Table 2). All the variables of the subscale Perceived competency and subscale Perceived relatedness were found to be valid (Table 3; Table 4).

Table 2. Validity of subscale Motivation for Learning Science

Variable	Item (IMLS)	r	r _{table}	Validity
Intrinsic motivation for learning science	It ₁₁	0.652**	0.113	Confirmed
	It ₁₂	0.360**		Confirmed
	It ₁₃	0.441**		Confirmed
	It ₁₄	0.214**		Confirmed
	It ₁₅	0.199**		Confirmed
	It ₁₆	0.548**		Confirmed
	It ₁₇	0.500**		Confirmed

Table 3. Validity of subscale Perceived Competency

Variable	Item(PC)	r	r _{table}	Validity
Perceived competence	It ₂₁	0.474**	0.113	Confirmed
	It ₂₂	0.283**		Confirmed
	It ₂₃	0.307**		Confirmed
	It ₂₄	0.286**		Confirmed
	It ₂₅	0.384**		Confirmed
	It ₂₆	0.253**		Confirmed
	It ₂₇	0.157**		Confirmed

Table 4. Validity of subscale Perceived Relatedness

Variable	Item (PR)	r	rtable	Validity
Perceived relatedness	It ₇₁	0.508**	0.113	Confirmed
	It ₇₂	0.144**		Confirmed
	It ₇₃	0.161**		Confirmed
	It ₇₄	0.285**		Confirmed
	It ₇₅	0.013		Confirmed
	It ₇₆	0.417**		Confirmed

The results of reliability test questionnaire showed that the instrument used is reliable (Table 5). It is shown from the value of Cronbach's Alpha is greater than the critical number that has been set at 0.6. All items of first, second and seventh subscale are reliable (Table 5).

Table 5. Reliability of subscales: Intrinsic Motivation for Learning Science

Subscale	Cronbach alpha	Reliability
First subscale (IMLS)	0.767	Reliable
Second subscale (PC)	0.688	Reliable
Seventh subscale (PR)	0.667	Reliable

3.4. Method of data processing

We used multiple regression analysis to test if the two basic psychological needs (perceived competence and relatedness) significantly predicted students' IMLS. Primary data collection was done by using the questionnaire instrument with ordinal Likert Scale. The respondents were asked to respond as well as to provide a statement that was expressed in the answers to the questionnaire. The Likert scale was changed to the interval scale. The transformation technique used in this research was a simple transformation technique using MSI (Method of Successive Interval) (Sarwono, 2015).

Multiple regression analysis (Equation 1) was used in order to find out the influence of independent variable is on students' perceived competence in science (x_1), as well as students' perceived relatedness at RRI mini projects (x_2) on dependent variable – intrinsic motivation for learning science through RRI activity (y).

$$y = a + B_1x_1 + B_2x_2 + \varepsilon \quad (1)$$

Where:

y = School students' IMLS

a = Constanta (Intercept)

B_1 = Regression coefficient between school students' IMLS and students' PC

B_2 = Regression coefficient between school students' IMLS and students' PR

x_1 = PC variable

x_2 = PR variable

ε = Error disturbances

4. Results

This research aimed at measuring simultaneous influence of perceived competence and relatedness on school students' intrinsic motivation for learning science in RRI activity. For this purpose, multiple regression analysis was chosen. 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 (K-S) was used in this study (Table 6). If the significance level of Kolmogorov-Smirnov sig ≥ 0.05 , it means that the data are normally distributed (Table 6).

The results of Kolmogorov-Smirnov test showed that the data of students' motivation for learning science ($p = 0.061 > 0.05$), the data of perceived competence ($p = 0.115 > 0.05$), and the data of perceived relatedness ($p = 0.055 > 0.05$) were normally distributed (Table 6).

Table 6: Testing normality: Kolmogorov-Smirnov (K-S) Test

	Motivation for learning science	Perceived competence	Perceived relatedness
Mean	68.281	70.37	57.594
STD	9.022	11.746	10.248
K-S test	1.855	1.488	1.991
Asymp. Sig. (2-tailed)	0.061	0.115	0.055
Skewness	-0.039	0.260	0.587
Kurtosis	0.0642	0.255	-0.641

The Variance Inflation Factor (VIF) test was conducted to measures the multicollinearity among the independents variables (perceived

competence and perceived relatedness) (Table 7). The test results revealed the absence of symptoms of multicollinearity in accordance with the value of each independent variable, VIF showing a value smaller than 4. Hence, multicollinearity does not occur in the model. The results of heteroscedasticity test showed that heteroscedasticity also did not occur. The heteroscedasticity of perceived competence is $0.000 < 0.050$, of perceived relatedness – $0.030 < 0.050$ (Table 8).

Table 7. Multicollinearity Test Results

Coefficients ^a		Tolerance	VIF
1	(Constant)		
	Perceived competence variable	0.952	1.050
	%		
	Perceived relatedness variables	0.973	1.028
	%		

a. Dependent Variable: Intrinsic motivation for learning science %

The F test was carried out to reveal the influence of students' perceived competence (X_1) and students' perceived relatedness (X_2) on their motivation for learning science (Table 8). We accept null hypothesis (H_0) if $F_{hitung} < F_{tabel}$. It means that independent variables (perceived competence and perceived relatedness) do not have a mutual influence on the dependent variable. The results of the F test showed that $F_{hitung} > F_{tabel}$ (at 5% significance level) (Table 8). The null hypothesis (H_0) is rejected. It means that both predicted variables statistically significant influence school students' IMLS (Table 8).

The regression results showed that the correlation between students' perceived competence and relatedness to intrinsic motivation for learning science was 0.614 and the correlation coefficient was positive (Table 8). The correlation coefficient (R) revealed the strength of the relationship between the dependent variable (IMLS) and both independent variables (PC and PR). In our case $R = 0.614$, which demonstrated a statistically significant relationship. It means that our model is a relatively good predictor of the outcome.

In order to determine the explanatory power of regression models that contain different numbers of independent variables, we used the coefficient of determination (R^2). The coefficient of determination was $R^2 = 0.377$. A small R^2 value ($R^2 < 0.20$) means the ability of the independent variables to explain

the dependent variation, which is very limited. The results of the regression indicated that the two predictors explained 37.7% of the variance ($R^2 = 0.377$, $F(2.398) = 120.183$, $p < 0.01$). In this case, it can be concluded that 37.7% of the variance in the data can be explained by the predictor variables. It was found that the motivation for learning science was significantly predicted by perceived competence ($B_1 = 0.616$, $p < 0.001$) and significantly predicted by perceived relatedness ($B_2 = 0.279$, $p < 0.05$) (Table 8).

Table 8. The influence of perceived competence and relatedness on school students' IMLS

Model	Unstandardized Coefficients		Standardized Coefficients		Sig.
	B	SEB	β	t	
(Constant)	26.084	3.519		7.413	0.000
1 Perceived competence	0.619	0.037	0.603	14.875	0.000
Perceived relatedness	0.279	0.051	0.114	1.020	0.030
Dependent Variable: Intrinsic motivation for learning science					
R = 0.614					
R ² = 0.377					
F _{hitung} = 11.122			F _{tabel} = 4.25		

Based on the result of multiple regression analysis, the regression equation for students' motivation for learning science can be:

$$y = 26.084 + 0.616 x_1 + 0.279 x_2 + \varepsilon \quad (2)$$

y – School students' IMLS

x_1 – PC variable

x_2 – PR variable

ε = Error disturbances

The results of multiple regressions (Equation 2) revealed the different influence of independent variables (perceived competence and relatedness) on the dependent variable – school students' intrinsic motivation for learning science. The constant (26.084) of the multiple linear regression equation (1) means that the independent variable consisting of students' perceived competence and relatedness was considered constant and showed a positive influence (Equation 2).

A greater value of the independent variable coefficient (x) determines a greater influence on the dependent variable (y). The students' perceived competence coefficient $B_1 = 0.619$ was greater than the regression coefficient of perceived relatedness $B_2 = 0.279$. Based on the results of

multiple regression equation, it can be concluded that if the students' perceived competence increases by 1 unit, then the students' intrinsic motivation for learning science also increases and has a positive effect of 0.619 or 61.6%. If the students' perceived relatedness with others increases by 1 unit, then their motivation for learning science increases and has a positive effect of 0.279 or 27.9%.

5. Discussion

This research was designed to study the influence of school students' perceived competence and relatedness on intrinsic motivation for learning science by solving problems of innovation implementation in the life of society. The results of others scholars' qualitative research disclosed that perceived competence and relatedness between peers and scientists engage students in science more deeply and move away from the teacher-centred way (Bayram-Jacobs et al., 2019; Nolen, 2003; Ocada, 2016). In line with the previous evidence, our quantitative study showed high relations between perceived competence, relatedness and students' intrinsic motivation for learning science.

Our quantitative approach to exploring intrinsic motivation of school students for learning science was based on the Basic Needs Sub-theory of SDT. As it was mention earlier, students are engaged in learning science when their main psychological needs are satisfied (the need for competence, for autonomy, and for relatedness) (Ryan & Deci, 2000; Deci & Ryan, 2012). We analysed the influence only of two basic needs (perceived competence and relatedness) on students' intrinsic motivation for learning science. Multiple regression analysis helped to answer the main research questions about RRI activity in the science classroom.

The correlation coefficient (R) of multiple regressions revealed a strong relationship ($R = 0.614$) between the outcome variable (intrinsic motivation for learning science) and both of the predictor variables (perceived competence and relatedness). It means that perceived competence and relatedness with others simultaneously influence students' intrinsic motivation for learning science. This result confirmed that perceived competence and relatedness with others in RRI activity (finding practical and complex problems of innovations, dilemma solving, planning solutions to innovation implementation, and performing collaborative research to solve problems of innovations) engage students in learning science. In practice, we agree with the view of others scholars that such an activity requires teachers and learners to play roles that are different from

the roles they have been accustomed to; students must take more responsibility for the acquisition of their social competences, and not just their academic competences (Bayram-Jacobs, 2015; Okada, 2015; Bayram-Jacobs et al., 2019).

New roles in RRI activity satisfied the basic psychological needs of school students. In RRI activity, the students fulfilled the need for competence seeking to control the outcomes of innovation implementation in the life of society, the need for relatedness – connecting with the peers and the scientist. Multiple regressions allowed us comparing the influence of two psychological needs: perceived competence and relatedness. The students' perceived competence coefficient $B_1 = 0.619$ was greater than the regression coefficient of perceived relatedness $B_2 = 0.279$ (equation 2). It means that perceived competence had a stronger influence on students' motivation for learning science than perceived relatedness in RRI. This result complied with the opinion of other scholars that a deep-reasoning dilemma in science classrooms, socio-scientific problems and ethical dilemma solutions give a possibility for the promotion of students' competences (Jurik, Gröschner and Seidel, 2014).

The coefficient of perceived relatedness was lower (equation 2), but it statistically significantly influenced the school students' motivation for learning science. Thus, the diversity of relatedness (student-peers; student-teacher; student-scientist) in RRI engaged them. Obviously, the influence of psychological needs depends on the educational reality: learning content, learning activity, and methods. Further research is needed to compare the influence of perceived competence and relatedness on school students' motivation for learning different school subjects according to RRI.

The result of our study on the influence of relatedness on the students' motivation for learning science highlighted the importance of continuities between formal and informal learning in RRI activity. Continuity approaches science content to everyday lives and allows school students to participate in diverse relations with societal actors. In the ENGAGE project carried out in Lithuania, learning occurred while the school students were in relatedness not only in formal education. The mini-projects of RRI activity encompassed formal (two lessons) and informal education. In formal education, the students learned new content, looked at scientific evidence, performed an experiment, and discussed the conclusions of the experiment. Formal education was characterized by the students' relatedness with peers and with the teacher. Carrying out mini-project in informal education, the students negotiated and resolved socio-scientific issues with scientists and other members of society; they discussed a

dilemma solution and analysed the benefits, risks and its possible sequences. The continuity between formal and informal learning allows the relatedness of students with the actors of RRI and scientific community. The results of our research confirmed that relatedness by continuity engaged the students in learning science and “allow students to become knowledgeable by participating in and contributing to the life of their community” (Roth & Lee, 2003, p. 264). We agree with the Roth & Lee (2003) that only institutional school set of relations “to prepare students for a world of many relations does not make sense” (Roth & Lee, 2003, p. 267). Science educators must focus on new continuous forms of science education out-of-school eliminating the discontinuities between formal and informal learning (Roth & Lee, 2003).

In our study, continuity in RRI was ensured through the mini-projects in small students groups. According Shin, Myeong-Hee (2018), small group activities play an important role in project-based learning: “Sometimes it is very easy for students to develop individual plans for a project, but it is necessary to determine the best solution through agreement and negotiation within the team” (Shin, Myeong-Hee, 2018, p. 97). This is always a challenge for students. Despite these difficulties, students’ participation in mini-projects motivated them for learning. Shin, Myeong-Hee (2018) state that the students have to be motivated in English learning when “the project is related to the students’ experience, purpose of learning, and real life” (Shin, Myeong-Hee, 2018, p. 108). Our research demonstrated that students had to be motivated for learning science when the mini-projects were related to the implementation of science innovation in real life. The comparison of the results of our research and other scholars’ research (Shin, Myeong-Hee, 2018) revealed that real life plays like the litmus paper that highlights the level of students’ motivation for learning regardless of the content of subjects.

Our research has some limitations according to the Basic Needs Sub-theory of SDT. We have made an effort to systematically rethink the role of perceived competence and relatedness in RRI activity. In general, this research is intended to build knowledge about the extent to which perceived competence and perceived relatedness affect students’ IMLS. We have chosen the research path based on theoretical literature that underlines the importance of communication and competence recognition in innovation processes (Leeuwis & Aarts, 2016; Leeuwis & Aarts, 2010; Stahl, 2013). We completely agree with the statement highlighting the role of relatedness in innovations “that innovation is a collective process that involves the contextual re-ordering of relations” (Leeuwis & Aarts, 2010, p. 9).

A lot of research remains to be done to study simultaneous influence of the three basic psychological needs (including autonomy) on intrinsic motivation of school students' for learning science in RRI activity. To further clarify the influence of basic psychological needs in RRI, more study is needed on more complex multi-dimensional regression models. We completely agree with the statement that "it is never possible to isolate variables in the educational field" (Bayram-Jacobs et al., 2019, p. 22). We recommend striving for a research design that will allow us highlighting the influence of a larger number of variables.

6. Conclusion

Our research revealed that school students' intrinsic motivation for learning science (IMLS) is simultaneously influenced by perceived competence and relatedness in RRI activity. We established a statistically significant relation between the students' IMLS and their perceived competence and relatedness. This implies that perceived competence and relatedness can be used as effective tools for promoting students' IMLS. These two predictor variables (perceived competence and relatedness) should be taken into consideration promoting school students' intrinsic motivation for learning science in RRI activity.

The results of our research revealed that the influence of perceived competence and relatedness on school students' IMSL is not the same in RRI. Perceived competence influences school students' intrinsic motivation for learning science more than perceived relatedness. Therefore, the general recommendation stemming from the conclusions of our research is to foster school students' intrinsic motivation for learning science by perceived competence in RRI activity.

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