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A THEORY-BASED INSTRUMENT TO EVALUATE MOTIVATIONAL TRIGGERS PERCEIVED BY STUDENTS IN STEM CAREER-RELATED SCENARIOS

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Abstract. *Students' lack of motivation in learning school science has been recognized as a problem, due to its negative impact on students´ STEM-related career choices. For supporting students´ motivation to study science, the use of an introduction which sets the scene, sometimes called a scenario, has been recommended. Although scenarios, which introduce STEM-related careers in an everyday life problem solving context, are seen as useful tools for the teachers, they are not automatically guaranteed to be motivating to students. The current research aims to develop an empirically tested and validated instrument to measure the impact of context-based scenarios, through evaluating perceived motivational triggers such as relevance, interest and enjoyment by 7th grade students. An analysis of students´ responses showed that the test scenario was able to trigger mostly situational interest toward the topic of energetics. Only a small number of students indicated motivation to take the learning of this topic further.*
Keywords: *STEM-related careers, STEM career-related scenarios, science teaching materials, motivational triggers, instrument evaluation.*

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Introduction

School science subjects are playing an increasing role in guiding students towards dealing with issues and concerns confronting everyday life and in being made aware of future careers. However, students' motivation to learn through school science and their unwillingness to pursue science-related careers has been recognized as a problem. Several influencers have been identified, which play a role in promoting students´ aspirations in science studies and possible science careers (DeWitt & Archer, 2015; Palmer, Burke, & Aubusson, 2017).

More specifically, from a negative consideration, students´ lack of relevance and interest toward science learning at school has been seen as a concern (Potvin & Hasni, 2014; Sjoberg & Schneider, 2010), because finding a subject interesting and enjoyable is considered to be the most important influencers to choosing, or rejecting a subject (Palmer et al., 2017). In fact, Krapp and Prenzel (2011) have drawn attention to the connection between students´ lack of interest and poor pedagogical practices such as frequent lecturing, which do not support the development of students' awareness about possible careers in STEM-related fields (Vaino, Vaino, Rannikmäe & Holbrook, 2015). Moreover interest, relevance and enjoyment are seen to promote motivation to study (Deci & Ryan, 2000; Keller, 1987; 2010).

Without promoting students' motivation to study science and without developing students´ awareness about the possibilities of modern STEM-related careers, the problem of lacking specialists is likely to remain (Bybee & McCrae, 2011). This is alarming due to the overall aging trend among STEM-professionals in European Union countries. The European Commission (2015) points out that more than 50% of STEM-professionals and associate professionals are at a senior age (45-64 years) in, for example, Estonia, Latvia, Germany and Croatia, which leads to major replacement demands in STEM-field occupations. This suggests a need for STEM programs to not only provide motivational approaches for studies, but also focus on the prospect of interesting jobs and careers (Holmegaard, Madsen & Ulriksen, 2014). Thus, incorporating STEM-career related information into motivational, experiential and hands-on activities involving teaching-learning materials (TLMs), is considered to be a possible approach to raising students´ career awareness in STEM-related areas, as well as providing motivation towards learning science (Michigan Department of Education, 2017).

Although these issues are strongly identified in the research literature, there still seems to be difficulties in developing TLMs, with initiating scenarios, that have the characteristics of being directly relatable to students, able to raise students´ interest toward the science topics and enabling students to see the link between the scientific issue and students´ everyday life, plus also have a perceived meaningful impact on students (Kotkas, Holbrook & Rannikmäe, 2016).

The aforementioned suggests that it is meaningful to initiate TLMs with a context that students find familiar and with which they have a sense of relatedness. But in order to see how well do students relate with the context, students need to be able to indicate the level of impact they perceive through their acquaintance with the context, such as in a scenario. Evaluation of the motivational triggers perceived by students in scenarios is thus seen as a useful step forward. However, in order to develop such an instrument, there is a need to consider the interrelating characteristics of different motivational concepts such as of relevance, interest and enjoyment (often expressed as like). Therefore it raises the need to deliberate on research literature concerning these theoretical constructs and their connections with motivation to form solid theoretical base for instrument development.

The current research aims to develop, empirically test and validate an instrument developed to measure the impact of context presenting scenarios, through evaluating perceived motivational triggers such as relevance, interest and enjoyment by students.

Theoretical Framework

The Interconnectedness of Interest, Relevance, Enjoyment with Motivation

Interest, enjoyment and relevance are seen as factors influencing motivation (Deci & Ryan, 2000; Keller, 1987; Wigfield & Eccles, 2000). Interest has long been an educational focus (Krapp & Prenzel, 2011), and researchers have addressed relevance through the question "What makes the learning in school relevant to students´ lives and their future?" (Stuckey, Hofstein, Mamlok-Naaman, & Eilks, 2013). However, in a science education context, both interest and relevance still remain a concern, as researchers are continuing to show a decline in students´ involvement in science studies, with progression through school years (DeWitt & Archer, 2015; Potvin & Hasni, 2014). Students´ low levels of interest and lack of perceived relevance toward school science are seen as jeopardizing students' learning and potential aspirations towards a career in STEM-related fields. Nonetheless, there is a lack of consensus among research articles on how to address relevance, interest, enjoyment and motivation, especially with respect to connections between these terms in a science education context and the use of these terms as synonyms. Moreover, enjoyment, as an emotional construct, is often seen as a quiescent component of intrinsic motivation and not always considered separately from interest (Niemiec & Ryan, 2009).

Interrelating Interest(s) and Enjoyment

Research on interest has mainly focused on how individual differences in interests influence content, or topic specific preferences and how surrounding factors in learning situations, or learning materials induce situation-specific interest in the learner (Krapp, Hidi & Renninger, 2014). Differences among interests are specific to individuals and are known as ´individual interests´ (aka ´topic interest´), whereas interest induced by environmental conditions of a situation is referred to as ´situational interest´ (Krapp, Hidi & Renninger, 1992; 2014). Individual interests are described as person specific, relatively enduring and including stored knowledge and values linked with positive emotions (Krapp, Hidi & Renninger, 2014; Renninger, Ewen & Lasher, 2002). Contrary to individual interests, situational interest tends to be shared among individuals (Krapp, Hidi, Renninger, 2014), and can be triggered by factors, such as: hands-on activities, cognitive conflict, novelty, food, social interactions, teacher modeling, games and puzzles, content, biophilia, fantasy, humor and narrative stories (Bergin, 1999).

All students have the potential to become interested, but the direction of interest development is guided by a learning activity, or study content (Hidi & Renninger, 2006). Therefore, interactions of individual and situational factors always contribute to the development, or lack, of interest (Bergin, 1999) and are person-situation specific (Renninger, Ewen & Lasher, 2002). Under the context of a person-object theory of interest (Krapp & Prenzel, 2011), new learning materials for students aim towards developing a sensation of interest. In this situation, introductory

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scenarios in such learning materials are the ´objects´ which, when in contact with students, aim to be perceived as interesting. The reasons for perceiving introductory scenarios as interesting are student specific and can be triggered by either individual factors, or by situational factors. Therefore, in classroom settings, teacher needs to consider not only factors inducing situational interest as these are easier to manipulate, but also students´ individual interests (Bergin, 1999), or give students opportunities to convert situational interest into individual interests. This is supported by the claim that situational interest over a period of time and perhaps over several interest inducing experiences, can become an individual interest to a person, although not always and not in every case (Hidi & Renninger, 2006).

One can appreciate that positive emotions are involved in connection with individual interest. However, positive feelings, for example ´like´, have been indicated by Iran-Nejad (1987) as arising from different causes compared with interest. Furthermore, situational interest may or may not include liking (Bergin, 1999). ´Like´ can be considered as a synonym of ´enjoyment´ and similarly with ´like´, ´enjoyment´ is not considered equitable with interest, but as emerging as a separate emotional construct (Ainley & Ainley, 2011). More specifically, interest can be seen as one possible reason for students perceiving enjoyment while learning (Krapp & Prenzel, 2011).

Reciprocal Interactions between Knowledge and Interest

Several theorists have considered prior knowledge to affect both situational and individual interest. From the perspective of situational interest, Berlyne´s theory of curiosity (1960) determines groups of variables, called ´collative variables´, which direct the potential of something to be interesting due to a comparison of incoming information with already existing knowledge. Added to this, according to Loewenstein´s information gap theory (1994), curiosity is induced when gaps in one´s knowledge are perceived.

Similarly to situational interest, a knowledge role has been recognised also in connection with individual interest. Kintsch (1980) proposes that individual interest (Kintsch used the term ´cognitive interest´) is low when there is little or no prior knowledge, increases as more is known, and decreases again when a perceived potential to gain new knowledge has subsided. Therefore, this suggests prior knowledge plays a role in determining situation specific and individual interest. Thus, as long as there is a perceived potential to learn, there is also a potential for interest development. By connecting prior knowledge or experiences with new information student gains through interacting with a scenario, has been shown by Wade, Buxton & Kelly (1999), as a factor to increase interest.

Overlap between Relevance and Interest

Relevance and interest have overlapping properties, but are not considered as identical constructs (Keller, 1987; Stuckey, et al., 2013). This is especially the case in the different interpretations of interest. Kintsch (1980), while separating cognitive interest from emotional interest related to stories, includes the terms ´meaningfulness´ and ´importance´. These can be considered as components of what can be called personal relevance i.e. why something is perceived relevant to a specific person. In his article, ´meaningfulness´ is used to describe the fit with either the reader´s knowledge structure, or text structure and ´importance´ as one of the main determinants of interest from three aspects: a) text macrostructure, b) task instructions and c) reader´s internal state: parts of the text with which the reader is more knowledgeable, or appear (cognitively) more important. Additionally, relevance is incorporated into the distinction between situational and individual interest by Krapp, Hidi & Renninger (1992; 2014). More specifically, in their interest development model, ´personal relevance´ is mentioned as a feature in ´triggering the gaining of situational interest´; ´meaningfulness of a task´ in ´maintaining a situational interest´ phase; ´stored value´ as a characteristic of ´emerging individual interest´; ´more stored value´ as a characteristic of ´well-developed individual interest´ (Hidi & Renninger, 2006). Derived from this, the value of some activity, or topic also deepens with interest development. This indicates the importance of perceiving learning tasks as valuable in supporting well-developed interest. The attempts to promote interest by showing 'relevance to students´ lives' have been shown to be effective, especially with high-school students of low-success expectancies in science (Hulleman & Harackiewicz, 2009). It is clear that relevance and interest are closely linked and therefore separating these terms seems to be artificial. Nonetheless, considering these terms as synonyms, is not justified either.

´Relevance´ as a term has several interpretations, varying from whose perspectives (educators´, curriculum developers´, policy makers´ or students´) it has been a focus (for a further review see Stuckey, et al., 2013). The current article focuses on students´ perspectives and covers personal relevance (aka value) from a meaningfulness, usefulness, importance, familiarity and relatedness (aka connectedness) perspective.

Levitt (2001) presents the perspective of students, by describing personally meaningful science learning, through the use of the words ´important´, ´useful´ and ´relevant´, which are determined by the needs and interests of a student. More specifically meaningful science learning is seen to be achieved with future perspectives in mind i.e. "being independent, being more alert about problems and surroundings and being involved", and by building on the knowledge with which students come to school.

Connectedness with students´ everyday life, in order to make learning meaningful, has been identified by John Dewey (1915) more than one hundred years ago, but is still proving to be appropriate today. Meaningfulness has been shown to raise interest toward science courses among students and achieve better results (Hulleman & Harackiewicz, 2009). Additionally, when personal relevance and meaningfulness are perceived associated with a science topic, students are more likely to feel enjoyment and interest while interacting with science content (Ainley & Ainley, 2011). Task enjoyment in mathematics classes has been shown to be improved, when students´ short or long term goals are met within the task (Gaspard, Dicke, Flunger, Brisson, Häfner, Nagengast, Trautwein, 2015). Moreover incorporating STEM-career information into the teaching of science has been shown to help students perceive the meaningfulness of school science (Orthner, Jones-Sanpei, Akos, & Rose, 2013). This indicates the important role of future goals, either for future studies, or careers, or both, in considering science studies as meaningful to students (Bergin, 1999) and therefore needs to be considered while developing teaching and learning materials (TLMs).

Theory-based Model of Possible Motivational Triggers in a Scenario

Derived from the theoretical overview presented in the current research, an illustrative model is developed (Figure 1). The model demonstrates motivational triggers – interest, relevance and enjoyment (like) and their possible interactions. Prior knowledge is seen as a mediator for both perceiving the scenario as interesting and relevant. More specifically, comparing prior knowledge with incoming information from the scenario and perceiving gaps in knowledge structure is known to induce interest and curiosity (a in Figure 1) (Berlyne, 1960; Loewenstein, 1994). While interacting with the scenario, situation specific aspects, for example scenario attributes and also individual factors, such as the learning topic, influence interest development among students.

Similarly in order to make the scenario meaningful, familiar, and relatable, connection with prior knowledge and also experiences (b in Figure 1) need to be perceived by students (Dewey, 1915; Levitt, 2001). In order to perceive

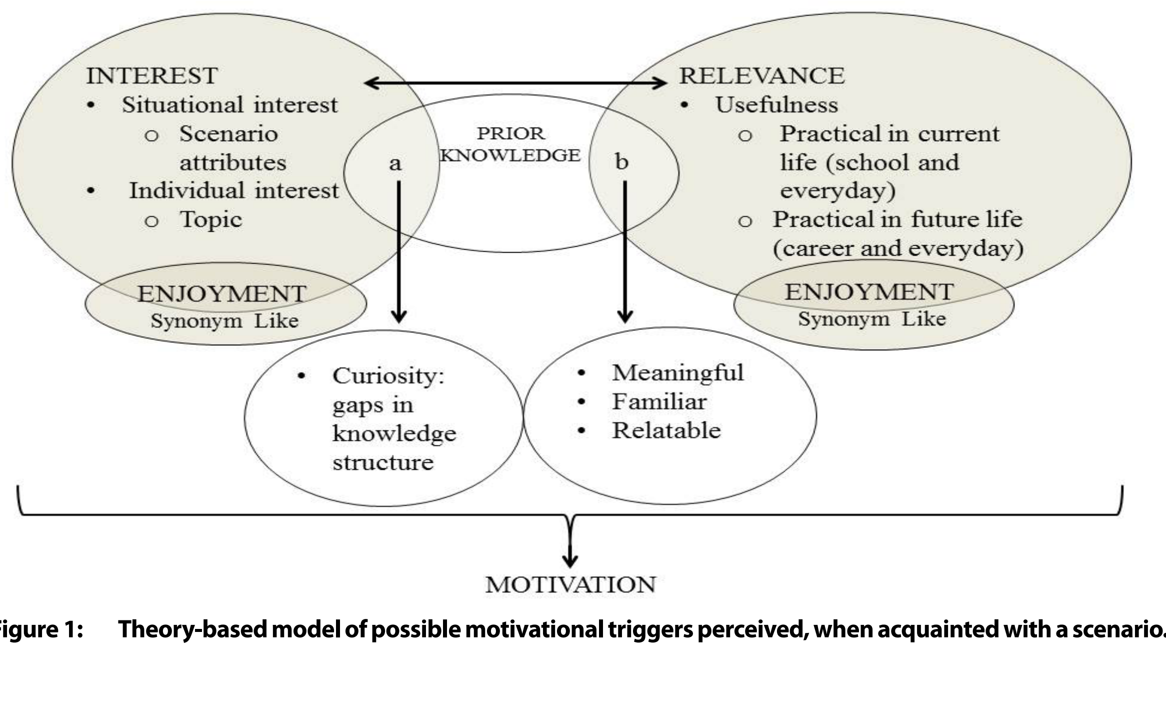

Figure 1: Theory-based model of possible motivational triggers perceived, when acquainted with a scenario.

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the usefulness of interacting with a scenario, students need to see the practicality of the information in a present-future dimension (Bergin, 1999; Stuckey et al., 2013). Although the model visually separates interest and relevance, the authors still recognize their reciprocal interactions (bilateral arrow in Figure 1) in motivation development.

Enjoyment (´like´) is not considered as equitable with interest (Iran-Nejad, 1987), but interest can be one possible reason to feel enjoyment while learning (Krapp & Prenzel, 2011). This is represented in the model by their overlapping areas, leaving the possibility for enjoyment to be perceived due to reasons other than interest. For example, enjoyment while studying can be perceived when practicality, in terms of short or long term goals, is perceived by students (Ainley & Ainley, 2011; Gaspard, et al., 2015).

Methodology of the Research

General Background

The current research is situated in the context of the EU project ´Promoting Youth Scientific Career Awareness and Its Attractiveness through Multi-Stakeholder Co-operation´ (MultiCO). This project aims to promote middle school students´ awareness of and interest in STEM-related careers. This aim is addressed through developing scenarios, which link science curriculum topics with STEM-related careers and everyday life. A scenario evaluation instrument is developed to determine characteristics in scenarios, which promote motivation to learn science topics and follows a design-based research approach, conducted in two phases:

1. Generation of the items and gaining feedback from international experts, teachers and 20 students;
2. Testing the instrument with 143 middle school students and examining the validity and reliability of an instrument.

Scenario Evaluation Instrument

The scenario evaluation questionnaire enables determination of three motivational triggers: interest, relevance and enjoyment. The instrument is based on a theoretical overview, presented in the current research and focuses on the following constructs, indicated as effectors of interest, and the perception of relevance, enjoyment and motivation:

- knowledge role in affecting interest and perception of relevance;
- perceived value of gained information for the future career choice or studies;
- relatedness to the situation described;
- the impact level in order to determine importance of the context;
- technical attributes of a scenario that could impact students´ responses;
- affective reactions such as interest and enjoyment.

The theoretical categorization is shown in table 1.

Table 1. Theoretical categorisation of the instrument items.

Category	Subcategory	Item no.	Item
3. Role of knowledge	-	1	This scenario enables me to gain new knowledge about the scenario topic.
		4	From this scenario, I am able to gain new knowledge about possible career(s).
		5	This scenario enables me to understand the responsibilities of the persons in the career position indicated.
		6	This scenario enables me to understand the skills that are necessary in this profession.
		28	This scenario makes me want to learn more about the topic.

Category	Subcategory	Item no.	Item
4. Perception of relevance	Usefulness	2	The knowledge I gain from the scenario may be useful in the future.
		3	I can put knowledge gained from the scenario into practice, to solve problems.
		12	I feel my future career may be connected with the topic covered in the scenario.
		13	I think my future studies at the gymnasium or university level may be connected to the topic covered in the scenario.
		14	I predict I will need to perform skills, described in the scenario, in my future career.
		15	I predict I need to perform science-related skills, described in the scenario, in my future career.
		26	I find the information in this scenario valuable to me.
	Impact level	7	I find this scenario topic important for me personally.
		8	I find this scenario topic important to my family.
		9	I find this scenario topic important for appreciating the work of our local community (town, country).
		10	I find this scenario topic important for learning school subjects.
		11	I find this scenario topic important for the whole world.
	Relatedness	16	The scenario describes the science community, to which I relate.
		17	The scenario presents a scientific problem, which is socially relevant.
		18	The scenario makes it easy for me to relate with the situation described.
5. Scenario attributes	-	19	The scenario is easy to follow.
		20	The scenario is easy to understand.
		21	I find this scenario enjoyable to watch.
		22	I like the format of the scenario.
6. Affective reaction	-	25	I find this scenario interesting to me.
		27	I like the scenario.

The 28 item questionnaire contains 22, 4-point Likert scale (Johnson & Christensen, 2000) items (1-totally disagree, 4-totally agree) plus four, 3-point Likert scale (agree, cannot make up my mind, do not agree) items. It is considered justified to include two different scales in the instrument due to the difference in the generalizability of the items. Thus items 1-22 (4-point Likert scale) are more specific making it easier to choose either an agreement or disagreement position. On the contrary, items 25-28 give students the possibility to choose a position between two opposites, because the items are naturally very broad (i.e. I consider the scenario as interesting) and are considered as difficult for 7th grade students to position themselves. Students may feel interested due to the information gain and due to the format of the scenario, yet students may have only positive reactions to the scenario. But students can consider the scenario topic as not interesting, but the format of the scenario as interesting, or vice versa. Students may not be able to choose which determinants of interest are more important, as the scenario contains several interest triggering factors. The same discussion issue is applicable for items focusing on overall value, enjoyment and motivation toward the scenario. In order to understand reasons behind students´ choices, a request to reason their perceptions is considered important for data triangulation purposes (Johnson & Christensen, 2000). The reasoning option for items 25-28 was added after gaining advice from international science education research experts.

Two additional items were included (items 23 and 24) to determine students´ self-perception of their knowledge related to the topic and careers covered in the scenario because prior knowledge was seen to affect interest and perception of relevance.

Instrument validation in the first phase of design process was conducted by two experienced international science education researchers and four experienced science teachers (all practicing teachers for over five years). The piloting was conducted with 20 seventh grade students, who were not part of the main research sample, in order to determine the understandability of the items for students.

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Sample

Data were obtained from seventh grade (13-15 years old, median age 14) students from four different Estonian public schools by purposive sampling (N=143; boys- 72, girls- 71), who were participating in a longitudinal European Commission Horizon 2020 project. The sample size was restricted with schools participating in a longitudinal study, with the aim to determine the effect of implementing STEM-career introducing, everyday life related scenarios on middle school students´ motivation to pursue STEM-related careers.

Testing of the Scenario Evaluation Instrument

In order to test the instrument, a scenario aiming to be relevant, interesting and enjoyable, was developed. The contexts for the scenario, chosen from the fields of EU strategic priorities (European Commission, 2010), in this case – renewable energy sources, was a story of a family, in which the father was concerned about increases in the monthly electricity bill. He blamed his teenage children, who were constantly using their smart devices. In trying to find a solution, he was thinking about installing solar panels on the roof of his house. Thus, in order to find out whether solar panels were beneficial for his household, he contacted a friend, who was an electrical engineer. During the scenario two other occupations- environmental protection specialist and materials scientist- were introduced, providing information about the responsibilities and competences needed for those occupations. The scenario, presented in a video format (Figure 2), was 11 minutes long and ended with a suggested solution by trying to make small solar panels to charge smartphones in a sustainable way. Students evaluated the scenario with the questionnaire directly after seeing it and it took approximately 10-15 minutes to complete.

Figure 2: An example of the scenario (*in Estonian*).

Data Analysis

The first step of the analysis was to confirm, or reject the theory-based hypothetical categorization of the items. The construct validity was tested by using confirmatory factor analysis (CFA) with Amos software. In order to evaluate the goodness of fit, the comparative fit index (CFI), root-mean-square-error-of-approximation (RMSEA) and normed chi-square ($\chi 2/df$) were taken into account. Depending on the sample size (N=143) and the number of items (n=26) under analysis it was suggested by Hair, Black, Babin and Anderson (2010) that CFI index, which varies from 0-1, values of 0.95 or higher showed a good model fit, for RMSEA a value less than 0.08 showed a good model fit on the population data and according to Kline (2011) normed chi-square ($\chi 2/df$) values ranging from 1.0 - 3 were recommended.

The second step was to determine the underlying structure and internal validity of the instrument, by implementing exploratory factor analysis (EFA) with a principal axis factoring (PAF) extraction method and by applying promax rotation. The promax rotation was chosen due to its property of allowing the factors to be correlated. This was considered as theoretically justified due to the overlapping properties of relevance, interest, enjoyment. The KMO test of sampling adequacy was used to ensure the appropriateness of the data for factor analysis, where an index above .80 indicated that the sampling was adequate (Kaiser, 1974). In order to determine the number of factors present, the Kaiser-Guttman rule of standard eigenvalue of greater than 1 criterion was applied (Kaiser, 1960).

After EFA analysis, internal consistency of the construct was determined by calculating Cronbach´s α firstly for each factor independently, followed by the overall instrument consistency calculations. In order to analyze the numerical data, 3-point scale items were transformed into 4-point scale. The exploratory factor analysis was conducted with IBM SPSS version 22.

The third step was to analyse students´ responses for reasoning perception of relevance, motivation, enjoyment and interest toward the scenario by using qualitative content analysis with a summative approach. This methodology was applied, due to its nature of exploring the usage of certain concepts in students´ responses (Hsieh & Shannon, 2005). Initial coding was based on the data, therefore inductive coding was applied (Johnson & Christensen, 2000). The coding and inductive categories were developed by one researcher in the following sequence:

1. The coding units, in this case reasoning for perceptions of interest, relevance, enjoyment and motivation, were annotated (Kurasaki, 2000) with the formation of initial codes.
2. Initial codes were categorized and category descriptions were developed. The category descriptions were developed based on students´ responses.
3. Responses were grouped under developed code categories.
4. Grouping of 10% answers under developed code categories for reasoning relevance, motivation, enjoyment and interest (14 responses in each), was conducted by a second researcher.

In order to check inter-coder reliability, the coherence percentage was calculated, resulting in 86% coherence between two researchers.

Results of the Research

Confirmatory Factor Analysis

Figure 3 gives an overview of the six-factor hypothetical theory-based model with standardized factor loadings and correlations among factors provided by Amos. It can be seen, that the standardized factor loadings vary from .33 to .86. According to Hair et al. (2010) in order to provide construct validity, standardized loadings needs to be over .50 and ideally over .70. It can be seen that six items out of 26 do not meet the criterion of exceeding .50 factor loading and only nine items exceed .70 factor loading.

Additionally, the fit of the model was assessed with three different indices and resulted with RMSEA=.10; CFI=.72 and $\chi 2/df=2.42$. RMSEA, CFI indices and p-value of $\chi 2$ test <.0001 do not meet the values representing a good model fit. Both the standardized factor loadings and goodness of fit indices do not support the hypothesized model, and therefore a new model needed to be identified.

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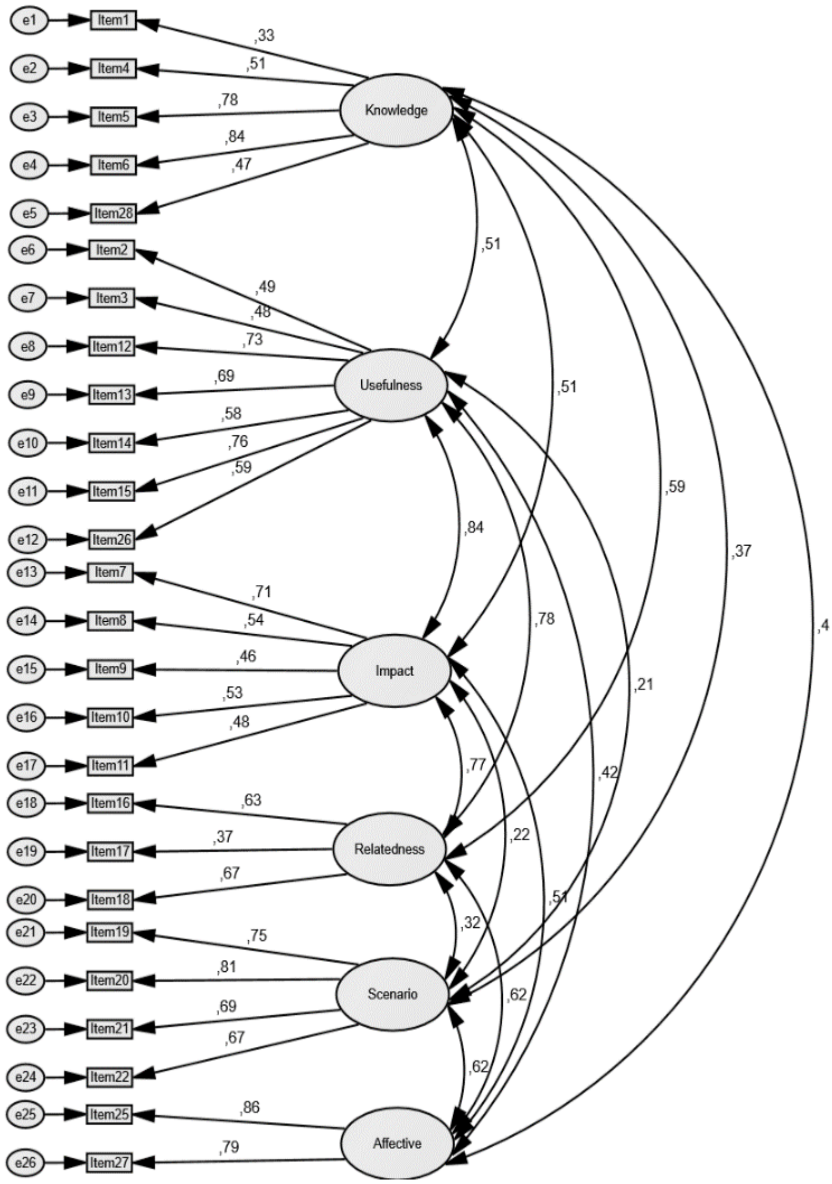

Figure 3: CFA of theory-based hypothetical model.

Note: χ^2=687.62; df=284; χ^2/df=2.42; χ^2 p value= <.0001; RMSEA=.10; CFI=.72. Only first word of the theoretical categorization presented in table 1 is shown.

Exploratory Factor Analysis

Before conducting exploratory factor analysis, KMO and Bartlett´s test of sphericity was conducted, resulting with sampling adequacy of .80 and Bartlett´s test as significant (χ2=1560.41, p<.001). This indicated that the sample was suitable for such EFA. Application of the standard eigenvalue of greater than 1 criterion resulted with a six factor solution with the total variance explained as 51.34%. The factor loadings were between .45 and .92 and Cronbach´s α of all 26 items was .90, which is considered as acceptable level (Bryman, 2001). According to (DeVellis, 2003) Cronbach´s α with values above .80 is considered as "very good" and .70 to .80 as "respectable", .60 to .69 as "undesirable to minimally acceptable". Internal consistency analysis of each factor separately resulted with values mostly over .85, which shows that the developed instrument is internally consistent. Nonetheless, the factor named as ´Social value` resulted with the minimally acceptable α value of .66. The item distribution among factors is shown in table 2.

The principal axis factoring resulted with a six-factor solution as was the initial hypothesized model. Nevertheless, the item distribution among factors differed. More specifically, item distribution, based on students´ responses combined knowledge and its value for personal level-related items into one factor (named as ´learning value´). The items, which referred to the future, form the second factor (named as ´vocational value´). It was found that items, which referred to relatedness and perceived impact level outside close relationships, like on a local or global community level, tended to group together. Similar to the initial hypothetical model, items about liking and interest formed a joint factor named ´affective reaction´ and items about scenario attributes formed a solid factor.

The principal axis factoring (PAF) analysis separates two factors that include only two items (´Career awareness´; ´Like and interest´). Both of these factors have factor loadings on a practical significant level, meaning that over 50% of the variance is accounted for by the factor (Hair et al., 2010). Based on the results obtained from PAF, it is found justified to keep all initial items and to further analyze the data according to the categories in table 2.

Table 2. Principal axis factoring analysis of the instrument with promax rotation.

Factor name	Factor description	Items	Factor loadings	α
Learning value	Learning value factor includes items with the common nominator of knowledge: possibility to learn; its value for the future and for close relationships including information value for the student personally. Item (It) 2: *The knowledge I gain from the scenario may be useful in the future*; It 4: *From this scenario I am able to gain new knowledge about possible career(s).*	1	.53	.80
		2	.74	
		3	.67	
		4	.45	
		7	.63	
		8	.48	
		10	.50	
		26	.55	
Vocational value	Vocational value factor includes items, which imply a future career, students´ present opinions of relatedness to the community of a possible future career, and what skills are necessary to be performed for a possible career. Additionally whether a student is already willing to make an effort to learn with the future in mind. It 12: *I feel that my future career may be connected with the topic covered in the scenario.* It 28: *The scenario makes me want to learn more about the topic.*	12	.77	.85
		13	.71	
		14	.61	
		15	.81	
		16	.65	
		28	.64	
Scenario attributes	Scenario attributes factor contains items about the technical aspects that can impact students´ opinion about the scenario. It 19: *The scenario is easy to follow.* It 22: *I like the format of the scenario.*	19	.74	.82
		20	.83	
		21	.63	
		22	.73	
Career awareness	Career awareness factor contains two items connected with understanding the responsibilities and skills of described occupations in the scenario. It 5: *The scenario enables me to understand the responsibilities of the persons in the career positions indicated;* It 6: *The scenario enables me to understand the skills that are necessary in these professions.*	5	.85	.83
		6	.81	
Like and interest	This factor includes items about interest and like toward the scenario. It 25: *I find this scenario interesting*; It 27: *I liked the scenario.*	25	.92	.81
		27	.73	

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Factor name	Factor description	Items	Factor loadings	α
Social value	Social value factor includes the items, which indicate a societal value, either on a local, or a global level. The situation may or may not be relatable to the student. It 11: *I find this scenario topic important for the whole world*. It 17: *The scenario represents a scientific problem which is socially relevant.*	18	.59	.66
		17	.53	
		11	.62	
		9	.49	

Analysis of Likert-type Item Responses

The results of the scenario evaluation are presented in table 3. The majority of the items in the questionnaire are on a 4-point scale (except 25, 26, 27, 28), giving a scale average of 2.5. All averages that exceed 2.5 are considered as a positive tendency and below that, considered as a negative tendency. One can see that students consider the information gained about energetics topic relevant (Cat.1, M=2.83, SD=0.46). The majority of students did value the knowledge for their future and for learning school subjects and considered the information gained from the scenario as valuable for them.

Nonetheless, students struggled to see the practical value of the scenario, as they did not consider energetics as their future field of occupation (Cat. 2, M=2.30, SD=0.59). Still students did see the need to perform skills that were described in the scenario. However, the scenario did not motivate students enough to make students learn more about energetics (M=2.05; SD=1.08).

Students did value highly technical attributes of the scenario (Cat. 3, M=3.08, SD=0.60), which means that students valued the video format; it was seen as easy to follow and understandable. Additionally, students valued the career awareness aspect of the scenario (Cat. 4, M=3.21, SD=0.52), and students could see the social relevance of the scenario topic (Cat. 5, M=3.03, SD=0.48). All in all, students liked the scenario and considered it as interesting (Cat. 6, M=3.08, SD=0.90). This can be linked with students´ mediocre prior knowledge about the topic and relating careers (items 23 and 24).

Table 3. The results of the scenario evaluation.

			M		SD	
Category	Item no.	Item	Per item	Per cat.	Per item	Per cat.
1. Learning value	1	This scenario enables me to gain new knowledge about the scenarios´ topic.	3.31	2.85 (N=137)	0.51	0.45
	2	The knowledge I gain from the scenario may be useful in the future.	3.22		0.59	
	3	I can put knowledge gained from the scenario into practice, to solve problems.	2.89		0.62	
	4	From this scenario, I am able to gain new knowledge about possible career(s).	2.94		0.7	
	7	I find this scenario topic important for me personally.	2.44		0.67	
	8	I find this scenario topic important to my family.	2.51		0.7	
	10	I find this scenario topic important for learning school subjects.	2.70		0.73	
	26	I find the information in this scenario valuable to me.	0.13 (2.70)		0.7 (1.05)	

			M		SD	
Category	Item no.	Item	Per item	Per cat.	Per item	Per cat.
2. Vocational value	12	I feel my future career may be connected with the topic covered in the scenario.	2.29	2.30 (N=135)	0.71	0.59
	13	I think my future studies at the gymnasium or university level may be connected to the topic covered in the scenario.	2.42		0.71	
	14	I predict I will need to perform skills, described in the scenario, in my future career.	2.54		0.81	
	15	I predict I need to perform science-related skills described in the scenario, in my future career.	2.36		0.75	
	16	The scenario describes the science community, to which I relate.	2.18		0.65	
	28	The scenario makes me want to learn more about the topic.	-0.30 (2.05)		0.72 (1.08)	
3. Scenario attributes	19	The scenario is easy to follow.	3.03	3.08 (N=135)	0.75	0.60
	20	The scenario is easy to understand.	3.25		0.64	
	21	The find this scenario enjoyable.	3.04		0.71	
	22	I like the format of the scenario.	3.01		0.80	
4. Career awareness	5	This scenario enables me to understand the responsibilities of the persons in the career position indicated.	3.34	3.34 (N=140)	0.62	0.57
	6	This scenario enables me to understand the skills that are necessary in this profession.	3.33		0.62	
5. Social value	9	I find this scenario topic important for appreciating the work of our local community (town, country).	3.01	3.03 (N=137)	0.60	0.48
	11	I find this scenario topic important for the whole world.	3.22		0.79	
	17	The scenario presents a scientific problem, which is socially relevant.	3.23		0.58	
	18	The scenario makes it easy for me to relate with the situation described.	2.63		0.75	
6. Like and interest	25	I find this scenario interesting to me.	0.31 (2.96)	3.08 (N=142)	0.66 (0.99)	0.90
	27	I liked the scenario.	0.46 (3.20)		0.64 (0.96)	
	23*	I know (…?) about the career described.	0.99 (N=142)		0.40	
	24*	I know (…?) about the topic in the scenario.	1.10 (N=140)		0.39	

*Note: For items 25, 26, 27, 28 the numbers in brackets refer to mean (M) and standard deviation (SD) after 3-point scale transformation into 4-point scale; *Background knowledge items. Scale defined for items 23, 24 as: 0- nothing, 1- a little, 2- a lot.*

Students´ Reasoning for Perceiving Relevance, Interest, Enjoyment and Motivation

In order to find out how students reason their perception of relevance, interest, like (enjoyment) and motivation toward the scenario, the questionnaire contained request to explain their perceptions. For overview purposes, students´ responses were divided between developed categories, which can be seen in appendix.

The analysis of the results showed that, for the majority of students, relevance is linked with the practical value of the scenario, either now, in near or far future (N=59) using words such as: *"When I grow up…", "In the future", "I presume I need…".* …, 16 students reasoned relevance or its absence with personal aspects such as importance for

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themselves or family. For 18 students, relevance was connected with gaining new knowledge. Only a small number of students (N=5) connected relevance with interest.

For the majority of students, motivation was linked with topic interest (N=57) and words such as: *"I am not interested in these topics", "I have been interested in this topic since…"* were used. Additionally, the practical use either for now, in the near or far future was the reason for 23 students: *"I believe I need this in the future"; I would like to make a solar panel by myself"; "I will not use it for my future profession"; "My family could use…"* Therefore interest toward the topic played a big role in motivating students to learn.

In reasoning, why they liked or disliked (enjoyed) the scenario, the majority of students related this with scenario attributes (N=55). For example, students used the following wordings: *"It was developed in an interesting way and made me think"; "It was easily understandable"; "easy to watch"; "Explained /discussed difficult problem/topic in an easy way."* For a large proportion of students, interest influenced whether they liked the scenario or not (N=23).

Similarly to reasoning likeability (enjoyment), for the biggest proportion of students (N=51), linked interest toward the scenario with scenario attributes. Students use the wordings such as: *"It was interesting, because I did not have to read and it had voiceover"; "… contained a problem, that I don´t think about in everyday life* [novelty aspect]; *"It was presented through life-related examples and it made it easier to understand."* Nonetheless, topic interest, or its absence, was mentioned by 23 students as the reason for considering the scenario as interesting or not.

Discussion

There are several factors that influence students´ interest, enjoyment and perception of relevance toward learning science. In the current article, a scenario about solar energy and relating occupations was used in an attempt to induce motivation through interest, enjoyment and relevance. In order to assess how students perceived the scenario, a scenario evaluation questionnaire was developed, tested and validated.

Initially, the hypothesized theory-based model did not represent a good model fit with confirmatory factor analysis and therefore exploratory factor analysis (EFA) was carried out. The EFA analysis, applying Kaiser-Guttman rule of standard eigenvalue greater than 1, resulted in a solid six factor solution, which proved to be internally valid. The number of factors matched the hypothetical model, although the item distribution was different. This indicated that the context of asking about relevance, interest, enjoyment and motivation was the primary focus for students.

Two factors included the same items, as anticipated in the hypothetical categorisation of items, that is, ´scenario attributes´ and ´affective reaction´. The ´scenario attributes´ category included the items that mostly addressed situational interest influencing factors. The analysis of students´ answers showed support for this claim, because, for majority of students´, perception of interest and enjoyment was related to technical aspects of the scenario. Therefore, it supported the claim of Ainley & Ainley (2011) that interest and enjoyment occurred as complementary functions, but emerged as separate emotion constructs.

Students did indicate high level of interest and enjoyment towards the scenario (Cat. 6, M=3.08, SD=0.90). This could be explained by the results showing that students´ prior knowledge about solar energy and relating occupations was mediocre, which indicated the possibility to perceive curiosity (Berlyne, 1960; Loewenstein, 1994) and interest (Kintsch, 1980) towards the scenario. Additionally, students valued highly the learning possibility, both about the scenario topic and related occupations, the usefulness and practicality of gained knowledge for their future, for school subjects and for themselves personally (Cat.1, M=2.83; SD=0.46). This indicated that the scenario met the goal of being perceived as meaningful by linking students´ prior knowledge to the topic to be learned (Levitt, 2001) and therefore supported the results of Hulleman & Harackiewicz (2009).

The format of the scenario and technical attributes, such as the understandability of the scenario, were highly valued by the students (Cat. 3, M=3.08, SD=0,60), which was also linked with interest development (Hidi & Renninger, 2006) and supported the perception of meaningfulness to the students (Levitt, 2001; Dewey, 1915). The effect of technical attributes, such as novelty, could also be detected in students' responses as to why they (dis)liked or were (not) interested in the scenario. If a student indicated that the scenario made him or her think, then holes in the knowledge schema had been detected between incoming information and the prior knowledge structure (Bergin, 1999) and this induced curiosity and interest (Loewenstein, 1994). The results of both Likert-type items and student reasonings indicated that the technical attributes influenced students' perception of both interest and enjoyment of the learning activity and therefore needed to be taken into consideration, when developing TLMs. This was especially important in science teaching, which was often accused of being too difficult and not connected with real-life (Krapp & Prenzel, 2011; Osborne & Dillon, 2008).

Students considered the alternative energy topic as highly relevant socially (Cat. 5, M=3.03; SD=0.48). Nonetheless, only a couple of students brought out the environment protection aspect in reasoning the perception of relevance and this topic was not considered as personally relevant by the majority of students (item 7, M=2.44; SD=0.67). This result could be considered as alarming from a sustainable development perspective, due to the fact that students would be expected to undertake decisions about fuel and energy sources in the future. When not considering alternative energy sources as personally important topics, such beliefs would impact on their actions (Levitt, 2001) and affect the consuming habits they face in their independent lives.

Items with a common denominator - future careers, formed the second factor (´vocational value´), which also included items that measured motivation to learn further about energetics topics. The results showed that for the majority of students, the scenario was not able to induce motivation for further learning of energetics. According to Ryan & Deci (2000), people behaved in an intrinsically motivated way in the presence of inherent interest and enjoyment. As the results of the current study showed, the majority of students were not interested in the energetics topic and the scenario was not enough, on its own, to develop individual interest, which in turn did not motivate students enough to learn this topic further.

Students mainly reasoned their (lack of) motivation associated with interest in the topic. Already as young as the 7th grade, students (in Estonia 13 years old in average) analyzed incoming information from an individual interest standpoint. Nonetheless, the majority of students did indicate a situational interest occurrence, by considering the scenario as different from the usual learning situation. Additionally, the current research results showed that this age group of students did analyze the learning task and the incoming information value from a practicality perspective for their future studies, or career choices and for their independent lives. This emphasized the need to describe future value to the students, who might not perceive it by themselves, due to their lack of experiences and knowledge.

The current analysis showed that it was not justified to equate interest and relevance, as they were induced by different reasons, at least when students were faced with a scenario about real-life and socially relevant science topic, such as renewable energy. Relevance was seen as connected with perceiving the scenario as valuable for the future, but in the case of interest, students considered the scenario as interesting, mostly due to technical attributes, such as the format and the novelty effect. It could be concluded that students indicated the occurrence of situational interest.

When STEM career- and everyday life-related scenarios are used, then it is possible to support the development of individual interest towards studying science. This approach, therefore, supports students´ interest in pursuing a career in this field, as interest in students of middle school age has been shown to be an influential factor in determining career choice in STEM-related fields (DeWitt & Archer, 2015).

Conclusions

Scenarios are often used as scene setting introductions for linking curriculum topics with everyday life, to support students´ motivation to study science. Nonetheless motivation to learn science topics is not automatically guaranteed to be induced by interacting with the scenario. The current research described the development, testing and validation of a new instrument, usable for evaluating motivational triggers in scenarios. As a result, the scenario evaluation instrument, containing 26 Likert-type items, distributed among 6 factors and supported with request to reason perceptions of relevance, interest, enjoyment, motivation and two background questions about prior knowledge, was successfully developed.

It was found that students did indicate situational interest toward the scenario, which contained STEM-career related information. Additionally, the science topic of energetics was contextualized in the scenario through students´ life-related issues, considered important for helping students to perceive meaningfulness of their studies. Students did consider the scenario valuable from learning perspective.

It was also found for the majority of students when asked to reason why they felt interested, or why they considered the topic valuable for themselves, relevance and interest stemmed from different factors. Therefore it was justified to include relevance and interest items in research instrument separately.

The majority of students indicated low levels of motivation toward studying energetics topics further, although the scenario was considered as enjoyable and interesting. This was found to be connected with students´ individual interest difference and the majority of students did not consider the energetics topic to be connected with their future career prospects.

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The results showed that seventh grade students value gaining information about possible STEM-related careers and responsibilities in that field highly. Therefore it is recommended to incorporate promotion of students´ awareness of occupations related with science into science teaching.

Although the current research showed positive results concerning perception of meaningfulness, interest and enjoyment toward the scenario, there is a need to be aware of the limitations. More specifically the sample was not representative to the whole Estonian 7th graders´ population and was purposefully chosen. Therefore large scale research was needed to support the results. Additionally this research represented the results after implementation of the first scenario of a TLM, out of 4 planned TLMs, in a longitudinal study. Therefore, the long term effects of implementing STEM career- and everyday life-related TLMs were still to be determined.

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Appendix

Distribution of Students´ Reasoning Responses for Scenario Evaluation

Table 1. Inductive categories for Relevance reasoning

Category	Subcategory	Description and samples	No. of students using this reasoning
1. WOA (Without answer)	-	No answer written	22
2. WOE (Without explanation)	-	Answer lacks explanation	9
3. Value	3.1 Practical value	Students´ response contains the implications to practical use or value either now, in near or far future. Examples of students responses under this category: "When I grow up…", "In the future", "I presume I need…", "In my future profession…", "I could use" etc.	**59**
	3.2 Intrinsic value	Student indicates value to him/herself or to his/her family (close relationships). Examples of students responses under this category: *"… not connected with myself personally", "I don´t know my families´ budget…", "valuable to me…", "Our families´…", "I have solar panels on our …".*	16
	3.3 Knowledge value	Student reasons relevance with knowledge gain and importance of knowledge. Examples of students´ responses under this category: *"Everyone should know about…", "the information is valuable to raise mine and others knowledge…", "gave information, "I can get to know…", "I know now".*	18
	3.4 Global value	Student reasons relevance from global standpoint. Examples of students´ responses under this category: "Nature protection is important"; "it is important for the world", "it is important for our environment", "we all wish to save".	**2**
4. Interest	4.1 Topic interest	Student reasons relevance/lack of relevance through topic interest. Examples of students´ responses under this category: *"I am not interested in these topics", "it was interesting", "it does not interest me much", "it was boring".*	5

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5. Multiple reasons in one answer	-	Students´ response combines several previous categories.	16

Table 2. Inductive categories for Motivation reasoning

Category	Subcategory	Description and samples	No. of students using this reasoning
1. WOA (Without answer)	-	No answer written.	15
2. WOE (Without explanation)	-	Answer lacks explanation.	14
3. Value	3.1 Practical value	Students´ response contains the implications to practical use or value either now, in near or far future. Examples of students responses under this category: “When I grow up…”, “In the future”, “I presume I need…”, “In my future profession…”, “I could use” etc.	**23**
	3.2 Knowledge/ information value	Student reasons motivation/lack of motivation with knowledge/ information appreciation. Examples of students´ responses under this category: “I have made some research on the topic by myself and it makes me want to learn more”; “I do not know about the topic…”; “It gave new information about…, and it could be useful” “I would like to gather some more information”.	10
4. Interest	4.1 Topic interest	Student reasons motivation/lack of motivation through topic interest. Examples of students´ responses under this category: “*I am not interested in these topics”, “I have been interested in this topic since…”; “not my topic”; “this topic does not excite me”; “I wish not to learn this topic”.*	**57**
	4.2 Motivation reasoned with just interest/ lack of interest	Student reasons motivation/lack of motivation with the following wording in his/her reason: “It was boring”, “It was/wasn´t interesting”, “Not interested”.	4
5.Scenario related reasoning	-	Student reasons motivation/lack of motivation with scenario characteristics. Examples of students´ responses under this category: *“Scenario was easy to understand and made topic more interesting”; “I didn´t like the scenario, and professions were not made interesting enough”; “It was different”.*	6
5. Multiple reasons in one answer	-	Students´ response combines several previous categories.	16
6. Multiple reasons in one answer	-	Students´ response combines several previous categories. For example: there is a combination of cat. 5 and 4.2.	8
7. Other	7.1 Rebellion/ ignorance	Student reasons their answer with: *“I´m not that easy to get influenced by one story”; “If the following videos are the same, then not”; “Maybe I´ll look at it in the future”; “I´m too lazy to study further”; I don´t really want to”.*	5
	7.2 Difficulty/ lack of skills	Student reasons their answer with: *“It does not fit with my skills”.*	1

Table 3. Inductive categorization of Enjoyment (Like) reasoning

Category	Subcategory	Description and samples	No. of students using this reasoning
1. WOA (Without answer)	-	No answer written	22
2. WOE (Without explanation)	-	Answer lacks explanation	9
3. Value	3.1 Knowledge value	Student reasons like with knowledge gain and importance of knowledge. Student uses following wording in his/her reason: *"Because I got new knowledge"; "It gave new information about…"; "It was very informative"; "It is important to talk about career opportunities to students"*	5
	3.2 Practical value	Students´ response contains the implications to practical use or value either now, in near or far future. Examples of students´ responses under this category: *"It might be useful in the future, when I´m buying a house"*	9
4. Interest	4.1 Like reasoned with just interest/ lack of interest	Student indicates like to him/herself by using following wording in his/her reason: *"It was boring at times"; "It was interesting".*	29
	4.2 Topic interest	Student reasons like/lack of like through **topic** interest. Student uses following wording in his/her reason: *"I am not interested in this topic at the moment", "I´m not really interested in electricity topic"; "It covered interesting topic".*	**3**
5. Scenario related reason	-	Student reasons like/dislike with **scenario characteristics**. Examples of students´ responses under this category: *"It was developed interestingly and made me think"; "It was easily understandable"; "easy to watch"; "Explained /discussed difficult problem/topic in an easy way";*	**55**
6. Multiple reasons in one answer	-	Students´ response combines several previous categories.	**17**
7. Emotional response	-	Student indicates like to him/herself by using following wording in his/her reason: *"Because it was cool"; "It was nice".*	2

Table 4. Inductive categorization of Interest reasoning

Category	Subcategory	Description and samples	No. of students using this reasoning
1. WOA (Without answer)	-	No answer written	14
2. WOE (Without explanation)	-	Answer lacks explanation; or says that wasn´t paying attention (why missing).	15
3. Value	3.1 Knowledge value	Student reasons interest with knowledge gain and importance of knowledge. Student uses following wording in his/her reason: *"It gave new knowledge about the field", "I got to know about the professions".*	16
	3.2 Global value	Student reasons interest from global relevance standpoint. Examples of students´ responses under this category: *"Because in reality we are running out of unrecoverable resources and we need to get energy from somewhere" (World related); "Because getting energy from the sun is very beneficial and it would solve a lot of problems in the world".*	4

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Category	Subcategory	Description and samples	No. of students using this reasoning
	3.3 Intrinsic value	Student indicates interest to him/herself or to his/her family (close relationships). Examples of students responses under this category: *"My dad is planning to insert solar panels to our home" (Family related)*	1
4. Topic interest		Student reasons interest/lack of interest due to the topic. Student uses following wording in his/her reason: "I´m still too young and I´m not interested in these topics"; "I´m just not interested in this topic".	23
5. Scenario related reason	-	Student reasons interest/lack of interest with scenario characteristics. Examples of students´ responses under this category: *"It was interesting, because I did not have to read and it had voiceover"; "… contained a problem, that I don´t think about in everyday life (novelty aspect); "It was presented through life-related examples and it made it easier to understand".*	**51**
6. Multiple reasons in one answer	**-**	Students´ response combines several previous categories.	19

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