SOCIETY. INTEGRATION. EDUCATION
Proceedings of the International Scientific Conference. Volume I, May 27th, 2022. 486-496

SCHOOL STUDENTS' MOTIVATION FOR LEARNING PHYSICS: HOW DOES INSTRUCTIONAL CLARITY IN PHYSICS LESSONS ENGAGE?

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Abstract: *The article deals with the eighth-grade school students' motivation for learning physics. The spectrum of factors influencing the school students' motivation for learning physics is very wide. This study addresses the phenomenon of school students' motivation for learning physics in the light of an educational factor. We analyze the role of instructional clarity in physics lessons on school students' motivation for learning physics based on TIMSS 2019 data set of Lithuania and Finland. To disclose the influence of instructional clarity in physics lessons on school students' motivation for learning physics confirmatory factor analysis (CFA) and structural equation modelling (SEM) was used. The results of our research reveal that instructional clarity in physics lessons is directly and positively associated with school students' motivation for learning physics. SEM results disclosed not only significance but magnitudes of associations between instructional clarity in physics lessons and school students' motivation for learning physics as well.*
Keywords: instructional clarity in physics lesson, motivation for learning physics, school student.

Introduction

In the first decade of the 21st century, researchers were concerned about the motivation of students to study science "Yet in recent times fewer young people seem to be interested in science and technical subjects. Why is this?" (Osborne & Dillon, 2008). The motivation for learning science remains relevant for education policymakers and for researchers in the third decade of the 21st century (European Union, 2016; Lavonen et al., 2021).

Physics is one of the natural science subjects. School students regards physics as very difficult to learn, as a result, physics at school continuously loses importance (Fisher & Horstendal, 1997). Effective instructional behaviors are teaching styles or strategies that can motivate students to learn effectively (Chan et al., 2021). TIMSS 2019 provides an opportunity to explore the peculiarities of instructional clarity in physics lessons of different countries. Therefore, it is relevant to explore the instructional clarity in physics lessons and its links to students 'motivation to learn physics.

https://doi.org/10.17770/sie2022vol1.6815

The situation discussed highlights **the scientific problem**, which is formulated as a question: How does the instructional clarity in physics lessons relate to school students' motivation for learning physics? The study aims at contributing to this body of literature by analyzing the relationship between the instructional clarity in physics lessons and the motivation for learning physics of school students.

The purpose of the research is to reveal the relationship of instructional clarity in physics lessons and motivation for learning physics of school students' and to highlight the influence of instructional clarity on the motivation for learning physics.

Research methods. We performed secondary analysis of TIMSS 2019 data using confirmatory factor analysis (CFA) and structural equation modelling (SEM).

Literature review

In recent years, number of studies have been conducted to investigate ways to improve students' motivation. Many investigations have shown that teachers' instructional behaviors can affect students' perceived self-determination and learning outcomes (Núñez & León, 2019). Instructional behaviors of teachers encompass four components: instructional clarity, instructional support and feedback, instructional support for student autonomy, and instructional support for cooperative learning (Chan et al., 2021). Researchers analyzed the relationship between the perceived instructional behaviors of teacher educators and pre-service teachers' self-reported levels of learning motivation and found that teacher educators' instructional clarity have significant and positive influences on pre-service teachers' intrinsic learning motivation (Chan et al., 2021).

Instructional clarity of teachers is revealed through the ability of the teacher to explain course objectives and content, assignments clearly, explain how to do homework to explain concepts or new theories clearly (Bolkan et al., 2016; Chan et al., 2021; Simonds, 1997). Research has shown that instructional clarity, constructive feedback is positively associated with students' intrinsic learning motivation and subjective task value (Federici & Skaalvik, 2014; Lazarides et al., 2019; Roksa et al., 2017).

Yagan (2021) investigated the relationships between teachers' classroom management and instructional clarity skills, and students' mathematics achievement and revealed that teachers' instructional clarity and classroom management skills and students' attitudes towards mathematics increased, mathematics achievement also increased. Redish and Kuo (2015) states that there is a positive relation between Physics and Maths „we explore math as a language and consider the language of math in physics through the lens of cognitive linguistics." Very abstract content of physics based on math language is one of the reasons for reducing the school students' interest in physics (Fisher & Horstendal, 1997). Effective instructional behavior, instructional clarity of physics teachers' is important in solving the problem with the school students' motivation for learning physics. Thus, we hypothesized: **H$_1$**. Instructional clarity in physics lessons will be positively associated with students' motivation for learning physics.

Methodology

Method of research. We performed secondary analysis of TIMSS 2019 data of two countries: Lithuania and Finland. To reveal the peculiarities of students 'motivation to learn physics, we decided to choose countries being very similar in terms of students' achievements. According to Average Science Achievement and Scale Score Distributions of TIMSS 2019 Finland ranks sixth and Lithuania seventh places.

This research aimed to measure the impact??? of the instructional clarity in physics lessons on school students' motivation for learning physics. For this purpose, confirmatory factor analysis (CFA) and structural equation modelling (SEM) was used. CFA and SEM were performed using structural equation modelling software AMOS 17.

The instrument of the quantitative research. TIMSS 2019 context questionnaire items were developed to be combined into scales measuring a single underlying latent construct TIMSS 2019 *Instructional Clarity in Physics Lessons* scale at the eighth grade seeks to measure school students' perceptions about the clarity of instruction in their physics lessons based on their responses to seven statements (Table 1). For each of the seven statements, students were asked to indicate the degree of their agreement with the statement: agree a lot, agree a little, disagree a little, or disagree a lot. Cronbach's Alpha Reliability Coefficient of these items is sufficient and varies from .85 (Finland) to .91 (Lithuania).

Table 1 ***The questions from TIMSS 2019 about the instructional clarity in physics lessons*** *(created by the author)*

Code of question	Physics teachers' instructional activity
BSBP39A	I know what my teacher expects me to do
BSBP39B	My teacher is easy to understand
BSBP39C	My teacher has clear answers to my questions
BSBP39D	My teacher is good at explaining physics
BSBP39E	My teacher does a variety of things to help us learn
BSBP39F	My teacher links new lessons to what I already know
BSBP39G	My teacher explains a topic again when we don't understand

The *Students Like Learning Physics* scale encompasses nine items about motivation for learning physics (Table 2). Cronbach's Alpha Reliability Coefficient of these items shows good internal consistency of items: Cronbach's Alpha Reliability Coefficient .93 based on Lithuanian data and .86 based on Finnish data.

Table 2 ***The questions from TIMSS 2019 about the students like learning physics*** *(created by the author)*

Code of question	Items about the motivation for learning physics
BSBP38A	I enjoy learning physics
BSBP38B	I wish I did not have to study physics
BSBP38C	Physics is boring
BSBP38D	I learn many interesting things in physics
BSBP38E	I like physics
BSBP38F	I look forward to learning physics in school
BSBP38G	Physics teaches me how things in the world work
BSBP38H	I like to conduct physics experiments
BSBP38I	Physics is one of my favorite subjects

In the case of CFA and SEM analysis, it is important that normality condition is met." We checked the normality of data including skewness and kurtosis, because TIMSS sample is large sized sample (e.g., $n > 300$). The data is normal if skewness is between -2 to +2 and kurtosis is between -7 to +7 (Byrne, 2010). The result of normality is desirable and can undermine CFA and SEM analyses (Table 3), (Table 4).

Table 3 ***Normality of motivation for learning physics data: asymmetry coefficients test*** *(created by the author)*

		BTBS								
		38A	38B	38C	38D	38E	38F	38G	38H	38I
LTU	Skewness	1.026	.953	.980	2.321	1.129	.454	2.052	1.998	.206
	Kurtosis	3.944	4.177	4.947	6.436	4.782	4.658	4.665	4.861	2.219
FIN	Skewness	1.650	1.391	1.848	2.202	1.767	1.362	2.348	1.784	1.002
	Kurtosis	6.039	6.248	6.290	6.660	6.709	5.070	6.128	5.331	6.580

Table 4 ***Normality of clarity in physics lessons data: asymmetry coefficients test*** *\(created by the author)*

		BTBS							
		39A	39B	39C	39D	39E	39F	39G	39H
LTU	Skewness	1.749	1.761	2.025	2.396	2.083	2.182	2.009	1.749
	Kurtosis	6.890	6.819	6.713	6.240	5.717	5.972	6.829	4.890
FIN	Skewness	1.865	1.526	1.481	1.514	1.704	1.768	1.904	1.865
	Kurtosis	6.707	5.982	5.962	7.008	6.227	5.667	5.866	6.707

The sample and sampling. We used TIMSS 2019 survey databases. The TIMSS survey ensures the reliability and representativeness of the survey samples. We removed incomplete questionnaires from the Lithuanian and Finnish databases. In our study, the Lithuanian sample consisted of 1600 students, the Finnish - of 1100 students.

Results

This research aimed to measure the influence of the instructional clarity in physics lessons on the school students' motivation for learning physics. TIMSS 2019 context questionnaire on the instructional clarity in physics lessons and motivation for learning physics items were developed based on theoretical background and updated to be combined into scales measuring a latent construct: the Instructional Clarity in Physics Lessons (ICPH) and the Motivation for Learning Physics (MLPH) (Figure 1).

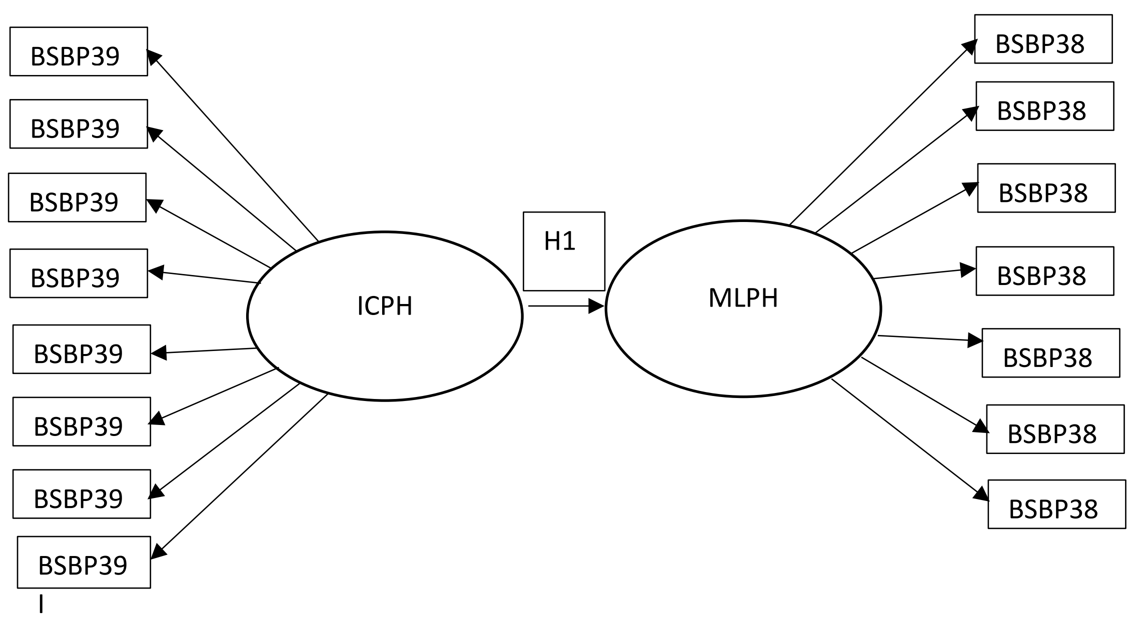

Figure 1 ***The theoretical model of the instructional clarity in physics lessons (ICPH) and students' motivation for learning physics (MLPH)*** *(created by the author)*

The measurement model fit the Lithuanian (LTU) and Finland (FIN) data well (Table 5). In our study **I**nstructional **C**larity in **P**hysics **L**essons (ICHP) latent variable is measured with seven observed variables (BTBP39A—BTBP39G), **M**otivation for **L**earning **P**hysics (MLPH) — variable with eight observed variables (BTBP38A—BTBP38I). The observed variables of both latent variables were measured by ordinal scale: a lot agree, agree a little, disagree a little, disagree.

Table 5 ***The fitness of items of measurement model: the instructional clarity in physics lessons and motivation for learning physics*** *(created by the author)*

	Absolute fit index			Relative fit index		
	χ^2/df	RMSEA	GFI	IFI	TLI	CFI
Assumed model (LTU)	4.212	.046	.969	.983	.973	.983
Assumed model (FIN)	4.233	.065	.945	.983	.974	983
Acceptance value	1-5	<.08	>.80	>.90	>.90	>.90

We analyzed the latent variable (MLPH) by the unstandardized beta (B), the standard error for the unstandardized beta (S.E.), the standardized beta (β), and the probability value (p) (Table 6). The probability value (p) shows that accept two cases based on Finland data (I enjoy learning physics; I wish I did not have to study physics) observed variables are significant when predicting the dependent latent variable (MLPH) (Table 6).

Table 6 ***Results of CFA: the latent construct is students' motivation for learning physics (MLPH)*** *(created by the author)*

Country	Observed variable	B	β	S.E.	p label
LTU	I enjoy learning physics	1.000	.884	.031	***
	I wish I did not have to study physics	-.508	-.405	.029	***
	Physics is boring	-.479	-.403	.024	***
	I learn many interesting things in physics	.784	.705	.021	***
	I like physics	1.067	.885	.021	***
	I look forward to learning physics in school	.850	.793	.030	***
	Physics teaches me how things in the world work	.804	.756	.029	***
	I like to conduct physics experiments	1.002	.888	.020	***
FIN	I enjoy learning physics	.080	.933	.035	.023
	I wish I did not have to study physics	.072	.072	.038	.058
	Physics is boring	.944	.060	.021	***
	I learn many interesting things in physics	1.015	.864	.019	***
	I like physics	.957	.909	.016	***
	I look forward to learning physics in school	.982	.932	.032	***
	Physics teaches me how things in the world work	.962	.876	.029	***
	I like to conduct physics experiments	.960	.911	.018	***

The analysis of the Lithuanian database revealed that unstandardized beta (B) is the highest for variable I like physics (Table 6). This value represents the association between predictor variable (I like physics) and the dependent variable (MLPH). It means that for every one unit increase in variable I like physics, the dependent variable (MLPH) increases by 1.067 units. The variable I like physics expresses an emotional attitude of school students towards the subject of physics. Thus, the secondary analysis of the Lithuanian database revealed that the emotional variable is an important variable of motivation for learning physics.

The analysis of the Finland database revealed that unstandardized beta (B) is the highest for variable I learn many interesting things in physics (Table 6). It means that for every one unit increase in variable I learn many interesting things in physics, the dependent variable (MLPH) increases by 1.015 units. The variable I learn many interesting things in physics expresses an intelligent attitude towards the subject of physics. It means that the variable of intellectual character is an important variable of Finland school students' motivation for learning physics.

We analyzed the latent variable Instructional Clarity in Physics lessons data (ICPH) by the main parameters: unstandardized beta (B), the standard error for the unstandardized beta (S.E.), the standardized beta (β), and the probability value (p) (Table 7). All independent variables (I know what my teacher expects me to do; My teacher is easy to understand; My teacher has clear answers to my questions; My teacher is good at explaining physics; My teacher does a variety of things to help us learn; My teacher links new lessons to what I already know; My teacher explains a topic again when we don't understand) statistically significant) predict instructional clarity in physics lessons (Table 7).

Table 7 ***Results of CFA: the latent construct is instructional clarity in physics lessons (ICPH)*** *(created by the author)*

Country	Observed variable	B	β	S.E.	p label
LTU	I know what my teacher expects me to do	.956	.894	.020	***
	My teacher is easy to understand	.973	883	.027	***
	My teacher has clear answers to my questions	1.003	.831	.025	***
	My teacher is good at explaining physics	1.065	.825	.029	***
	My teacher does a variety of things to help us learn	1.015	.783	.024	***
	My teacher links new lessons to what I already know	.956	.765	.026	***
	My teacher explains a topic again when we don't understand	1.000	.629	.	***
FIN	I know what my teacher expects me to do	.879	.911	.022	***
	My teacher is easy to understand	.987	.849	.022	***

My teacher has clear answers to my questions	1.012	.915	.022	***
My teacher is good at explaining physics	1.020	.925	.023	***
My teacher does a variety of things to help us learn	1.022	.947	.021	***
My teacher links new lessons to what I already know	.971	.897	.022	***
My teacher explains a topic again when we don't understand	1.000	.881	.	***

We performed an unstandardized beta (B) values analysis based on the Lithuanian and Finnish databases and observed very similar trends. Based on both the Lithuanian and Finnish databases, the highest coefficients were determined for the following variables: My teacher has clear answers to my questions (B_{LTU} = 1.003; B_{FIN} = 1.012); My teacher is good at explaining physics (B_{LTU} = 1.065; B_{FIN} = 1.020); My teacher does a variety of things to help us learn (B_{LTU} = 1.015; B_{FIN} = 1.022) (Table 7). Hence, instructional clarity in physics lessons is mostly associated to the ability of a physics teacher to give clear answers on students' questions, to the ability explain the physics phenomenon, and to the ability to aid in learning physics.

The main purpose of this study was to reveal the role of the instructional clarity in physics lessons in the motivation for learning physics of school students. We examined the one direct effect for significance and magnitudes (Table 5). We found that the direct path was significant in the final model (Table 9). The statistically significant path coefficient in the model was detected based on Lithuanian and Finland data (Table 9).

Table 9 ***The associations between the students' motivation for learning physics and instructional clarity in physics lessons: paths coefficients and statistical significance*** *(created by the author)*

Country	Hypothesis	Paths	Paths coefficients (β)	p value	R^2	Results
LTU	**H_1.** Instructional clarity in physics lessons is associated with students' motivation for learning physics.	Instructional clarity in physics (ICPH) → students' motivation for learning physics (MLPH)	.770	***	.515	Support
FIN	**H_1.** Instructional clarity in physics lessons is associated with students' motivation for learning physics.	Instructional clarity in physics (ICPH) → students' motivation for learning physics (MLPH)	.634	***	.487	Support

We performed hypotheses testing by aspect of R-squared (R^2). Our model has independent variables that are statistically significant and has high R-squared value (Table 9). This combination of p-value and R-squared indicates that the independent variables are correlated with the dependent variable and explains much of the variability in the dependent variable (Table 9).

Discussion

The purpose of this study was to determine the associations between instructional clarity in physics lessons and school students' motivation for learning physics. The results obtained in the study are in accordance with our hypotheses (H_1). The results of our study are in the line with these theoretical insights. Teacher can reduce students' extraneous cognitive loads in learning physics using several methods in their teaching including segmenting information, providing concise and uncluttered information to students, and getting rid of unnecessary or redundant course material (Mayer & Moreno, 2010).

We revealed the highest unstandardized coefficients of these variables: My teacher has clear answers to my questions (B_{LTU} = 1.003; B_{FIN} = 1.012); My teacher is good at explaining physics (B_{LTU} = 1.065; B_{FIN} = 1.020); My teacher does a variety of things to help us learn (B_{LTU} = 1.015; B_{FIN} = 1.022) (Table 7). Researchers (Bolkan et al., 2016) revealed that motivation interacted with instructor clarity to increase test scores. Results of their study indicated "that even with clear instruction, test scores were not increased when students' motivation to process was low" (Bolkan et al., 2016, p.129).

These results highlight the limitations of our study. We did not examine the relationship between instructional clarity, motivation, and students' achievement. We focused exclusively on school students' motivation for learning physics in the light of instructional clarity in physics lessons, but it is possible to include more factors (achievement, gender, performance, self-confidence in physics learning) at the class level and establish the mediating role of other factors on students' motivation for learning physics.

Conclusions

The results of SEM analysis revealed that the instructional clarity in physics lessons statistically significantly predicts Lithuanian and Finnish school students' motivation for learning physics. SEM results disclosed not only statistical significance but magnitudes of associations between instructional clarity in physics lessons and school students' motivation for learning physics as well.

The results of CFA disclosed that instructional clarity in physics lessons is mostly associated to the ability of a physics teacher to give clear answers to students' questions, to the ability explain the physics phenomenon, and to the ability to aid in learning physics.

Acknowledgment

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS 2019 Copyright © 2021 International Association for the Evaluation of Educational Achievement (IEA). Publisher: TIMSS & PIRLS International Study Center, Lynch School of Education and Human Development, Boston College.

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