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STUDENTS' PERFORMANCE AND TEACHING PRACTICES IN SCIENCE ACROSS EU COUNTRIES: EVIDENCE FROM PISA 2015

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Abstract

Teaching practices are the most significant factors in explaining students' academic outcomes (Caro et.al 2016). They vary across education systems and their effectiveness depends on the composition of other factors (Kyriakides, 2008). This study investigates the effects of students' perceived teaching practices during science lessons (enquiry-based science teaching practices, adaption of instruction, teacher support, and perceived feedback) on student science performance whilst considering socioeconomic characteristics. Also, we compare these associations across various EU learning contexts. Data from 24 EU education systems that participated in PISA 2015 were used. Our results suggest that the prevalence of analyzed teaching practices is different across EU countries. The results of multiple linear regression show that the models explained from 14% to 25% variance of student science performance across EU countries. The adaption of instruction is positively related and perceived feedback is negatively related to science performance. These patterns of associations are similar across all observed EU countries. The association of enquiry-based teaching with performance is negative in the majority of EU countries. Teacher support does not work in the same manner as we obtain both positive and negative effects across EU countries. Our results confirm the difference of effectiveness of teaching practices across EU learning contexts.

Keywords: Teaching practices, student performance, PISA 2015.

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1. Introduction

The acquisition of comprehension of scientific principles and theories during school years increasingly gains greater value as science-related employment is expected to grow (Fayer, Lacey, & Watson, 2017). However, the students' interest in science is declining through school years (Osborne, Simon & Collins, 2003, Potvin & Hasni, 2014). These circumstances pose the question about how the science disciplines could be taught at schools in order to keep students' interest in science and help them to gain the understanding of its concepts and practices. Science-related competences that are acquired at school would enable the students to develop science-related careers in the future.

Education effectiveness theory (Creemers & Kyriakides, 2010) proposes that classroom level processes are critical in enhancing academic outcomes and metacognitive skills of students. Classroom level processes are influenced by different factors of various levels: teacher (through communicational and teaching styles), student (through personal characteristics such as gender, age, socio-economic status and etc.), school (through school policies on teaching), and education system (through developing and evaluating educational policy at country level). This means that educational settings should be considered as complex and multidimensional, and the effectiveness of teaching practices depends on the composition of the factors at the same and different levels (Kyriakides, 2008). Therefore, the science teaching practices that are effective in some classrooms may not work in another.

Classroom level processes involve teachers and students; however, the role of the teacher is critical in promoting students' learning (Hanushek, 2011). Teachers choose instructional practices, organize instructional time and educational resources as well as build interpersonal relationships with students (Cordero & Gil-Izquierdo, 2018). Even though it is recognized that high-quality teachers are the most important asset of school (Hanushek, 2011) and the effectiveness of various teaching practices is analyzed in various studies, however, there is still no agreement which teachers' behavior in science teaching are reliably related to students' science performance.

The person-environment fit theory (Eccles et al., 2003) proposes that when teachers' behavior is attuned to students' needs during the science classes, students possess high level learning motivation and are engaged in learning. The self-determination theory (Ryan, Deci, 2000; Vansteenkiste, Ryan, 2013) proposes that three basic psychological needs for autonomy, competence, and relatedness are important and serve as nutriments for students' activity and thriving. When students feel they act on their own will (satisfaction of the need for autonomy), can be effective in school tasks (satisfaction of the need for competence), and have close and supportive relationships with others at school (satisfaction of need for relatedness), they are able to integrate their school experience and develop high-level motivation for learning. Such students assume responsibility for their studies, are able to regulate the learning process, employ deep learning strategies, and achieve high academic results (Ryan, Deci, 2000; Wentzel, Barry, & Caldwell, 2004).

In this study, we focus our attention on four student-oriented teaching practices – enquiry-based teaching, adaption of instruction, perceived feedback, and teacher support. Enquiry-based practice creates an environment where students engage in active investigation, design and plan experiments, interpret and communicate the results, and connect their findings with real-life problems (OECD, 2016b, Teig, Scherer, & Nilsen, 2018). This teaching practice promotes students' autonomy (Silva & Galembeck, 2017).

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Adaption of instruction refers to teachers' flexibility in constructing the lessons (OECD, 2016b). When employing this practices teachers take into the consideration students' skills, abilities, and knowledge, thus creating environments where students perceive themselves as able to successfully perform during the class. This corresponds with the students' satisfaction of the need for competence (Vansteenkiste et al., 2012). Perceived feedback is considered as the information teachers provide about students' knowledge and learning activities in order to improve their learning (Burnett, 2002; Shute, 2008). This teaching practice is also related to the students' need for competence as the feedback helps to modify the learning behavior. Teacher support refers to expressing interest in students and dedicating time and resources to help students. Teacher support affects the quality of the teacher-student relationship and therefore allows students to satisfy their need for relatedness.

Some previous studies have demonstrated that these teaching practices have a significant influence on students' engagement, attitudes and other academic outcomes (etc., Blanchard et al., 2010; Wolf & Fraser, 2008; den Brok, Levy, Brekelmans, Wubbels, 2005; Dietrich et al., 2015; Furrer, Skinner, 2003; Wentzel, Battle, Russell, Looney, 2010; Koka, Hagger, 2010). Many studies that analyzed the effects of teaching practices on students' functioning at school were based on small, country-specific samples, that does not allow the generalization of the results to population and comparison between countries. International large-scale assessment (ILSA) data provide this opportunity for generalization. Currently secondary ILSA data analyzes are available that investigate the links between teaching practices and students' performance (for example, Caro, Lenkeit, Kyriakides, 2016; Chi, Liu, Wang, Won Han, 2018; Cairns & Areepattamannil, 2017; Lau & Lam, 2017; Teig, Scherer, Nilsen, 2018; Cordero, Gil-Izquierdo, 2018). Some of the studies (such as Cairns, Areepattamannil, 2017; Chi et al., 2018; Teig et al., 2018) used the data from one country and only a few (Caro et al., 2016 and Lau & Lam, 2017) have analyzed the effectiveness of teaching practices across different countries. The study of Caro et al. (2016), which is based on PISA (Programme for International Student Assessment) 2012 data from 62 countries, found that associations between students' oriented learning strategies and mathematics performance are inconsistent across education systems. Lau and Lam (2017) study used PISA 2015 data from 10 top-performing regions (among which two countries – Estonia and Finland – were from EU). The results of that study showed that the patterns of associations between teaching practices and science performance are the same in all analyzed countries. Adaptive instruction, teacher-directed instruction and interactive application (which is a sub-construct of enquiry-based teaching) were positively related, while perceived feedback and investigation (another sub-construct of enquiry-based teaching) were negatively related to student science performance. Despite the mentioned studies, the secondary analyzes about the effectiveness of teaching practices are still not common. Therefore, the evidence is still scarce about the associations between the teaching practices and students' science performance across different countries. Moreover, such teaching practices as enquiry-based teaching, adaption of instruction and feedback were studied more than teacher support.

2. Problem Statement

Given the growing importance of science-related competencies in the labor market, finding the ways for the effective development of those competencies at school is becoming critical. Teaching practices are the most significant factors in explaining students' science performance (Caro et al., 2016). Both the person-

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environment fit and the self-determination theories propose that students are more likely to engage in learning and be effective when their psychological needs are satisfied in the school environment. Teaching practices vary across education systems and their effectiveness depends on the composition of other factors. However, the secondary International large-scale assessment (ILSA) data that would compare the effectiveness of teaching practices in various education systems are still scarce.

3. Research Questions

We analyzed the education systems of EU and contribute to the existing literature by answering the following questions: 1) How similar are the teaching practices (enquiry-based teaching, adaption of instruction, perceived feedback, teacher support) and science performance across EU countries? 2) How are the teaching practices (enquiry-based teaching, adaption of instruction, perceived feedback, teacher support) related to science performance across EU countries?

4. Purpose of the Study

This study investigates the effects of students' perceived teaching practices related with science teaching and learning (enquiry-based science teaching practices, adaption of instruction, teacher support, and feedback) on student science performance whilst considering student socioeconomic characteristics. Also, we compare these associations across EU learning contexts.

5. Research Methods

5.1. Data

PISA 2015 data, which evaluate 15-year-old students' knowledge and abilities application of science, was used in the study. Data from 24 representative national samples of EU countries were analyzed. Cyprus, Malta, Slovenia, and Romania were excluded from the analysis as at least one of the study variables were not available. Original names of scales from PISA 2015 were maintained. Sample size of each country was restricted to students with non-missing observations in independent variables.

5.2. Variables

Science performance (PV_SCIE). Student performance in science was selected as a dependent variable in the study. Student performance was evaluated with science tasks. Using the Item Response Theory and Plausible Value methodology, 10 plausible values were produced for each student to evaluate their science performance. All plausible values were used in the analysis to obtain an average regression estimates and adjusted standard errors (SE).

Adaption of instruction (ADINST). ADINST scale consists of three items: "the teacher adapts the lesson to the class's needs and knowledge"; "the teacher provides individual help when a student has difficulties understanding a topic or task"; "the teacher changes the structure of the lesson on a topic that most students find difficult to understand". For each item, students were asked to indicate how often it happens in their lessons for the <school science> course using a 4-point Likert scale from 1 (never or almost

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never) to 4 (every lesson or almost every lesson). The higher score of ADINST scale indicates the higher frequency of perceived instruction adaptation.

Enquiry-based science teaching (IBTEACH). IBTEACH scale consists of eight items: "students are given opportunities to explain their ideas"; "students spend time in the laboratory doing practical experiments; students are required to argue about science questions"; "students are asked to draw conclusions from an experiment they have conducted"; "the teacher explains how a <school science> idea can be applied to a number of different phenomena (e.g. the movement of objects, substances with similar properties)"; "students are allowed to design their own experiments"; "there is a class debate about investigations"; "the teacher clearly explains the relevance of <broad science> concepts to our lives". Students were asked to indicate the frequency of these specific teaching and learning activities occurring in their science lessons using a 4-point Likert scale from 1 (in all lessons) to 4 (never or hardly ever). IBTEACH scale was reverse-coded so that the higher score of the scale indicates the higher level enquiry-based teaching and learning practices.

Perceived feedback (PERFEED). PERFEED scale consists of five items: "the teacher tells me how I am performing in this course"; "the teacher gives me feedback on my strengths in this <school science> subject"; "the teacher tells me in which areas I can still improve"; "the teacher tells me how I can improve my performance"; "the teacher advises me on how to reach my learning goals". For each item, students were asked to indicate how often it happens in their lessons for the <school science> course using a 4-point Likert scale from 1 (never or almost never) to 4 (every lesson or almost every lesson). The higher score of the PERFEED scale indicates more frequent perceived feedback in science classes.

Teacher support (TEACHSUP). TEACHSUP scale consists of five items: "the teacher shows an interest in every student's learning"; "the teacher gives extra help when students need it"; "the teacher helps students with their learning"; "the teacher continues teaching until the students understand"; "the teacher gives students an opportunity to express opinions". Students were asked to indicate the frequency of teacher support in science classes using a 4-point Likert scale from 1 (every lesson) to 4 (never or hardly ever). TEACHSUP scale was reverse-coded so that the higher score of the scale indicates the higher level of teacher support in science classes.

Student economic, social and cultural status (ESCS). The index of ESCS consists of three indicators: parental education, highest parental occupation and home possessions including books in the home. The principal component analysis (PCA) was performed to obtain ESCS values.

The dependent variable, science performance, was scaled to have mean of 500 and a standard deviation of 100 across OECD countries. ADINST, IBTEACH, PERFEED, TEACHSUP and ESCS indices were transformed to an international metric with a mean of 0 and a standard deviation of 1 across OECD countries. OECD assessed the internal consistency of each scale within the countries calculating Cronbach's alpha coefficient. The coefficient values ranges from .71 to .94 depending on the scale and country (more details about indices construction might be found in PISA 2015 Technical report, Chapter 16 (OECD, 2016c).

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5.3. Analysis

IEA IDB Analyzer version 4.0.21 and IBM SPSS version 25 was used to handle plausible values and replicated weights. Multiple linear regression was employed for each education system independently. Firstly, science performance (PV_SCIE) was regressed against each teaching practice controlling for ESCS. PERFEED entered as significant variable for all, IBTEACH for 21, ADINST for 18 and TEACHSUP for 13 countries (results are available on request). Secondly, we calculated the variance inflation factor (VIF) for multicollinearity estimation between independent variables. VIF values ranged from 1.17 to 1.98 (depending on variable and country) meaning no collinearity between selected variables. As the last step, we estimated a multiple linear regression model for the estimation of the associations between teaching practices and science performance while controlling for student economic, social and cultural status:

$$PV\_SCIE^i=\beta_0^i+\beta_1^i ESCS^i+\beta_2^i\ ADINST^i+\beta_3^i\ IBTEACH^i+\beta_4^i\ PERFEED^i+\beta_5^i\ TEACHSUP^i+\varepsilon^i, \quad (1)$$

where superscript $i=1,...,25$ is a number of education systems, $\beta_0,..., \beta_5$ are regression parameters and ε random error. Regression results are discussed in the next section and estimates of equation (1) are reported in Table 2.

6. Findings

When analyzing science performance in EU countries (Table 1) we can rank the countries from the best (Estonia, Finland) to the worst (Greece, Bulgaria) performing country. The arithmetic average of the countries is equal to 504 points (for non-missing observations in independent variables) and it is above 493 points of OECD average (OECD, 2016a).

In respect to ESCS half of EU countries have higher index than OECD average and half of them – lower, that indicate that students' environment is heterogeneous in terms of parental occupation, education and home welfare in 24 EU countries. Scandinavian countries (Denmark, Sweden) have the highest index, Spain and Latvia are on the lowest level across EU countries.

Already from descriptive statistics (Table 1) we see that teaching strategies (adaption of instruction, enquiry-based teaching, perceived feedback, teacher support) vary between EU countries. Adaption of instruction (ADINST) is higher than OECD average in 8 EU countries (Portugal has the highest index followed by Denmark, Bulgaria) and lower in 16 countries (Belgium, Luxembourg, France, and Austria have the lowest indices). In countries where this index is higher teachers adapt instructions according to the students' needs more often than in countries with a lower value of this index.

Enquiry-based teaching (IBTEACH) is higher than OECD average in 10 EU countries (Denmark, Portugal, and Sweden have the highest indices) and lower in 14 countries (Finland, Austria, Netherlands, Slovak Republic and Spain have the lowest indices). In those education systems, where IBTEACH is higher students report doing experimentation, hands-on activities and are encouraged to develop a conceptual understanding of scientific ideas (OECD, 2016b) more often than in countries where this index is lower.

Perceived feedback (PERFEED) is higher than OECD average in 11 EU countries (the highest index is in Bulgaria, followed by UK, Latvia, Poland, and Lithuania) and lower in 13 countries (the lowest index is in Germany, followed by Finland, Denmark, Austria, and Luxembourg). In countries where this index is

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higher students report that their teachers give feedback (how performing, where strengths and weaknesses are, how to improve performance and reach learning goals) more often than in countries with lower PERFEED.

Table 01. Means and standard errors of study variables and number of observations in EU education systems

Country	PV_SCIE	ESCS	ADINST	IBTEACH	PERFEED	TEACHSUP	*N*
	M*±*SE	***M*±*SE***	***M*±*SE***	***M*±*SE***	***M*±*SE***	***M*±*SE***	
Austria	517.5 ± 2.6	.20 ± .02	-.29 ± .03	-.28 ± .03	-.22 ± .02	-.47 ± .03	5109
Belgium	525.5 ± 2.0	.27 ± .02	-.38 ± .02	-.21 ± .02	-.16 ± .02	-.24 ± .02	7560
Bulgaria	466.5 ± 4.0	.02 ± .03	.23 ± .02	.17 ± .03	.40 ± .02	.07 ± .02	4552
Croatia	487.1 ± 2.5	-.19 ± .02	-.16 ± .02	-.20 ± .02	.05 ± .02	-.33 ± .02	4862
Czech Rep.	504.3 ± 1.9	-.16 ± .01	-.16 ± .02	-.05 ± .02	-.09 ± .02	-.32 ± .02	6114
Denmark	511.9 ± 2.0	.63 ± .02	.28 ± .02	.35 ± .02	-.28 ± .02	.07 ± .02	5932
Estonia	539.1 ± 2.0	.05 ± .01	-.17 ± .02	-.08 ± .02	-.09 ± .02	-.05 ± .02	5230
Finland	538.4 ± 2.3	.27 ± .02	-.01 ± .02	-.30 ± .02	-.28 ± .02	.20 ± .02	5281
France	513.3 ± 1.8	-.07 ± .02	-.29 ± .02	.15 ± .02	-.14 ± .01	-.17 ± .02	5108
Germany	533.2 ± 2.9	.20 ± .02	-.22 ± .02	.06 ± .02	-.29 ± .02	-.39 ± .02	3821
Greece	463.0 ± 3.6	-.05 ± .03	.06 ± .03	-.08 ± .03	.06 ± .03	.04 ± .03	5014
Hungary	486.1 ± 2.8	-.20 ± .02	-.12 ± .02	-.22 ± .02	.01 ± .02	-.30 ± .02	4278
Spain	501.7 ± 2.2	-.47 ± .04	.15 ± .02	-.25 ± .02	.13 ± .02	.08 ± .02	5160
UK	520.4 ± 2.4	.24 ± .02	.16 ± .02	-.01 ± .02	.37 ± .02	.21 ± .02	11810
Ireland	511.0 ± 2.3	.19 ± .02	-.02 ± .02	.01 ± .02	0 ± .02	.08 ± .02	4991
Italy	488.5 ± 2.5	-.05 ± .02	-.07 ± .02	-.21 ± .02	.07 ± .02	-.12 ± .02	9977
Latvia	495.0 ± 1.6	-.43 ± .02	.19 ± .02	.13 ± .01	.25 ± .02	-.05 ± .02	4363
Lithuania	483.2 ± 2.6	-.05 ± .02	-.12 ± .02	.17 ± .01	.19 ± .02	.07 ± .01	5668
Luxembourg	498.0 ± 1.4	.16 ± .01	-.31 ± .01	.13 ± .02	-.19 ± .01	-.32 ± .02	4218
Netherlands	521.0 ± 2.4	.20 ± .02	-.07 ± .02	-.25 ± .02	-.07 ± .02	-.39 ± .02	4075
Poland	505.2 ± 2.5	-.39 ± .02	-.07 ± .02	-.08 ± .02	.21 ± .02	-.17 ± .02	4267
Portugal	507.6 ± 2.9	-.40 ± .03	.54 ± .02	.32 ± .02	.11 ± .02	.47 ± .02	4995
Slovak Rep.	474.8 ± 2.5	-.04 ± .02	-.24 ± .02	-.25 ± .03	-.04 ± .02	-.29 ± .02	5292
Sweden	505.7 ± 3.2	.36 ± .02	.14 ± .03	.30 ± .02	-.03 ± .03	.16 ± .03	4718
Above OECD average		*12*	*8*	*10*	*11*	*10*	
Below OECD average		*12*	*16*	*14*	*13*	*14*	

Note. M – mean; *SE* – standard error; PV_SCIE – science performance; ESCS - student economic, social and cultural status, ADINST – adaption of instruction; IBTEACH - enquiry-based science teaching and learning practices; PERFEED – perceived feedback; TEACHSUP – teacher support; *N* – sample size with non-missing observations in independent variables.

Teacher support (TEACHSUP) is higher than OECD average in 10 EU countries (Portugal, UK, Finland and Sweden with the highest indices) and lower in 14 countries (Austria, Netherlands, and Germany with the lowest indices). In those education systems, where TEACHSUP is higher students report that their

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teachers provide supportive relationship to students in science classes more often than in countries with lower TEACHSUP.

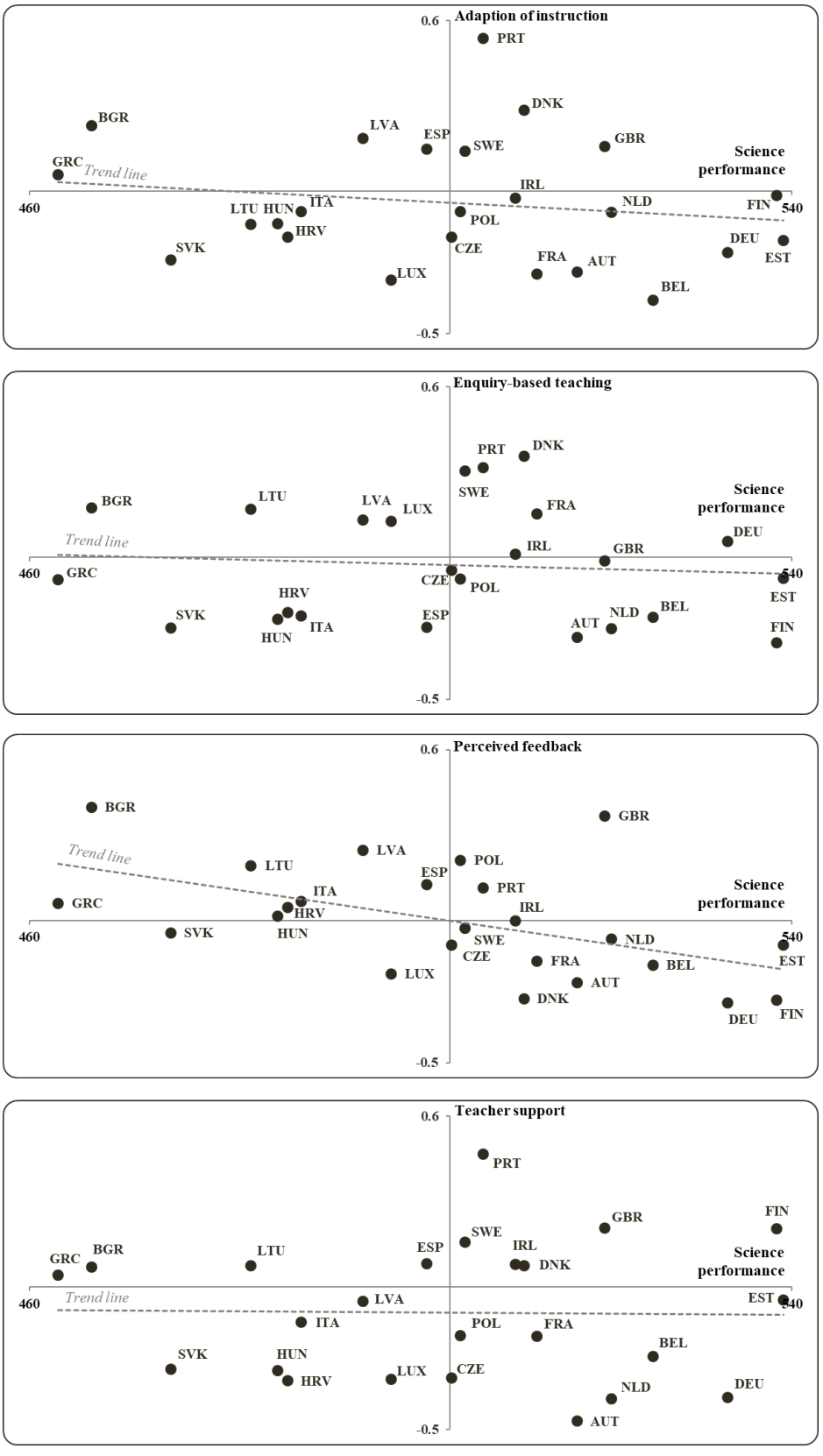

Figure 01. Relationship between teaching practices (adaption of instruction, enquiry-based teaching, perceived feedback, teacher support) and science performance in EU countries. *The values of teaching*

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practices are displayed in the vertical axis, while in the horizontal – the science performance of students in PISA 2015. A trend line indicates the general direction (tendency) of this relationship in each graph.

Figure 1 represents the relationship between teaching practices (ADINST, IBTEACH, PERFEED, TEACHSUP) and science performance in EU countries. From univariate analysis, we see that only perceived feedback (PERFEED) has a clear downward trend in PISA 2015. Other three teaching practices have no obvious association with science performance. We cannot identify clear patterns between EU countries according to the relationship between teaching practices and science performance.

The results of the multivariable regression are reported in Table 2. On average model explain 19% of science performance differences across 24 EU countries. Adjusted coefficient of determination range from .14 in UK and Latvia to .25 in Hungary, Luxembourg, and Bulgaria. ESCS is a significant predictor for all education systems.

As was expected, adaption of instruction (ADINST) significantly contributes to students' performance in all EU education systems. The strongest positive association is in the Netherlands (b=39.52, p<.05), the weakest in France (b=4.35, p<.05). The results indicate that students perform better in science when teachers adapt instructions to students' knowledge, skills and abilities more often. It seems that students' need for competence is satisfied when teachers are perceived as adapting their instructions to students' diverse experience and cognitive preferences. The students' experience that they can be effective in science lessons, therefore they are more likely to engage in learning and their science performance is improving. These results are similar to the ones of Lau and Lam (2017), who analyzed the effectiveness of various instructional practices (adaptive instruction as well) on science performance in 10 top-performing regions. Lau and Lam (2017) established that adaptive instruction positively predicted the science performance in all participating countries; however, only in four Chinese regions and Japan these links were statistically significant. The results of our study reveal that students in all EU countries would benefit from adaptive instruction. However, the extent to which the adaption of instruction is beneficial can be dependent on the education system.

Enquiry-based teaching (IBTEACH) is significantly and negatively associated with science performance in the majority of education systems (17 from 24). Considering the significant results, the strongest association is in Estonia (b=-20.77, p<.05), the weakest is in Croatia (b=-4.37, p<.05). We expected that inquiry based teaching would have a positive effect on science performance, as this teaching practice creates opportunities for students to satisfy the need for autonomy, which should be related with higher motivation for learning science and therefore better performance. However, the results of our study showed the opposite relationship between enquiry-based teaching and science performance. The primary analysis of PISA 2015 conducted by OECD also established the negative links in 56 out of 63 participating countries (OECD, 2016). The negative association between enquiry-based teaching and science performance documented in some secondary analyzes (etc., Lau, Lam, 2017; Chi et al., 2018; Gil-Flores, Garcia-Gomez, 2017) as well. As suggested in PISA 2015 report (OECD, 2016b), teachers who encounter the students' unwillingness to study may be inclined to choose practical science activities in order to enhance their learning motivation. However, in order to be effective, enquiry-based teaching requires students to engage actively and assume responsibility for their learning. Students might be unprepared for that. It seems that the goals of enquiry-based instruction might not be achieved without students' active

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participation. The results of our study indicate that the patterns of effects of inquiry-based teaching on science performance in EU education systems are similar. Still, we cannot claim that enquiry-based teaching is not effective in EU countries, as the effects may be moderated by other student- and class- level factors (Chi et al., 2018, Teig et al., 2018). Further studies are needed to investigate the effect of enquiry-based teaching on achievement considering both the quality of enquiry-based practices and moderators.

Regarding perceived feedback (PERFEED), we obtained the negative association between PERFEED and science performance across all EU countries. The strongest association is in the Netherlands (b=-29.36, p<.05), the weakest in France (b=-10.57, p<.05). These results indicate that perceived feedback is a significant factor for students' performance in science in all EU education systems. However, the direction of this relationship is opposite to the one that was expected. Our results are in line with the results of other studies (OECD, 2016b; Lau, Lam, 2017; Gil-Flores, Garcia-Gomez, 2017). Hattie and Timperley (2007) indicate that the impact of feedback can be either positive or negative. The interpretation of information provided by the teacher and the effect of this information on the satisfaction of the need for competence is based on students' subjective perceptions. The perceived feedback will not be effective if information about learning is not appreciated as constructive. In the view of PISA test design, it is obvious that only the frequency of received feedback was evaluated. We do not have information whether the students perceived the feedback as constructive or not. Therefore, further research is needed to evaluate various aspects of feedback in different education systems.

Table 02. Estimated multivariable linear regression models for EU education systems, estimated parameters, and standard errors

Country	Intercept	ESCS	ADINST	IBTEACH	PERFEED	TEACHSUP	$\overline{R}^2$
	$b \pm SE$	$b \pm SE$	$b \pm SE$	$b \pm SE$	$b \pm SE$	$b \pm SE$	
Austria	506.5±2.45*	39.96±2.3*	9.02±1.72*	-.49±1.78	-19.29±1.8*	-2.56±2.03	.18
Belgium	514.2±1.55*	41.55±1.61*	8.64±1.56*	-.27±1.5	-19.34±1.45*	-1.28±1.55	.20
Bulgaria	470.68±3.06*	36.79±2.06*	21.73±1.85*	-18.66±1.61*	-16.47±2.12*	.15±1.78	.25
Croatia	496.89±2.28*	34.86±1.76*	11.63±1.48*	-4.37±1.44*	-21.23±1.74*	3.04±1.62	.17
Czech Rep.	510.97±1.82*	48.27±1.98*	18.24±1.58*	-4.61±1.86*	-12.6±1.63*	-8.29±1.91*	.21
Denmark	484.57±2.17*	29.61±1.77*	17.54±1.66*	-3.74±2.42	-16.18±1.95*	5.7±2*	.15
Estonia	537.1±1.88*	31.32±1.77*	13.66±1.74*	-20.77±2.01*	-17.45±1.87*	8.44±1.85*	.15
Finland	518.95±2.22*	36.37±2.14*	20.28±1.85*	-6.89±2.05*	-21.45±1.54*	8.52±1.7*	.16
France	516.64±1.73*	51.2±2.07*	4.35±1.66*	-.42±1.98	-10.57±1.52*	.5±1.91	.20
Germany	522.78±2.77*	37.77±1.83*	20.13±1.96*	1.22±2.16	-19.9±2.32*	-3.45±2.14	.20
Greece	463.17±2.82*	31.79±1.76*	16.29±1.89*	-17.01±1.77*	-16.47±1.69*	1.78±1.59	.20
Hungary	496.63±2.52*	42.99±2.12*	12.75±1.91*	-5.32±1.91*	-23.53±1.9*	3.92±1.96*	.25
Spain	513.95±1.88*	26.84±1.11*	10.39±2.03*	-3.36±1.73	-16.65±1.7*	1.52±1.8	.17
UK	512.49±2.18*	36.00±1.69*	19.75±2.3*	-12.41±2.32*	-14.71±1.9*	6.22±1.98*	.14
Ireland	504.32±2.2*	34.96±1.57*	13.26±1.72*	-6.36±2.64*	-14.43±1.67*	3.4±2.08	.15
Italy	490.97±2.3*	29.09±1.61*	15.06±2.08*	-7.57±2.13*	-23.08±1.96*	-.94±1.85	.16
Latvia	509.16±1.47*	25.93±1.6*	15.46±1.98*	-14.39±2.34*	-15.35±1.7*	5.76±2.1*	.14

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Lithuania	491.41±2.17*	34.22±2.1*	14.91±1.9*	-9.74±1.48*	-19.01±1.8*	7.95±1.47*	.17
Luxembourg	493.35±1.65*	38.93±1.18*	14.01±1.52*	-4.94±1.68*	-23.52±1.36*	3.25±1.94	.25
Netherlands	509.03±2.39*	41.28±2.72*	39.52±2.12*	-2.56±1.94	-29.36±2.45*	-9.97±2.44*	.23
Poland	522.05±2.21*	36.94±1.82*	16.55±1.7*	-16.2±1.89*	-11.63±1.58*	.94±1.95	.18
Portugal	515.37±2.65*	34.44±1.87*	19.2±2.02*	-5.56±2.01*	-18.9±1.88*	-.63±1.94	.22
Slovak Rep.	475.63±2.14*	35.52±2.01*	16.11±1.9*	-7.31±1.45*	-16.7±1.76*	-6.62±1.77*	.17
Sweden	489.93±2.33*	39.3±2.09*	21.4±1.92*	-10.47±2.01*	-18.84±2.06*	7.32±2.1*	.18
Positive	*24*	*24*	*24*	*1*	*0*	*16*	
Significant	*24*	*24*	*24*	*0*	*0*	*8*	
Negative	*0*	*0*	*0*	*23*	*24*	*8*	
Significant	*0*	*0*	*0*	*17*	*24*	*3*	

Note. $\bar{R}^2$- adjusted coefficient of determination; *b* – estimated unstandardized regression coefficients; *SE* - standard error; PV_SCIE – science performance; ESCS - student economic, social and cultural status, ADINST – adaption of instruction; IBTEACH - enquiry-based science teaching and learning practices; PERFEED – perceived feedback; TEACHSUP – teacher support; $*p < .05$.

Given the evidence that teacher support (TEACHSUP) provides the opportunities to satisfy students' need for relatedness, we expected that this teaching practice would lead to better science performance. The outcome supports our assumption only partially. A significant association between TEACHSUP and science performance is strongest in the Netherlands (b=-9.97, p<.05) and weakest in Hungary (b=3.92, p<.05). We estimated the positive links between TEACHSUP and science performance in 16 EU education systems, however only in 8 countries (Finland, Estonia, Lithuania, Sweden, UK, Latvia, Denmark, Hungary) those links are statistically significant. Chi et al. (2018) established a positive relationship between teacher support and science achievement in four Chinese regions as well. However, the effect of teacher support, when other personal and school level factors were included in regression, was not statistically significant. Quite unexpectedly, the results proved the negative relationship between teacher support and science performance in 8 EU countries, and in 3 countries (Netherlands, Czech Republic, Slovak Republic) those links were statistically significant. In other words, the more students reported receiving teacher support during science classes the worse was their science performance in these countries. Similar results were in Gil-Flores and Garcia-Gomez (2017) study, where they analyzed the effect of teacher support on science performance together with educational policy and institutional culture factors in Spain. It is not obvious how to interpret negative associations that were obtained. We can assume that the respondents in these countries did not perceive teachers as creating close emotional bonds while offering support. Thus, the results of our analysis show diverse patterns of the association between teacher support and science performance across EU countries.

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Table 03. Groups of EU countries according to the significant association between teaching practices and science performance

1 group	2 group	3 group		4 group	
ADINST (+) PERFEED (-)	ADINST (+) PERFEED (-) IBTEACH (-)	ADINST (+) PERFEED (-) TEACHSUP (-)	ADINST (+) PERFEED (-) TEACHSUP (+)	ADINST (+) PERFEED (-) IBTEACH (-) TEACHSUP (-)	ADINST (+) PERFEED (-) IBTEACH (-) TEACHSUP (+)
Austria	Bulgaria	Netherlands	Denmark	Czech Republic	Estonia
Belgium	Croatia			Slovak Republic	Finland
France	Greece				Hungary
Germany	Poland				UK
Spain	Portugal				Latvia
	Ireland				Lithuania
	Italy				Sweden
	Luxembourg				

Note. (+) positive statistically significant association between teaching practice and science performance; (-) negative statistically significant association between teaching practice and science performance; ADINST – adaption of instruction; IBTEACH - enquiry-based science teaching and learning practices; PERFEED – perceived feedback; TEACHSUP – teacher support.

Summing up the results of the multivariable regression analysis, EU countries might be classified into four groups according to the patterns of significant association between teaching practices and science performance (Table 3). Five countries are grouped into the first group that might be characterized by the effects of two teaching practices – adaption of instruction and perceived feedback (both related with student competence need). The effects of three teaching practices characterize the second and third groups. The groups are similar in the patterns of association between adaption of instruction and perceived feedback but differ in the pattern of association between the third teaching practice and performance. It is a significant association between enquiry-based teaching (related with autonomy need) and performance in the second group (8 countries) and between teacher support (related with relatedness need) and performance in the third group (2 countries). The largest group (9 countries) is the fourth that is defined by significant effects of all four analyzed teaching practices. The analysis suggests that the effects of teaching practices that are related to student competence need are consistent across EU countries. However, the effects of teaching practices related to student autonomy or relatedness need are diverse in EU.

7. Conclusion

Although teaching practices are considered as the most significant factors in explaining students' achievement, each country is making efforts to find more effective ways of teaching science. From the current study we conclude that the prevalence (based on students' reports from PISA 2015) of four student-oriented teaching practices – enquiry-based teaching, adaption of instruction, perceived feedback, and teacher support – is different across EU countries. We observe similar patterns of association for adaption of instruction and perceived feedback (both related with student competence need) with science performance in all EU countries, although adaption of instruction has a positive effect and perceived

feedback - negative. As regards to other teaching practices, we estimate different patterns of effects. Teacher support does not work equally as we obtain both positive and negative effects across EU countries. Enquiry-based teaching is important in the majority of EU countries with a negative effect on science performance. This confirms the differences of the effectiveness of teaching practices in EU learning contexts. One should treat the negative effect of perceived feedback and enquiry-based teaching with caution due to methodological issues in PISA 2015.

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