International Journal of Instruction *October 2019 ● Vol.12, No.4*
e-ISSN: 1308-1470 ● www.e-iji.net *p-ISSN: 1694-609X*
pp. 767-788

Received: 26/01/2019
Revision: 10/07/2019
Accepted: 16/07/2019
OnlineFirst:16/09/2019

Optimizing Teacher Quality Based on Student Performance: A Data Envelopment Analysis on PISA and TALIS

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The present study aims to determine the relative efficiency of 28 countries participated in PISA 2015 and TALIS 2013 based on student performance and teacher quality, and to sort the countries according to their efficiency scores by using a super efficiency model. Moreover, this study attempts to reveal important improvements countries must make in terms of teacher quality to have better results for student performance. Using data of 28 countries from TALIS 2013 for determining the variables of teacher quality and PISA 2015 for student performance, a data envelopment analysis was performed. Four negative attributes of the teachers were included as input variables and students' performance on reading, mathematics and science as output variables in the analysis. According to the research findings, the most efficient countries on the basis of the determined inputs and outputs are Finland, France, Japan, South Korea, Norway, Singapore, while Brazil, Bulgaria, Chile, Czech Republic, Denmark, Iceland, Italy, Latvia, Netherlands, Portugal, Slovak Republic and Spain are inefficient. The potential improvement is required for all input variables, but its amount varies by country. However, a higher rate of potential improvement is needed for developing countries whose populations are younger.

Keywords: teacher quality, student performance, data envelopment analysis, PISA, TALIS, optimization, efficiency analysis

INTRODUCTION

Teaching has been one of the primary professions necessary for the development of individuals and society from the beginning of humanity. Early humans performed teaching to ensure that the meanings and knowledge they gained are passed on to future generations. The intensification of social life with the increasing complexity of

Citation: Mammadov, R., & Çimen, İ. (2019). Optimizing Teacher Quality Based on Student Performance: A Data Envelopment Analysis on PISA and TALIS. *International Journal of Instruction*, 12(4), 767-788. https://doi.org/10.29333/iji.2019.12449a

information has brought this profession to a different level. From this point onwards, teaching has found its place in social engineering as a founding, protective and transforming element of culture. As education became increasingly widespread and turned into a necessity, the need for teachers has increased, and their role in society has started to be questioned (Novoa, 2000; Sedlak & Schlossman, 1986; OECD, 2005). Survived to the present day, that questioning includes many aspects, one of which is the quality of teachers and its effect on students.

Organization for Economic Co-operation and Development (OECD) is one of the critical international organizations seeking an answer to that questioning on the quality and effects of teachers. OECD's main arguments on education emerge from the assessments and reports such as Programme for International Student Assessment (PISA), Survey of Adult Skills (PIAAC), Teaching and Learning International Survey (TALIS) and Education at a Glance. Among these, PISA gives satisfying data on the skills and knowledge of 15-year-old students. Being an extensive assessment, PISA covers the performance of 28 million 15-year-old students from 72 countries in science, mathematics, and reading. PISA operationalizes the term 'student performance' as "*the extent to which 15-year-old students … have acquired key knowledge and skills that are essential for full participation in modern societies."* On the other hand, TALIS provides data about the professional development teachers have received, beliefs and practices of teachers about the teaching, the assessment of their work, and other school leadership, management and workplace issues.

While OECD's data reveals valuable information about teaching and learning, secondary analysis of those data is also used to make an inference about the different aspects of education including relationships between students' performance and other contextual factors by releasing more detailed and multifaceted conclusions (Azigwe, 2016). In this regard, there is much research using OECD's data to comment on teaching and learning in different countries by performing secondary analysis (e.g., Doğan & Yurtseven, 2018; Lafontaine, Baye, Vieluf, & Monseur, 2015; McConney & Perry, 2010; Petko, Cantieni, & Prasse, 2017). However, those kinds of studies analyzing the relationship between student performance and teacher quality are still scarce and not so conclusive. Moreover, studies showing efficient countries in teacher quality and trying to make optimization for other countries accordingly are little if any. That disparate indicates a need for more research studies employing different approaches. Therefore, the present study aims to optimize teacher quality by analyzing relevant data of PISA and TALIS with non-parametric methods. In this regard, those research questions below were answered:

1. Which participating countries in PISA and TALIS are efficient in terms of teacher quality and student performance?
2. Which variables related to teacher quality needs to be optimized for better student performance?

As the development of student performance is the main goal of many schools around the world, and student performance was found to be related with teacher quality, this study reveals promising results for the policymakers about what precautions may be taken within the context of teacher quality. Moreover, by using a secondary analysis of big

data, the authors hope to reveal more satisfying and detailed information to be used in the next research and other studies on teacher quality and student performance. The existing studies in the literature generally attempted to explain the relationship between the teacher quality and student performance by using positive attributes of teachers (e.g., Ascher & Fruchter, 2001; Doğan & Yurtseven, 2018; Förtsch et al. 2016; George et al., 2017; Metzler & Woessmann, 2010; Yoon et al., 2007). However, there are a few studies that reveal insights on how negative attributes of teacher quality can affect student performance and most of them focus on teacher turnover, burnout or attrition (see, Adnot, Dee, Katz & Wyckoff; Borman & Dowling, 2017; Ronfeldt, Loeb & Wyckoff, 2013) In this research, unlike the studies in the literature, an efficiency analysis was conducted on the basis of the level of effect of teachers' negative qualification indicators on student performance. This study also differs from others with its sample and population as it counts on a large-scale data of PISA and TALIS. Moreover, the present study reveals more generalizable results as it simultaneously analyses the data of different countries and compares them according to their efficiency. Authors anticipate that those results can inform the inefficient countries about the negative attributes of teacher quality that they need to improve by benchmarking the efficient ones.

Teacher Quality

Teacher quality sides with many positive outcomes for schools and overall society. Above all, it is regarded as an indispensable part of school improvement and student performance (Hopkins, 2001). It is highly emphasized by focusing on the ability of teachers in using professional skills to create productive learning environments, to establish expectations for students, to plan for success and to develop efficient learning outcomes in the school development frameworks created by different organizations (ACT Government, 2009; ACER, 2012; MDE, 2014). There are empirical findings of much research relating teacher quality with student performance (Rockoff, 2004; Nye, Konstantpoulus, & Hedges, 2004; Rothstein, 2010; Harris & Sass, 2011). Moreover, teacher quality becomes more vital, especially when it comes to improving the performance of underachieving students (Ascher & Fruchter, 2001; Mincu, 2015; Stipek & Chiatovich, 2017). Additionally, teacher quality was found to be a contributing asset to the economic condition of a country (Lakdawalla, 2006; Hanushek, 2011).

Although the importance and the results of teacher quality are highly emphasized in the literature, there is no consensus about what it includes. For this reason, definitions and explanations of teacher quality vary according to different approaches. Strong (2011) associates teacher quality with (i) qualities reflecting teacher competence such as graduation type and grade, certificates for development and experience, (ii) individual and psychological attributes of teacher such as warm-heartedness, honesty, commitment, and fairness, (iii) standards in teaching such as using different techniques and approaches, classroom management skills and creating a favorable classroom climate, (iv) contribution to students' learning by employing efficient and successful teaching. Likewise, Kennedy (2008) explains teacher quality as comprising cognitive sources which include knowledge, belief, and attitudes of a teacher, performance displayed by a teacher in the classroom and the effects of these two instructional factors on students. In

his literature-based implications, Rice (2003) presents the constitutive expression of teacher quality as teacher experience, preparation programs, and degrees, certification process of teachers, coursework taken in preparation for teaching and test scores of teachers. Similarly, Darling-Hammond (2000), identifies teacher quality with measurements of academic ability, the background of teachers, teaching experience, subject matter and teaching knowledge, certification of teachers, and behaviours of the teacher in the classroom.

Based on the literature, teacher quality may be examined by dividing it into two categories such as teacher training and teacher practice, which Lewis et al. (1999) did. They emphasized two essential dimensions of teacher quality as (1) teacher training that defines how a teacher acquires his/her professional skills and which learning processes he/she undergoes, and (2) teacher practices connected mostly with the qualities reflected from the in-school actions of a teacher. Teacher training is important in terms of determining the qualitative characteristics of the teacher when he/she first steps into the profession. It depends on the qualified training and courses a teacher takes (Hanushek, 2011). On the other hand, teaching practices highlight aspects of a teacher related to the students, classroom, and management dimensions. Therefore, teaching practices are associated mostly with instruction and instructional quality.

In most studies, the quality of teaching practices, in other words, instructional quality, was communicated with three dimensions: effective classroom management, individual learning support, cognitive activation (Warwas & Helm, 2018). Effective classroom management is a teacher's ability to orchestra students in different situations within the classroom. It is to ensure that interruptions in the classroom and disciplinary problems are prevented from occurring beforehand, and most of the time is devoted to the learning process (Garrett, 2014). Individual learning support refers to creating a supportive and positive climate in the teaching-learning process, being sensitive to students' needs and differences, caring and encouraging (Hamre & Pianta, 2005; Warwas & Helm, 2018). Cognitive activation is about the qualification of teachers in revealing students' cognitive potential. The activation aims to provide the students with problem-solving situations, thus creating the environments in which they evaluate, associate, and apply the information and stimulate higher-order thinking (Baumert et al., 2010).

All of the discussion about teacher quality seems to aim at improving student performance. Whether the discussions depend on teacher training or teaching practices, the targeted output is improved student performance. Therefore, there is much research investigating how the quality of teachers can affect students.

Student Performance

The development of students' academic knowledge, skills, talent and competence is directly related to their performance. Performance is an effort of students to transfer the learning experience to real-life situations through cognitive, affective and psychomotor skills such as research, critical thinking, decision making, creativity and problem solving (Akay & Küçükkaragöz, 2016). Therefore, according to Kapur (2018), student performance is a determinant of students' goals and objectives for the future.

In educational institutions, numerous factors may affect the performance of students. Observations that reveal student performance may include classroom participation, classroom and homework assignments, exams, and other activities. These activities are also related to school management, teacher, family and environmental factors. As a result of these relationships, strategies focusing on better student performance are developed, and they serve as a motivating factor in encouraging extra classes for students, introducing effective teaching-learning methods and teaching strategies, using technology, employing the rewarding mechanisms (Nyagosiya, 2011). However, one of the most important factors in student performance is about the quality of teachers (Darling-Hammond, 2000), as the positive behavioral and cognitive changes are directly related to having more qualified teachers or not (Kapur, 2018).

Teacher Quality and Student Performance

Goe (2007) frames teacher quality as qualifications and characteristics of a teacher which influence his/her instruction process and eventually student outcomes. Therefore, most research heavily associates teacher quality with the performance of students (Hanushek & Rivkin, 2006). That kind of association stems from outcome-based measurements in which quality equates increasing student performance. The empirical findings of the relevant research can be analysed under four different groups as (i) teachers training and preparation, (ii) subject matter knowledge (SMK), (iii) classroom management, and (iv) cognitive activation.

According to the findings of Darling-Hammond (2000), teacher preparation and certification type are the strongest predictors of student performance. Goldhaber and Brewer (2000) analysed the comparison between teachers with probationary certification, emergency certification, private school certification or no certification in the subject matter and teachers with standard certification. They found that teachers with standard certification have a more positive impact on student performance. As teacher preparation and certification may continue in-service, there are also findings supporting that teachers' participation in professional development activities brings out better student performance (Diamond, Maerten-Rivera, Rohrer, & Lee, 2014; Vescio, Ross, & Adams, 2008; Yoon, Duncan, Lee, Scarloss, & Shapley, 2007).

While the answers to the question of what SMK teachers need to know are still contradictive, it is a commonly-held assumption that SMK is essential for students' performance. In the end, teachers help students in learning, and they need to possess an understanding of what to be taught (Houston, 1990). In this regard, there is much research examining how SMK of teachers affect students' learning and revealing the importance of SMK (e.g., Diamond et al., 2014; Metzler & Woessmann, 2010; Hill & Chin, 2018; Olasehinde-Williams, Yahaya, & Owolabi, 2018).

There has been a consensus that effective classroom management is another predictor well worth the attention for student performance since the 1980s (Brophy, 2006). In this regard, teachers' verbal instruction, corporal punishment usage, instructional supervision or delegation of authority to students may affect students academic performance (George, Sakirudden, & Sunday, 2017). For example, as Kane, Taylor, Tyler, and Wooten (2010) pointed out in their research, student performance will grow

more for students whose teacher is relatively better than his peers at classroom management. Freiberg, Huzinee, & Templeton (2009) also found in their 2-year period study that students whose teachers employed more effective classroom management had better results for reading in 64 % and mathematics in 67 % than other students.

Cognitive activation of teachers includes their ability to employ reasoning, problem-solving, critical thinking strategies to enhance students' performance. This ability of teachers provides opportunities for students to activate their cognition and increase their problem-solving abilities (Stigler & Hilbert, 2004). Some empirical studies provided evidence on the positive effect of cognitive activation on students' performance. For example, Förtsch, Werner, von Kotzebue and Neuhaus (2016) showed that there was a positive and significant effect of cognitive activation on students' learning and it could predict 15 % of the variance in students' performance. Other studies such as Baumert et al. (2010), Grönqvist & Vlachos (2016) and Kunter et al. (2013) also provide additional evidence.

METHOD

Research Model

This research is modeled based on the cost-benefit analysis, and access to the optimum point is designed with input minimization on the basis of non-parametric model. A mathematical function-based method was preferred to analyse the efficiency of countries and make optimization for teacher quality. In general, mathematical function-based research employs parametric techniques analyzing *multiple inputs* and *single output* variables. However, there were *multiple input and output* variables in the present study, which necessitates using nonparametric techniques to include all the determined variables (Baysal & Toklu, 2001). For analyzing the efficiency and making optimization with nonparametric techniques, the Data Envelopment Analysis (DEA) is one of the most commonly used tools. It is due to the fact that instead of a specific production function, DEA can perform optimization by using linear programming based on the variables of the most efficient unit (Fanchon, 2003).

DEA, which was introduced by Charnes, Cooper, and Rhodes as a mathematics-based research method in 1978, allows measuring the relative efficiency of Decision-Making Units (DMU) (Kuah, Wong, & Behrouzi, 2010). It also enables to identify the inactive benchmarks of DMUs and reveal their potential to reach an efficient level (Cook & Seiford, 2009). There are two kinds of DEA as (1) constant returns to scale model (CCR) and (2) variable returns to scale model (BCC). The model developed by Charnes, Cooper and Rhodes (1978) is known as the constant returns to scale model in which the potential improvement amount in the input variable causes a change in the output at the same level. In the variable returns to scale model developed by Banker, Charnes and Cooper (1984), the potential improvement in the input variable has a variable effect on the output (Ruggiero & Bretschneider, 1998). Additionally, there are models labeled as input oriented and output oriented. It is aimed to determine minimum input for the current output level in the input-oriented model, while a maximum output analysis is performed for the current input in the output-oriented model (Cooper, Seiford, & Tone, 2000).

As the student performance is mostly considered as an output for educational institutions (EUROPEAN COMMISSION, 2001), it will be more appropriate to make changes in the variables affecting it.

Sample and Population

The sample of the research covers the countries participated in PISA 2015 and TALIS 2013. Therefore, countries were selected as decision-making units. While determining the population of the study, authors choose the countries whose input variables were also available. Consequently, the countries having information about output variables but not about input variables were excluded. Table 1 shows 28 countries included in the population of the study.

Table 1
The population of the Research

No	DMU	No	DMU	No	DMU	No	DMU
1	Australia	8	Estonia	15	Korea	22	Romania
2	Brazil	9	Finland	16	Latvia	23	Singapore
3	Bulgaria	10	France	17	Mexico	24	Slovak Republic
4	Chile	11	Iceland	18	Netherlands	25	Spain
5	Croatia	12	Israel	19	Norway	26	Sweden
6	Czech Republic	13	Italy	20	Poland	27	England (United Kingdom)
7	Denmark	14	Japan	21	Portugal	28	United States

Source: OECD (2014; 2018)

The countries in Table 1 are participating countries to both TALIS 2013 and PISA 2015. Thus, the entire universe was included in the study based on the input and output variable.

Data Set

The research was conducted based on OECD data, and it includes a secondary analysis of two large-scale data sets, TALIS-2013 and PISA-2015. For input and output variables, the data of TALIS-2013 and PISA-2015 were employed, respectively.

Therefore, as stated in the literature and in the introduction part of the present study, some attributes of teacher quality (input) is related to student performance (output) such as to be able to use educational technologies, to be aware of professional responsibility, to have subject matter knowledge, to support the development of students according to their individual differences, to prepare convenient materials for introduction, to have a student-centered approach, to have thematic approach skills, to use alternative measurement and evaluation methods, to give satisfying and constructive feedback to students, to communicate with families, to manage the classroom efficiently, to provide counseling to students, to co-operate with colleagues, to provide positive learning environment (Arslan & Özpınar, 2008; Demirci, 1993; Özdemir, 2016; Wolf et al., 2004). Therefore, variables matching to those attributes in the TALIS-2013 and PISA-2015 were selected as input and output variables.

The negative attributes of teacher quality of the 28 countries were selected as input variables, and PISA 2015 success rate of the students in the level of 6 in reading, science and mathematics as output variables in the study. Level 6 was specially selected

as it shows the ability of students to use their school-based learnings at the top level. Thus, the model was established to determine the level of efficiency of the teachers based on the negative qualification indicators of the teachers and the ability of the students' performing at the top level. The data and the source used in the research are presented in table 2.

Table 2
Input and Output Variables

Variables	Explanation	Source
O1	15-year-old students who are top performers only in reading at PISA 2015 (Reading success)	Programme for International Student Assessment (PISA) 2015
O2	15-year-old students who are top performers only in science at PISA 2015 (Science success)	
O3	15-year-old students who are top performers only in mathematics at PISA 2015 (Mathematics success)	
I1	The percentage of teachers that are not precisely master in their field. (SMK)	The OECD Teaching and Learning International Survey (TALIS) 2013
I2	Percentage of teachers who did not undertake some professional development activities in the previous 12 months (Certification and Development)	
I3	The percentage of teachers considering curriculum as more important than thinking and reasoning process of students (Cognitive Activation)	
I4	Percentage of teachers who can't provide class silence in a short time in the classroom (Classroom Management)	

Note: 'O' for output and 'I' for input variables

The research was modeled on three inputs and six output variables from 28 countries. Input variables included in the study were used for the year 2013 data and output variables were selected for 2015. The assumption for this choice is the continuity of education and the fact that the qualifications of teachers will not change in a short time. At the same time, because the input variables are lower secondary education variables, it is accepted that the students who are educated by these teachers took the PISA exam in 2015.

Analysing the Data

Both the CCR and the BCC model were used to determine the efficacy score in the study. The main aim here is to select an efficient model for revealing the potential improvement after determining the efficiency score. The research was carried out with DEAP-XP 2.1 and EMS 1.3 package programs.

FINDINGS

An input-oriented model was established based on the variables included in the study. As the effect of teacher quality on student performance was taken as a basis, it was aimed to achieve maximum output with the minimum input of selected variables. Table 3 shows the efficiency scores of the DMUs in both constant and variable models.

Table 3
Efficiency Scores of Countries

No	DMU	CCR	Benchmarks	BCC	Benchmarks	Scale
1	Australia	1,000	-	1.000	-	crs
2	Brazil	0,139	5, 11	0.349	5, 23	irs
3	Bulgaria	0,574	15, 14, 9, 5	0.833	23, 5	irs
4	Chile	0,276	9	0.574	5, 23	irs
5	Croatia	1,000	-	1.000	-	crs
6	Czech Republic	0,755	14, 15, 9, 5	0.821	20, 14, 23, 5,	irs
7	Denmark	0,739	9, 14, 15, 5	0.830	5, 23, 14, 20	irs
8	Estonia	1,000	-	1.000	-	crs
9	Finland	1,000	-	1.000	-	crs
10	France	0,806	5, 20	1.000	-	drs
11	Iceland	0,614	5, 23, 12, 9	0.688	5, 23, 9, 12	irs
12	Israel	1,000	-	1.000	-	crs
13	Italy	0,900	15, 14, 20	0.945	23, 20, 5	irs
14	Japan	1,000	-	1.000	-	crs
15	Korea	1,000	-	1.000	-	crs
16	Latvia	0,639	23, 28, 5, 8	0.759	23, 5	irs
17	Mexico	0,061	23, 20, 5	0.727	23, 5	irs
18	Netherlands	0,907	8, 23, 20	0.908	9, 23, 20, 8	irs
19	Norway	0,787	9, 5	1.000	-	drs
20	Poland	1,000	-	1.000	-	crs
21	Portugal	0,729	23, 12, 9, 5	0.796	5, 23, 9	irs
22	Romania	0,518	20, 14, 5	1.000	-	irs
23	Singapore	1,000	-	1.000	-	crs
24	Slovak Republic	0,504	15, 14, 23	0.781	5, 23	irs
25	Spain	0,429	5, 23, 9, 12	0.534	5, 23	irs
26	Sweden	0,811	14, 15, 9, 5	1.000	-	drs
27	England (UK)	1,000	-	1.000	-	crs
28	United States	1,000	-	1.000	-	crs
MEAN		**0,757**		**0,877**		

Note: Calculated by the DEAP-XP

According to the findings in Table 3, the number of countries with efficient variables in the constant model is 11. In the variable model, the number of efficient countries is 15. Both of the variable and fixed models have reduced efficiency in France, Norway and Sweden, while other countries yield stable results. Inefficient countries are 17 in the CCR model and 13 in BCC model. All of these countries have increased returns to scale. Mexico has the lowest efficiency rating in the CCR model, while Brazil is the lowest in the BCC model.

According to another finding in Table 3, there is a constant return to scale (crs) in Australia, Croatia, Estonia, Finland, Israel, Japan, Korea, Poland, Singapore, England (United Kingdom), and the United States. France, Norway, and Sweden, on the other hand, assume the decreasing returns to scale (drs). Other countries have increasing returns to scale (irs). In countries with fixed returns, 1% improvement in teacher quality affects student performance at the same rate. 1% improvement in teacher performance in countries with decreasing returns has a lower positive effect on student performance. In the case of increased returns, the improvement in teacher quality has an impact on student performance by more than 1%.

Super efficiency scores of DMUs were determined in the next stage. The purpose of this analysis is the proportional calculation of the level values of the countries with an efficiency score. Table 4 presents the findings of the super efficiency scores of DMUs.

Table 4
Super Efficiency Scores of Countries

No	DMU	Score (%)	Benchmarks
1	Australia	279,46	
2	Brazil	34,90	5 (0,81), 23(0,19)
3	Bulgaria	83,38	5 (1,00)
4	Chile	57,40	5 (0,37), 23 (0,63)
5	Croatia	171,64	
6	Czech Republic	82,18	5 (0,73), 14 (0,05), 20 (0,12), 23 (0,09)
7	Denmark	83,05	5 (0,20), 14 (0,07), 20 (0,62), 23 (0,11)
8	Estonia	120,73	
9	Finland	big	
10	France	big	
11	Iceland	68,87	5 (0,03), 9 (0,20), 12 (0,04), 23 (0,63)
12	Israel	133,50	
13	Italy	94,57	5 (0,17), 20 (0,58), 23 (0,25)
14	Japan	big	
15	Korea	big	
16	Latvia	75,82	5 (0,80), 23 (0,20)
17	Mexico	72,86	5 (1,00)
18	Netherlands	90,53	8 (0,43), 20 (0,46), 23 (0,50)
19	Norway	big	
20	Poland	191,86	
21	Portugal	79,54	5 (0,15), 9 (0,35), 23 (0,50)
22	Romania	124,02	
23	Singapore	big	
24	Slovak Republic	78,11	5 (0,70), 23 (0,30)
25	Spain	53,37	5 (0,61), 23 (0,39)
26	Sweden	101,61	
27	England (UK)	110,10	
28	United States	135,92	

Note: Calculated by the EMS

When Table 4 is examined, the countries with the highest value are Finland, France, Japan, South Korea, Norway, and Singapore. These countries achieve maximum output with data input. In other words, students' performance levels are maximum with teachers of existing negative qualification indicators.

According to another finding in table 4, the first numbers in the fourth column (Benchmarks column) are the country's sequence number. The number in parentheses indicates the ratio of the reference. Accordingly, Croatia is the most referenced country. It is a reference point especially for the developing countries. For example, for Bulgaria, it is the country that needs to be 100% reference, but only 3% for Iceland. In other words, inefficient countries indicate that they should reference the data from Croatia in order to minimize their inputs.

Based on the findings in Table 3 and Table 4, the optimization proposition has been developed for inefficient countries. This proposal is calculated by the changes to be made on inputs based on reference countries. The findings are given in Table 5 based on

the BCC model. Since the effect of the selected variables is dealt with as quality, there is a possibility that the output is one unit and the output is more or less than one unit.

Table 5
Original and Projected Values in Inefficient Countries

DMU	Value	Input Variables				Output Variables		
		I1	*I2*	*I3*	*I4*	*O1*	*O2*	*O3*
Brazil	Original	27,40	8,50	30,30	53,30	0,20	1,00	0,40
	Mov. %	*-71,50*	*-65,06*	*-71,29*	*-65,10*	*300*	*139*	*860*
	Projected	7,81	2,97	8,70	18,60	0,80	2,39	3,84
Bulgaria	Original	9,70	14,80	33,70	17,30	0,50	1,50	2,00
	Mov. %	*-47,73*	*-78,38*	*-70,98*	*-16,70*	*22*	*73,34*	*2,5*
	Projected	5,07	3,20	9,78	14,41	0,61	2,60	2,05
Chile	Original	31,00	28,30	59,60	49,00	0,30	1,40	0,60
	Mov. %	*-54,71*	*-91,34*	*-88,74*	*-42,63*	*310*	*36,43*	*1216,6*
	Projected	14,04	2,45	6,71	28,11	1,23	1,91	7,90
Czech Republic	Original	37,80	17,50	36,50	20,20	0,80	2,10	3,50
	Mov. %	*-80,58*	*-76,23*	*-70,05*	*-17,82*	*0*	*15,71*	*0*
	Projected	7,34	4,16	10,93	16,60	0,80	2,43	3,50
Denmark	Original	36,30	13,60	73,90	21,30	0,90	1,80	5,10
	Mov. %	*-80,08*	*-56,18*	*-80,78*	*-16,95*	*0*	*27,78*	*0*
	Projected	7,23	5,96	14,20	17,69	0,90	2,30	5,10
Iceland	Original	45,10	8,90	31,80	46,90	0,40	2,20	5,20
	Mov. %	*-61,35*	*-31,12*	*-79,43*	*-31,15*	*320*	*0*	*54,81*
	Projected	17,43	6,13	6,54	32,29	1,68	2,20	8,05
Italy	Original	22,10	24,60	30,90	21,80	0,40	2,20	5,90
	Mov. %	*-65,25*	*-80,81*	*-61,46*	*-5,46*	*125*	*0,46*	*0*
	Projected	7,68	4,72	11,91	20,61	0,90	2,21	5,90
Latvia	Original	10,40	3,90	40,50	26,80	0,70	1,80	2,30
	Mov. %	*-24,13*	*-24,10*	*-78,57*	*-30,15*	*14,29*	*32,23*	*69,13*
	Projected	7,89	2,96	8,68	18,72	0,80	2,38	3,89
Mexico	Original	23,20	4,40	56,20	19,70	0,00	0,20	0,20
	Mov. %	*-78,45*	*-27,28*	*-82,92*	*-27,31*	*60000*	*1200*	*900*
	Projected	5,00	3,20	9,60	14,32	0,60	2,60	2,00
Netherlands	Original	12,30	6,80	34,70	64,20	1,40	2,10	5,00
	Mov. %	*-9,27*	*-9,26*	*-63,95*	*-66,62*	*0*	*7,62*	*0*
	Projected	11,16	6,17	12,51	21,43	1,40	2,26	5,00
Portugal	Original	21,50	11,50	34,40	39,90	1,00	2,50	4,60
	Mov. %	*-20,46*	*-24,43*	*-79,42*	*-22,16*	*90*	*0*	*49,13*
	Projected	17,10	8,69	7,08	31,06	1,90	2,50	6,86
Slovak Republic	Original	27,70	26,70	44,70	26,90	0,60	0,90	4,40
	Mov. %	*-66,10*	*-89,40*	*-81,65*	*-21,93*	*50*	*151,12*	*10,46*
	Projected	9,39	2,83	8,20	21,00	0,90	2,26	4,86
Spain	Original	29,70	15,70	37,00	43,00	0,80	2,10	3,10
	Mov. %	*-64,11*	*-82,61*	*-78,92*	*-46,63*	*25*	*3,34*	*83,87*
	Projected	10,66	2,73	7,80	22,95	1,00	2,17	5,70

Note: Calculated by the DEAP-XP

According to the findings in Table 5, it is recommended to reduce all DMUs as a potential improvement in all input variables. As it is known, the selected input variables are negative qualities of teachers. For inefficient countries to become more efficient, it is necessary to provide an improvement in all of the negative qualities of teachers.

Especially in developing countries, this improvement rate is higher than in other inefficient countries. A reduction of 80,58% is recommended for the Czech Republic, based on the first input variable. According to the second input variable, 91,34% and third input variable 88,74% for Chile, 66,62% for the Netherlands based the fourth input variable is recommended. That is, inefficient countries should not only minimize the input variables but also improve the output variables so that it will become an efficient country.

DISCUSSION

The results of the present study show efficient countries on teacher quality and reveal a starting point on how to reach the same level for efficient ones. It is not possible to eliminate all of the negative attributes of teachers to have better student performance. However, this study provides information on possible rates of the elimination for some basic attributes. While the rates may vary from country to country based on their efficiency in relevant variables, one can conclude what precautions need to be taken according to the findings.

First of all, the percentage of teachers that are not precisely master in their field, in other words, teachers with limited subject matter knowledge has negative impacts on countries efficiency score. As subject matter knowledge is a key factor for teacher quality and student performance relationship (Diamond et al., 2014; Metzler & Woessmann, 2010; Hill & Chin, 2018; Houston, 1990; Olasehinde-Williams et al., 2018), countries pay specific attention to improve their teachers' subject matter knowledge. It is a widely accepted idea that a teacher having limited competence on what to teach cannot help student learning in an efficient way (Houston, 1990). Moreover, the subject matter of knowledge of teachers affects their trust in their teaching and teaching practices (Harlen & Holroyd, 1997; National Research Council, 2007). In terms of this variable, it is seen that Brazil, Czech Republic, Denmark and Mexico need more improvement. As according to DEA optimization findings, the optimization recommendation rate in these countries is over 70 %.

Secondly, it has been concluded that teachers who did not do some professional development activities in the previous 12 months or expressed differently, negatively affect student performance and thus the efficiency of countries. This result found that teachers' professional development is an important factor in student performance and is important for the efficiency demonstrated by previous research findings (Darling-Hammond, 2000; Goldhaber & Brewer, 2000). In furtherance, Maurer (2000) emphasizes that the primary focus of professional development will ultimately improve student learning and this can only be achieved through continuing education and development. In Bulgaria, Chile, the Czech Republic, Italy, the Slovak Republic and Spain, which are inefficient in terms of the second variable, the optimization proposal is over 70%. Therefore, it is a priority for these countries to put more emphasis on the second input variable than other inactive countries.

The third variable is the percentage of teachers who think that the curriculum is more important than students' thinking and reasoning process. In other words, it is the proportion of teachers who believe that the implementation of the curriculum is more

important than communication and feedback with students. However, cognitive activities are needed to improve student performance. Here, cognitive activation refers to the use of practices that can force students to motivate and encourage high-level skills such as critical thinking, problem-solving and decision-making. This strategy not only encourages students to find creative and alternative ways to solve problems, but also allows them to share their thinking processes and results with their peers and teachers. (OECD, 2016). According to the DEA optimization findings, this variable is more important in improving student performance for all inefficient countries except Italy and the Netherlands. It can be said that the reason for this negative situation is that teachers avoid student-based plan and preparation for each lesson. The existence of this situation in the vast majority of inefficient countries can be expressed based on the OECD (2016) report. According to the report, less than half of teachers give different studies and assignments for students who have difficulty in learning and can progress rapidly. The rest approaches the whole class at the same level, not student-based.

The fourth input variable, the proportion of teachers who could not provide silence in the classroom in a short time, leads us to discussions of classroom management and student performance. Korpershoek et al. (2016) divide intervention programs for classroom management into four categories as teachers' behaviour-focused, teacher-student relationship-focused, students behaviour-focused and students social-emotional development-focused interventions. Since the results of this study show the percentage of teachers who cannot provide silence in a short time, teachers' behavior-oriented intervention to improve classroom management in order to maintain order, to present rules and procedures and to maintain discipline is addressed. Indeed, many studies have focused on teachers' classroom management skills to achieve better student performance (Freiberg et al. 2009; George et al. 2017). Besides, according to the findings of Dicke, Elling, Schmeck, & Leutner (2015), that kind of intervention becomes more important for beginning teachers who face a reality shock in their first years. Classroom management is particularly important for Brazil and Netherlands. Because the rate of change in DEA optimization findings for Brazil and the Netherlands are above 60%.

In terms of the importance of the research, it is important to discuss the findings one by one. For this reason, in terms of inefficient countries, the results determined are evaluated based on literature. Guimaraes et al. (2014) agree to this finding and state that there is a need for greater sources to increase the subject matter knowledge of teachers in Brazil. According to the OECD (2015) report, 25% of teachers in Brazil did not complete the teacher-education program. At the same time, 50% of teachers received formal pedagogical training for all subjects they taught. Moreover, they receive less feedback from external institutions or other teachers than the classroom observations required for teachers 'classroom management and students' performance development. The fact that approximately one-quarter of the teachers did not complete the teacher-education program is explanatory of these findings.

Shewbridge et al. (2016), state that in the Czech Republic, teachers have low status in society. At the same time, low salaries and poor working conditions negatively affect teachers' motivation and for this reason the profession is not attractive for highly qualified candidates. Moreover Santiago et al. (2012) point out that there is no unified

approach in teacher evaluation and that there are no standards and criteria for systematic evaluation. Inadequate mentoring training is negatively reflected in the professional development of teachers. Because teachers can not receive feedback about their teaching and can not turn to professional development (Kašparová, 2014). So, it can be said that insufficiency of teacher standards in the Czech Republic and the failure of the teacher assessment system to form a career basis have a negative effect on the subject matter knowledge of teachers (Janík, Spilková & Píšová 2014).

The PISA exam has influenced educational policies for Denmark, triggering the development of national testing systems. As a result of the reform studies initiated in 2007, radical school reform changes were realized in 2014 (Sortkær, 2015). In contrast to the existing curriculum, the new curriculum defines learning outcomes in terms of student competence. Despite the change in curricula, it has been found that teachers' knowledge and skills or self-efficacy necessary to carry out such teaching activity are still open to improvement (Clausen,2016). The problems of teachers' adaptation to changing curriculum support the findings.

In Mexico, there are fewer teachers in secondary education than in higher education. For this reason, teachers generally work in several schools on a part-time and hourly basis. In this case, it can be said that teachers do not teach in some classes (Santibañez, 2006). About one quarter of teachers in the country state that they are not prepared to provide education. In addition, the majority of them do not receive feedback and mentoring support from institutions (OECD, 2016). In particular, teachers working in several schools and low motivation may cause them not to dominate the given educational content and this situation has a negative impact on student performance.

The average age of teachers in Bulgaria is 47 years (OECD, 2016). This may indicate that the vast majority of teachers provide education in the old Communist approach and the difficulties in transition to the new system. Beginning in the 90s, education reforms were implemented. One of these reforms is the development of teachers' training and performance evaluation system between 2011-2014. As a matter of fact, it was stated that the professional development of teachers is needed in this program. For this reason, it is aimed to provide professional development to teachers by continuously developing existing knowledge, gaining new skills, adopting new education and training methods, working skills in an intercultural environment, using ICT technologies, research activities, foreign language, adult education and other subjects (European Comission, 2018). These indicators, which exist in the literature, support the findings obtained from the research. Because according to the research findings, the proportion of teachers in Bulgaria who do not participate in professional development programs in the last 12 months should be reduced. The situation expressed for Bulgaria can also be said to apply to Chile. Because the average age of teachers in Chile is 41 years (OECD, 2016). Considering the age factor, the professional development of teachers is important. As a matter of fact, the 'Teachers' Development System Law' was adopted in April 2016 and put into effect gradually until 2026. It is aimed to involve all teachers in Chile in the professional development process (Santiago, 2017). With this application, professional development of teachers can be supported and positive effect on student performance can be achieved. It was also concluded that for Italy and the Slovak Republic, teachers

remained inadequate for their professional development and this had a negative impact on student performance. As a matter of fact, the situation which is valid for Bulgaria and Chile is valid for both countries. Because the average age of teachers in Italy is 49, 43 in the Slovak Republic (OECD, 2016). Age status is a common variable in countries where teachers need professional development support.

The situation in Spain has some similarities to the Czech Republic. According to the OECD (2016) report, in Spain, as in the Czech Republic, the majority of teachers do not receive feedback. They also do not observe the classes of other teachers. Furthermore, 59% stated that they did not receive mentoring support. This hinders their professional development. As a matter of fact, they stated that they could not get support in accessing professional training.

It is concluded that the situation in the Netherlands needs to be corrected in terms of the fourth variable. Accordingly, teachers spend more time in maintaining order in the classroom. The finding is consistent with the OECD (2016) report. According to this report, student absenteeism is 53% weekly. Three quarters of the teachers work in schools with late students. As a result of absenteeism and late arriving in class, it is possible that the in-class education and training activities will be interrupted. Although this situation is seen as teacher-based, it can be said that it is actually from school management and students.

CONCLUSION

In the macro level, educational policies aim to improve the socio-economic level of society and welfare of states (OECD, 2005). Teachers are one of the primary sources for achieving this goal (Hanushek, 2011), and increasing teacher quality is a key element for successful educational systems (Schleicher, 2011). Many states around the world press this issue to provide better education to their citizens, and thus, to have much more preferable place in the competitive landscape of the world's economy (West, 2012). In recent years, one of the primary sources used for those efforts to become more eligible in the educational and economical arena have been education indicators of OECD. Those indicators also provide a basis for monitoring teacher quality and benchmarking, especially for developing and undeveloped countries. As a contribution to such basis, this study aimed to determine the relative efficiency of 28 countries participated in PISA 2015 and TALIS 2013 on the basis of student performance and teacher quality and to optimize the teacher quality based on student performance. An input-oriented BCC model of DEA-based analysis were preferred for those aims. Teachers' SMK, Certification and Development, Cognitive Activation, and Classroom Management were included as input variables of teachers' negative attributes. As the output variable, top performers were included in the research according to the different areas of the PISA exam.

When the findings are evaluated together, the negative indicators of teachers are also low in the countries that have excelled in PISA. This low rate does not significantly affect student performance. However, in developing and young countries, teachers' negative attributes harm student performance. This effect is seen through teachers' field knowledge, professional development, cognitive activation, and management skills.

RECOMMENDATIONS

Based on the findings, some recommendations are made for educational policymakers in inefficient countries. In terms of SMK variable, it can be stated that it is important to concentrate on this subject in case of a candidate teacher. Because this qualification develops in the process of university education received by individuals who choose the teaching profession. Therefore, it is recommended to give priority to teacher training policies in universities and to check the quality of these policies. Countries need to find ways to help them participate in professional development activities in order to achieve better student performance through their teachers. It is recommended that teachers are encouraged to participate in professional development programs that provide feedback to them both during the candidacy and during the teaching process. From the perspective of the third variable, it can be said that policymakers in both teacher preparation and intervention programs, developing in-school and national level programs to enrich teachers' point of view of reasoning, criticism and problem solving will have a positive effect on gaining confidence in their eyes and improving their performance. In terms of classroom management, it can be encouraged to offer observation opportunities especially to new teachers and to conduct lessons together with experienced teachers. Thus, classroom management skills can be developed based on observation and experience.

For the next research, we offer different secondary analyses of 'key data' of OECD and other organizations. The reports of TALIS and PISA 2018 will be released in June and December of 2019, respectively. Those reports can generate data for future studies and provide opportunity for comparative studies with this research. For this reason, it is recommended that researchers can conduct different research on the basis of the results of the present study. However, as a limitation, this study has a limited number of input variables about teacher quality, which makes it possible for next research to include other negative or positive attributes of the teacher quality.

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