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Teacher Behaviours Explaining Turkish and Dutch Students' Mathematic Achievements

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ABSTRACT

The purpose of this study was to examine the differences between Turkish and Dutch students' mathematics achievement and to examine the predictive level of teacher behaviours for student performance. The participants were 3210 students and principals from 168 schools in Turkey and 2541 students and principals from 156 schools in the Netherlands, who attended the Program for International Student Assessment in 2012. According to the results of the multilevel latent class and three-step analyses, for both countries, teacher behavior related to student orientation, teacher focus on student achievement and formative assessment predicted the mathematical achievement. It is seen that a high level of teacher behavior related to student orientation and formative assessment plays an important role in schools' achievement at very low, low, and low-medium levels for Turkey and at medium and medium-high levels for the Netherlands. Furthermore, it was determined that the students who had low- or medium-level achievement were more affected by teacher characteristics/behaviours.

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1. INTRODUCTION

The outcomes of large-scale international assessments have an influence on the decisions of policy-makers around the world [1]-[3]. One of these assessments is the Program for International Student Assessment (PISA) managed by the Organization for Economic Co-Operation and Development (OECD). PISA focuses on the assessment of knowledge and ability in mathematics, science, and reading on a three-year cycle, and is used to compare different education systems. This process also aims to evaluate fundamental knowledge and abilities that students need to have in order to place themselves among the members of modern societies [4].

During each assessment, emphasis is placed on one of the three learning fields. In PISA 2012, the weighted field was mathematics. The results of PISA 2012 show that 37% of the variance in the mathematics score of students from OECD member countries was explained by the differences between schools [5]. Among all the participating countries in PISA 2012, the largest gap regarding achievement between schools was observed in the Netherlands, followed by Turkey. However, despite the achievement gap between schools, Dutch students' mathematics achievement remained high placing the Netherlands in the top ten countries with an average mathematics score of 523 points. Turkey, having an average mathematics score of 448 points, ranked 44th in this assessment. Therefore, it is considered important to investigate and compare some probable background variables that may be related to student achievement in the contexts of the Netherlands and Turkey. Thus, this study made an attempt to better understand the reasons for the different achievement levels of schools to offer ways of closing the gap. This requires the identification of the background factors causing the large achievement gap between high schools in the Netherlands and Turkey. The purpose of this study was to identify the latent classes for the mathematics achievement of the students who participated in PISA 2012 from Turkey and the Netherlands and use the identified classes to determine the predictive ability of i) teacher support in mathematics classes, ii) teacher behaviours during the teaching process, iii) teachers' use of cognitive activation strategies, and iv) teachers' focus on student achievement adopting a multilevel approach.

1.1. Theoretical background and research questions

As Hanushek [6] suggests, the best thing a school can supply for its students is good teachers. In this context, it has been observed that the quality of relationship between the teacher and student influences students' learning process and academic success [7],[8]. Therefore, it is important to determine the extent to which teachers play a role in students' different levels of achievement. Moreover, Hattie [9] described good teachers as those who challenged their students. Recent meta-analysis studies [10]-[13] have provided evidence for the effects of teacher behaviours on student achievement.

1.1.1. Learning theories and teaching strategies

A variety of learning theories used by teachers in the learning process also have an effect on student achievement. These theories focus on one or more behavioral, emotional, and cognitive aspects of learning [14]. "Behaviorism is a theory of learning focusing on observable behaviours and discounting any mental activity. Learning is defined simply as the acquisition of new behavior" [15]. "Constructivists view that learning takes place when new information is built into and added onto an individual's current structure of knowledge, understanding and skills" [15]. Furthermore, not only do teachers utilize different theories but also there are differences in practices resulting from cultures and characteristics of teachers themselves.

Teachers taking a behavioral approach generally use teacher-directed instruction. The National Mathematics Advisory Panel [16] defined teacher-directed instruction as "instruction in which primarily the teacher is communicating the mathematics to the students directly and in which the majority of interactions about the mathematics are between the teacher and the student" (p45), and student-centered instruction as "the instruction in which primarily students are doing the teaching of the mathematics and that the majority of the interactions about the mathematics occurs among students" (p45). Teachers adopting a constructivists approach generally use student-directed instruction. There is a considerable amount of research that provides supporting evidence for the relationship between teachers' instructional behaviours and student achievement. While some researchers have suggested that teacher-directed practices increase students' mathematics achievement [17]-[19], other comparative studies found student-centered practices to be more influential [11],[20].

Another variable that may affect student achievement is the teachers' use of formative assessment, which is described as "the process of recognizing, describing, and using students' prior knowledge in instruction" [21]. The results of the National Mathematics Advisory Panel [16] suggest that adapting formative assessments has advantages for all students at all ability levels. There are many studies in the literature that support the argument that the use of formative assessment leads to the improvement of student achievement and eliminates the gap between students regarding achievement [22]-[24]. As for cognitive activation, is about teaching students strategies, such as summarizing, questioning, and predicting, which they can refer to when solving mathematical problems [25]. Furthermore, cognitive activation is significantly related to higher mathematics achievement [26],[27].

A review of the literature shows contradictory findings regarding teachers' effect on the differences in student achievement. It is considered that there are various factors that may affect student achievement and their effects also vary between different cultures. In most applications in educational fields, individuals (level-1) are sampled from level-2 clusters such as class and society. This situation result in correlations between the observations from the same cluster [28]. However, there are not errors caused from correlation due to the fact that students and school level are handled separately in multi-level models [29]. In the related literature, there are only a limited number of studies regarding multilevel latent class models [29]-[32] and most do not focus on the differences between schools in terms of student achievement except the study by Finch and Marchant [31]. Therefore, this study aimed to fill the gap in the literature by using latent class models based on a multilevel data structure to identify latent classes at the school level for the inter-school mathematics achievement of the students that participated in PISA 2012. This research sought answers to the following questions in the context of Turkey and the Netherlands:

1. What are the latent classes regarding schools' mathematics achievement in PISA 2012?
2. To what extent are the identified latent classes predicted by teacher support in mathematics classes, teacher behaviours related to teacher- or student-directed instruction, student orientation, and formative assessment, teachers' use of cognitive activation strategies, and teachers' focus on students?

2. RESEARCH METHOD

2.1. Sample

The target population was 15-year-old students and school principals who participated in PISA 2012 from Turkey and the Netherlands (student number = 4848 and 4460, respectively; school number = 170 and 179, respectively). The students were selected via two-stage stratified sampling. In the first stage, the schools were determined and in the second stage, 15-year-old students were randomly sampled from these schools [4]. The PISA student questionnaire consists of four forms; A, B, C, and UH [33]. Since the student-level variables chosen in this study were related to the content of the B and C forms of the questionnaire, data belonging to students who had not completed these forms was excluded from analyses. After eliminating the missing data, the sample of the study consisted of 2541 students from 156 schools in the Netherlands and 3210 students from 168 schools in Turkey. Furthermore, the student final weights were included in the analyses for both Turkey and the Netherlands.

2.2. Instruments

Data regarding PISA 2012 was obtained from the website of PISA and included a mathematics literacy test and two different questionnaires, one for students and the other for school principals. In this research, the variables representing mathematics literacy were selected as four plausible values (the first of five plausible values) predicted from the mathematics subscale scores. Mathematics content subscale scores were composed of the four mathematics subscales of Change and Relationships (MATCR), Quantity (MATQ), Space and Shape (MATSS), Uncertainty and Data (MATUD). The independent variables were chosen from indices variables which were the scales consisting of several questionnaire items to measure one fundamental latent construct. The indices selected from the students' data regarding teacher support in mathematics classes (TEACHSUP), teacher-directed instruction (TCHBEHTD), teachers' student orientation (TCHBEHSO), teachers' use of formative assessment (TCHBEHFA), teachers' use of cognitive activation strategies (COGACT) and index selected from school data regarding teachers' focus on students (TCFOCST). The reliability estimates for the dependent variables were high with the coefficients ranging from .88 to .90 for Turkey and from .93 to .95 for the Netherlands. The reliability estimates for internal consistency of the independent variables were also generally high with the Cronbach's alpha varying between .75 and .85 for Turkey and between .61 and .86 for the Netherlands [34].

2.3. Data analyses

As the first step, a multilevel latent class analysis (MLCA) was used to investigate the number of multilevel latent classes for inter-school mathematics achievement of students. Then, a three-step analysis was performed to determine the predictive ability of independent variables for the constructed multilevel latent classes. After assigning the group averages of the student-level variables to the groups, a school-level analysis was conducted by applying the aggregated student-level scores. In the following section, both analyses are explained in more detail.

2.3.1. Multilevel latent class and three-step analyses

Contrary to standard latent class analyses, in which model parameters are assumed to be the same for all individuals, multilevel latent class analyses allow certain model parameters to differ between groups or clusters. This makes it possible to investigate how level-2 units affect level-1 indicators, which define the membership of latent classes. In addition, multilevel latent class analyses allow the assessment of conceptual predictors (level 2) and extend the assessment of explanatory variables to an individual level [35]. In this study, the three-step procedure was also used. In the first step, a latent class model was developed in which the scores in separate individual-level predictors were used as indicators for a group-level latent class variable (measurement model). In the second step, this latent class model was used to aggregate the individual-level predictors by group by assigning the groups to the latent classes. In the final step, a group-level analysis was conducted based on aggregated measures related to the group-level variables (structural model) that remained [36]. The model which is the simplest, has the minimum latent classes and has the least predictive parameter is preferred in the model selection [29]. To obtain the optimal number of clusters, the log-likelihood (LL), and the Bayesian information criterion (BIC) were used. Regarding the choice of model, the study of Lukočienė, et al. [37] is made to reference, it includes a simulation study that displays why BIC is the right fit index by referring that its sample size is even with the group level observations. Latent Gold 5.1 package program was used for the data analysis [38].

3. RESULTS AND ANALYSIS
3.1. Latent school classes
First, the MLCA was conducted considering the nested data structure. Table 1 presents values the log-likelihood and the BIC and the numbers of parameters for the estimated multilevel latent class scaling models for both Turkish and Dutch participants.

Table 1. Fit Measures of the Results

	Model	LL	BIC (LL)	Npar
Turkey	9Cluster-5GClass	-65578.1990	132090.9389	116
	9Cluster-6GClass	-65551.3218	132109.6922	125
Netherlands	9Cluster-4GClass	-51546.2094	103930.2161	107
	9Cluster-5GClass	-51524.4516	103957.1693	116

Considering the results of the MLCA, 9Cluster-5GClass model was a better fit for the data obtained from Turkey. Table 2 shows the class probabilities of the 9Cluster-5GClass model and the means at each class of the dependent variables. Also, the 9Cluster-4GClass model was found to be the preferred model for the Netherlands. The mean values at each class of the 5GClass and 4GClass models and the class probabilities of these models are shown in Table 2. The classes are ordered by the increasing scores.

Table 2. Class Probabilities of the 5GClass and 4GClass Models and Means at Each Class of the Dependent Variables

	GClass	1	2	3	4	5
Turkey	Size	0.21	0.50	0.10	0.11	0.08
	MATCR	374.81	418.20	476.86	538.67	598.26
	MATQ	363.71	410.68	473.25	539.58	601.39
	MATSS	359.33	406.47	473.23	548.04	622.55
	MATUD	374.49	418.12	475.10	535.75	595.82
Netherlands	Size	0.28	0.26	0.31	0.15	
	MATCR	430.92	497.32	580.48	620.88	
	MATQ	438.49	507.83	589.72	626.29	
	MATSS	422.54	482.66	557.60	597.91	
	MATUD	435.11	504.76	590.36	631.40	

As shown in Table 2, the GClasses or school classes can be described using student scores. The table also presents the percentage of each class size. For Turkey, the following school classes were identified: GClass 1 schools with quite low achievement (QLA) (21%), GClass 2 schools with fairly low achievement (FLA) (50%), GClass 3 schools with low achievement (LA) (10%), GClass 4 schools with medium achievement (MA) (11%), GClass 5 schools with high achievement (HA) (8%). For Netherlands: GClass 1 schools with FLA (28%), GClass 2 schools with MA (26%), GClass 3 schools with fairly high achievement (FHA) (31%), and GClass 4 schools with HA (15%).

3.2. Explaining the latent GClass membership
Following the determination of the classes obtained according to the 5GClass and 4GClass models, a three-step analysis was conducted on the data composed by aggregating the student-level variables. Table 3 presents the conditional probability of schools in each GClass for the individual variables for Turkey.

Table 3. Conditional Probability of Turkish Schools in Each GClass for the Individual Variables

Variables, their levels and size		Wald	R^2	GClass 1 QLA	GClass 2 FLA	GClass 3 LA	GClass 4 MA	GClass 5 HA
Level				0.23	0.44	0.11	0.13	0.09
TCHBEHSO		127.22*	0.42					
-0.822 → -0.0277	very low			0.24	0.12	0.00	0.37	0.26
-0.026 → 0.260	low			0.34	0.35	0.01	0.22	0.08
0.271 → 0.468	medium			0.30	0.53	0.04	0.10	0.04
0.483 → 0.768	high			0.21	0.58	0.15	0.05	0.01
0.775 → 2.347	very high			0.07	0.42	0.51	0.01	0.00
TCHBEHFA		15.79*	0.14					
-0.625 → -0.107	very low			0.25	0.29	0.00	0.31	0.15
-0.097 → 0.127	low			0.27	0.43	0.01	0.20	0.09
0.138 → 0.309	medium			0.30	0.46	0.02	0.14	0.08
0.310 → 0.473	high			0.23	0.48	0.16	0.08	0.05
0.485 → 1.996	very high			0.10	0.34	0.51	0.03	0.02
TCFOCST		10.57*	0.06					
-1.763 → -0.998	very low			0.49	0.25	0.16	0.09	0.02
-0.675 → -0.675	low			0.43	0.25	0.13	0.17	0.02
0.009 → 0.0095	medium			0.46	0.24	0.13	0.11	0.05
0.702 → 0.702	high			0.32	0.22	0.17	0.17	0.12
1.283 → 2.120	very high			0.24	0.20	0.18	0.18	0.20

Note: proportions over 0.30 are in bold face. *$p < 0.05$

As revealed in Table 3, according to the three-step analysis conducted on the last model, teacher behavior related to student orientation and formative assessment as well as teacher focus on student achievement significantly predicted the mathematical achievement. In addition to, though teacher related to student orientation and formative assessment were found to be at low, medium, high or very high levels, the schools were usually placed in GClass2 (schools with FLA), which had the largest class sizes. Furthermore, even when the teacher focus on student achievement was at very low, low, medium or high levels, the schools were usually placed in GClass1 (schools with QLA). The conditional probability for GClass2 (schools with FLA) schools corresponding to the fourth cell in Table 3 was 0.58 indicating a 58% probability that the students from the GClass2 (schools with FLA) schools in terms of teacher behavior related to student orientation would be at the high level. It is seen that a high degree of teacher behavior when performing student orientation and conducting formative assessment plays an important role not only in 'schools with QLA' but also in 'schools with FLA or LA'. Additionally, as teachers' student-oriented practices and formative assessment increased from low to high, the percentage of students in the category of GClass5 (schools with HA) decreased. Table 4 presents the conditional probability of the schools in the Netherlands each GClass for the individual variables.

Table 4. Conditional Probability of the Netherlands Schools in Each GClass for the Individual Variables

Variables, their levels and size		Wald	R^2	GClass1 FLA	GClass2 MA	GClass3 FHA	GClass4 HA
Size	Level			0.27	0.28	0.29	0.15
TCHBEHSO		143.99*	0.49				
-0.995 → -0.470	very low			0.15	0.52	0.01	0.33
-0.467 → -0.220	low			0.32	0.41	0.02	0.25
-0.220 → 0.0927	medium			0.37	0.33	0.15	0.15
0.137 → 0.406	high			0.39	0.09	0.47	0.05
0.408 → 1.397	very high			0.09	0.01	0.89	0.01
TCHBEHFA		20.56*	0.15				
-0.746 → -0.370	very low			0.44	0.27	0.01	0.27
-0.362 → -0.158	low			0.32	0.40	0.05	0.24
-0.154 → -0.016	medium			0.29	0.35	0.20	0.17
-0.011 → 0.199	high			0.22	0.23	0.46	0.09
0.221 → 0.965	very high			0.06	0.10	0.82	0.02
TCFOCST		7.91*	0.05				
-3.794 → -1.763	very low			0.49	0.06	0.21	0.24
-1.213 → -1.040	low			0.35	0.24	0.24	0.18
-0.675 → -0.675	medium			0.23	0.31	0.31	0.15
-0.025 → 0.0095	high			0.21	0.36	0.28	0.14
0.702 → 1.283	very high			0.07	0.62	0.23	0.07

Note: proportions over 0.30 are in bold face. *$p < 0.05$

As revealed in Table 4, according to the results of three-step analysis, teacher behavior related to student orientation and formative assessment as well as teacher focus on student achievement significantly predicted the mathematical achievement. In addition, teacher behavior concerning student orientation was considered to be as important as the effect of a student's mathematical achievement and more important than teacher behavior related to formative assessment for both countries. The conditional probability for GClass1 (FLA) schools corresponding to the fourth cell in Table 4 was 0.39 indicating a 39% probability that the students from the GClass1 (FLA) schools in terms of teacher behavior regarding student orientation would be at the high level. It was seen that a very high level of student orientation and formative assessment played an important role in 'schools with FHA'. Furthermore, as the teachers' student orientation, formative assessment, and focus on student achievement increased from low to high, the percentage of students in GClass4 (HA) decreased. GClass3 (FHA) represented the group in which the teachers tended to conduct more formative assessment than the OECD average (-0.28).

The results indicate that teacher behavior related to student orientation and formative assessment, and teacher focus on student achievement significantly predicts the membership of different achieving schools for both Turkish and Dutch students. The findings of the present study are supported by those reported in the literature (e.g., [11],[20],[22]-[24]). The results also demonstrate that teacher behavior related to student orientation plays an important role in both Turkish and Dutch students' achievement. These finding are supported by other studies [11], [20] in which learner-centered practices were found to have more impact on student achievement. Teachers adopting a constructivist approach generally prefer student-directed instruction. In this context, the constructivist approach appears to be more effective than other approaches for student achievement in both countries.

The comparative results between the two countries show that teacher behaviours related to student orientation and formative assessment are a stronger predictor of the Dutch students attending schools with MA or FHA compared to the Turkish students. This situation may result from cultural differences since variables affect different cultures in different ways. For example, students in a collectivist culture may hesitate to speak up in larger groups without the teacher nominating them. Moreover, in an individualist society, the assignment of common works more easily causes the formation of new groups than in a collectivist society [39]. For this reason, it is expected that teacher behavior is more influential in the achievement of students from the Netherlands, which has an individualist society structure than in Turkey with a collectivist cultural structure. Moreover, according to the results of the Teaching and Learning International Survey, in larger classes, a less number of student-oriented practices are employed [18]. This indicates that each individual student has less chance of being communicated because of the limitation caused by the large class size. The result of this research supports these findings. Teachers may be adopting a less student-oriented approach due to the larger classes in Turkey compared to the Netherlands [40], resulting in lower student achievement in the former.

Furthermore, according to the results of this study, teacher support has a fairly low a significant effect on different levels of school achievement. This may be because the students attending these schools at all achievement levels may be in need of teacher support. Moreover, students with HLA may not need additional help or instruction in the learning process, which, in turn, may lead to less teacher support in schools attended by students with HA. This result may also be attributed to the different perceptions of students and teachers concerning support; a teacher who considers themselves to support their students may not be perceived as supportive by the students [41]. Therefore, since the data was got from the students, the results reflect their perceptions of teacher support.

The impact of teachers' use of cognitive activation strategies in their mathematic lessons is not significant to account for the discrepancy in Turkish and Dutch students' achievements. Considering some items of a study by Burge et al. [24], eliciting the teachers' use of cognitive activation strategies in reference to the frequency of their teacher helping them learn from their errors, the ability groups were similar. However, Hattie [9] emphasized that it was not only students with low ability who made mistakes, students of all abilities made mistakes, and therefore learning from mistakes is valid for all students.

The results of this study revealed no significant effect of teacher-directed practice on student achievement. There are several studies reporting that teacher-directed practices pave the way for greater mathematics achievement for students [17]-[19]. However, in his study, Jones [42] found no significant difference between student-centered or teacher-directed instruction in terms of the academic achievement level of students. Similarly, Delen and Bellibas [43] showed that teacher-directed instruction had no substantial contribution to Turkish students' science success. Moreover, some research findings have shown that teachers may not be fully accountable for their students' performance when it is relatively weak; thus, it can be suggested that working in schools where the education system is inadequate does not appeal to skilled individuals [44].

4. CONCLUSION

The current research addresses several important issues. For both Turkish and Dutch students, teacher behaviours related to student orientation and formative assessment, and teacher focus on student achievement were found to predict the student achievement. In addition, the analyses suggested that teacher focus on student achievement had an effect only on schools with fairly low mathematical achievement in Turkey. Even in schools, where teacher behavior related to student orientation and formative assessment were at the low, medium or high levels, the schools with the most crowded classes were found to have VLA. In the Netherlands, teacher behaviours related to student orientation and formative assessment and teacher focus on student achievement had different degrees of effect on the four latent classes identified based on the achievement level of the schools. Moreover, for both countries, the variables of teachers' use of cognitive activation strategies and teacher-directed instruction in mathematics classes had a fairly low and non-significant effect on student success. It is seen that a high level of teacher behavior related to student orientation and formative assessment plays an important role in schools' achievement at very low, low, and low-medium levels for Turkey and at medium and medium-high levels for the Netherlands. In both countries, the relationship between high student achievement and teacher behaviours/characteristics was fairly low. In other words, students with HA did not result from a certain teacher characteristic or behavior. However, it was determined that the students who had low- or medium-level achievement were more affected by teacher characteristics/behaviours. The findings concerning student and school groups are expected to be useful for teachers, policy makers, and other education stakeholders in terms of providing recommendations about teacher characteristics that would increase students' success in mathematics.

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