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Testing the validity of the dynamic model at school level: a European study

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ABSTRACT

This European project investigates the impact of the school factors included in the dynamic model of educational effectiveness on student achievement. In each participating country (Belgium/Flanders, Cyprus, Germany, Greece, Ireland and Slovenia), a sample of at least 50 schools was drawn and tests in mathematics and science were administered to all grade 4 students ($n = 10,742$) at the beginning and end of school year 2010–2011. Teachers completed a questionnaire measuring school policy on teaching, the school-learning environment and the evaluation of school policy. Multilevel analysis revealed that the school factors measuring policy on teaching, the school-learning environment and the evaluation of school policy explain student achievement gains in mathematics and science across countries and in each participating country. The effect sizes of these factors are equally important for explaining variation in student achievement in each subject. Descriptive analyses also show that there is scope for improving the factors included in the dynamic model in each country. Implications for research, policy and practice are drawn.

KEYWORDS

Educational effectiveness research; school-learning environment; school policy; school evaluation; international study

Introduction

While evidence can be found that schools with favourable environments are academically more successful with students, it has been argued that conclusions about these relationships are premature because the data on school-level environments (SLE) and student outcomes have been confounded by several other issues. Weaknesses in the methods used to study the impact of the SLE and in the conceptual framework used to explain how the SLE affects student learning have been identified (Sammons, Hillman, and Mortimore 1995; Scheerens and Bosker 1997). Furthermore, studies investigating the impact of the SLE on student outcomes are mainly cross-sectional, reporting correlations between the skills of students and the SLE (e.g. Fisher and Cresswell 1998; Fisher and Fraser 1991). Two recent meta-analyses (Kyriakides et al. 2010; Scheerens et al. 2005) reveal that only a few studies (e.g. Den Brok, Brekelmans, and Wubbels 2004; Webster and Fisher 2003) explicitly investigate direct and indirect effects of the SLE upon student outcomes. This paper builds upon previous research associated with the development and testing of a dynamic model of educational effectiveness (Creemers and Kyriakides 2008) which

refers to the impact that the school-learning environment (SLE) and school policy for teaching can have on promoting student learning outcomes. More specifically, four longitudinal studies testing the validity of the dynamic model have been conducted (Creemers and Kyriakides 2009, 2010a, 2010b; Kyriakides et al. 2015). These studies revealed that school factors can explain variation in student achievement gains in different learning outcomes (both cognitive and affective). However these studies were national in character and thereby their findings cannot be used for supporting the generic nature of the school factors. Thus, one of the main aims of the study reported here was to test the generalisability of the findings of these studies by searching for the impact of school factors on student achievement gains in six different European countries. Specifically, this paper investigates the extent to which each school factor included in the dynamic model concerned with school policy for teaching and the SLE can explain variation in student achievement in mathematics and science in six countries with very different educational systems: Belgium, Cyprus, Germany, Greece, Ireland and Slovenia. In the next section, the main assumptions of the dynamic model are, therefore, provided. Since the paper is concerned with the school-level factors of the model, these factors are also described. In the final part of the paper, the methods and the main findings on the impact of these factors are also presented. Finally, implications of findings for school effectiveness research, policy and practice are drawn.

The dynamic model of educational effectiveness: an overview

The essential characteristics of the dynamic model

The main characteristics of the dynamic model are as follows. First, the dynamic model takes into account the fact that effectiveness studies conducted in several countries reveal that the influences on student achievement are multilevel (Teddlie and Reynolds 2000). Therefore, the model is multilevel in nature and refers to factors operating at the four levels shown in Figure 1. Teaching and learning is emphasised and the roles of the two main actors (i.e. teacher and student) are analysed. Above these two levels, the dynamic model refers to school-level factors which are expected to influence the teaching-learning situation by developing and evaluating the school policy on teaching and the policy on creating the SLE. The system level refers to the influence of the educational system through a more formal way, especially through developing and evaluating the educational policy at the national/regional level. The teaching and learning situation is also influenced by the wider educational context in which students, teachers and schools operate. Factors such as the values of the society for learning and the importance attached to education play an important role both in shaping teacher and student expectations, as well as in the development of the perceptions of various stakeholders about effective teaching practice.

Second, the model supports that factors at the school and system level have both direct and indirect effects on student achievement, since they are able to influence not only student achievement but also the teaching and learning situation. Third, the dynamic model assumes that the impact of the school- and system-level factors has to be defined and measured in a different way than the impact of classroom-level factors. Policy on teaching and actions taken to improve teaching practice must be measured

Figure 1. The dynamic model of educational effectiveness.

over time and in relation to the weaknesses that occur in a school. The assumption is that schools and educational systems, which are able to identify their weaknesses and develop a policy on aspects associated with teaching and their SLE, are also able to improve the functioning of classroom-level factors and their effectiveness status. Only changes in those factors for which schools face significant problems are expected to be associated with the improvement of school effectiveness. This implies that the impact of school- and system-level factors depends on the current situation of the objects under

investigation (Creemers and Kyriakides 2009). Therefore, the dynamic model can assist the better understanding of the processes of change and the way effectiveness factors operate and evolve over time (Heck and Moriyama 2010; Hofman, Hofman, and Gray 2010; Sammons 2009). Fourth, the model assumes that there is a need to carefully examine the relationships between the various effectiveness factors which operate at the same level. This implies that there is a need to refer to the relationships between the effectiveness factors which operate at the same level. Such approach to modelling educational effectiveness may reveal groupings of factors that make teachers and schools effective (Muijs and Reynolds 2000). Therefore, strategies for improving effectiveness which are comprehensive in nature may emerge (see Creemers and Kyriakides 2012).

Finally, the dynamic model is based on the assumption that each factor can be defined and measured by using five dimensions: *frequency*, *focus*, *stage*, *quality*, and *differentiation*. Frequency is a quantitative way to measure the functioning of each effectiveness factor whereas the other four dimensions examine qualitative characteristics of the functioning of each factor at the system/school/classroom level. The use of different measurement dimensions reveals that looking at just the frequency dimension of an effectiveness factor does not help us identify those aspects of the functioning of the factor which are associated with student achievement. Considering effectiveness factors as multidimensional constructs not only provides a better understanding of what makes teachers and schools effective, but may also assist the development of more comprehensive strategies for improving educational practice (see Creemers and Kyriakides 2012).

School factors

In regard to the school factors, the dynamic model gives emphasis to the following two main aspects of the school policy which affect learning at both the level of students and teachers: (1) *school policy for teaching* and (2) *school policy for creating a learning environment at school*. Guidelines are seen as one of the main indications of school policy and this is reflected in the way each school-level factor is defined. However, by using the term guidelines, we refer to a range of documents, such as staff meeting minutes, announcements and action plans, which make the policy of the school more concrete to the teachers and other stakeholders. These two factors do not imply that each school should simply develop formal documents to install its policy. The factors concerned with the school policy mainly refer to the actions taken by the school to help teachers and other stakeholders have a clear understanding of what is expected from them to do. Support offered to teachers and other stakeholders to implement the school policy is also an aspect of these two school factors.

Based on the assumption that the essence of a successful organisation in the modern world is the search for improvement, the dynamic model is also concerned with the processes and the activities which take place in the school in order to improve the teaching practice and its learning environment. For this reason, the processes which are used to evaluate the school policy for teaching and the SLE are investigated. Thus, the following four overarching factors at the school level are included in the model:

- (a) school policy for teaching and actions taken for improving teaching practice;
- (b) evaluation of school policy for teaching and of actions taken to improve teaching;

- (c) policy for creating a SLE and actions taken for improving the SLE and
- (d) evaluation of the SLE.

In regard to the school factor concerned with teaching, the dynamic model is concerned with aspects of school policy for teaching associated with: (1) quantity of teaching; (2) provision of sufficient learning opportunities and (3) quality of teaching. Actions taken for improving the above three aspects of teaching practice, such as the provision of support to teachers for improving their teaching skills, are also taken into account. School policy on quantity of teaching is mainly concerned with the attempt of the various school stakeholders to make sure that the time allocated for teaching is not lost for any group of students. Specifically, the following aspects of school policy on quantity of teaching are taken into account: (1) school policy on the management of teaching time (e.g. lessons start on time and finish on time; there are no interruptions of lessons for staff meetings and/or for preparation of school festivals and other events); (2) policy on student and teacher absenteeism; (3) policy on homework and (4) policy on lesson schedule and timetable. The importance of this factor is stressed in early educational effectiveness models (e.g. Carroll 1963; Creemers 1994) and meta-analyses of studies demonstrating its impact on student learning outcomes (e.g. Hattie 2009; Kyriakides et al. 2010; Scheerens et al. 2005).

The second aspect of school policy for teaching is concerned with the learning opportunities that schools offer to their students beyond those included in the official curriculum. Therefore, school policy on *providing learning opportunities* is examined by looking at the extent to which teachers and other school stakeholders take actions to ensure that students are offered extra-curricular activities which promote student learning (Scheerens 2013; Wang 1998). For example, school trips are organised to enrich the learning opportunities offered to students during the school hours. Schools could also encourage teachers to offer extra-curricular activities during outside school hours (e.g. participating in projects and charity activities, preparing students for competitions). Schools may also provide further support to students with special needs (including gifted or talented children). Secondary analyses of international studies show that schools with effective policies on providing learning opportunities can better support student learning (Schleicher 2014). In this way, the dynamic model investigates the extent to which a school attempts to capitalise on excursions and other extra-curricular activities for teaching/learning purposes.

The third aspect of school policy for teaching is concerned with the attempt of schools to improve the teaching practice by supporting teachers to develop effective teaching skills (see Creemers and Kyriakides 2012; Scheerens 2013). Specifically, school policy on *the quality of teaching* is concerned with the extent to which the school stakeholders have a common understanding and guidelines for effective teaching practices. These practices are expected to refer to teacher behaviours in the classroom such as the degree to which the teacher provides orientation and/or structuring tasks, gives feedback and poses appropriate questions. Therefore, the examination of school policy on teaching reveals that effective schools are able to make decisions to maximise the use of teaching time and the learning opportunities offered to their students. In addition, effective schools support their teachers in their attempts to help students learn by using effective teaching practices (Brühwiler and Blatchford 2011).

In regard to the factor concerned with the SLE, the dynamic model investigates school policy on the following five aspects which define the environment of the school:

- (a) student behaviour outside the classroom;
- (b) collaboration and interaction between teachers;
- (c) partnership policy (i.e. the school's relations with the community, the parents, and the advisors);
- (d) provision of sufficient learning resources to students and teachers and
- (e) values in favour of learning.

The first three aspects refer to the rules which the school has developed for establishing a learning environment inside and outside the classroom. Here the term learning does not refer exclusively to student learning. Apart from the first element which is directly related to student learning, the next two elements underscore how student learning can be facilitated through two main additional stakeholders: teachers and parents. For example, collaboration and interaction between teachers may not only contribute to their professional development (i.e. teacher learning), but may also have an effect on teaching practice and thereby may improve student learning (Goddard, Goddard, and Tschannen-Moran 2007). Similarly, by involving parents in the functioning of schools and also providing them with suggestions on how to support the learning of their children at home, the school facilitates student learning at two fronts: through the classroom learning environment (e.g. when parents provide teachers with information regarding their children or bring human and other resources to the school) and the home learning environment (e.g. when parents are informed on how to support/supervise their children when doing their homework) (Fan and Chen 2001).

The fourth aspect of the SLE factor refers to the policy on providing resources for learning. The availability of learning resources in schools may not only have an effect on student learning but may also encourage the learning of teachers. For example, the availability of computers and software for teaching geometry may contribute to teacher professional development since it may encourage teachers to use the software in their teaching to become more effective. The last aspect of this overarching factor is concerned with the strategies which the school has developed in order to encourage teachers and students to develop positive attitudes towards learning. To investigate the extent to which the factors included in the dynamic model are associated with student achievement gains in different European countries, an international effectiveness study was conducted and its methods and main results are presented below.

Methods

Participants

In each participating country (Belgium/Flanders, Cyprus, Germany, Greece, Ireland and Slovenia), stratified sampling procedure (Cohen, Manion, and Morrison 2000) was used to select a sample of at least 50 primary schools and tests in mathematics and science were administered to all grade 4 students ($n = 10,742$) at the beginning and at the end of school year 2010–2011. Additionally, all the teachers of the school sample ($n = 2923$)

Table 1. Number of students, teachers and schools per country from which data were collected and number of students, teachers and schools per country used in the analyses concerned with the impact of school factors' effect on student achievement.

Country	Data collected			Data used in the analyses		
	Students	Teachers	Schools	Students	Teachers	Schools
Belgium/Flanders	1748	535	45	1526	523	40
Cyprus	1899	294	59	1836	291	57
Germany	1022	363	45	925	358	41
Ireland	2268	342	57	1797	327	46
Slovenia	2155	1389	59	2155	1389	59
Total sample	9092	2923	265	8239	2888	243

were given a questionnaire measuring school policy on teaching and the SLE. However, in Greece this was not possible and less than four questionnaires per school were administered. For this reason, the data collected from the teacher questionnaires in Greece were not used for any analyses concerning the school factors and, therefore, in this paper we will present results on the impact of school factors on student achievement in the other five countries. In addition, schools with a teacher response rate below 30% were removed from the analyses. Table 1 shows the number of students, teachers and schools that were used in the multilevel analyses which were conducted in order to identify the impact of school factors on student achievement. It is therefore shown that from the remaining five countries, 22 out of 265 schools in total were removed from the analyses due to low teacher response rates. Specifically, five schools were removed from Belgium, two schools were removed from Cyprus, four schools were removed from Germany and 11 schools were removed from Ireland. In Slovenia, no schools had to be removed as for all the schools the response rate was greater than 30%. In total, data concerning the school factors were collected from 2888 teachers of the sample.

Dependent variables: student achievement in mathematics and science at the end of grade 4

Data on student achievement in mathematics and science were collected at the beginning and the end of school year 2010–2011 by using external forms of assessment designed to assess knowledge and skills in these two subjects. For the construction of the tests used to measure student achievement, permission was obtained from IEA to use the released items of TIMSS 2007. The properties of each item and its relation with the curricula of grades 3 and 4 in each country were taken into account for developing the two types of test. For the estimation of the achievement data in each of the two subjects, data scaling was conducted by applying the Partial Credit Model (Masters and Wright 1997) as implemented in the software ConQuest (Wu, Adams, and Wilson 1998). As estimation algorithm, an adaptation of the quadrature method described by Bock and Aitken (1981) was used. Thus, for each student two different scores for his/her achievement in each subject at the beginning and the end of grade 4 were generated.

Explanatory variables at student level

Regarding the student level factors, we restricted ourselves in collecting data concerning prior knowledge, SES, ethnicity and gender. These factors have been found to explain the

majority of variance at student level (Creemers and Kyriakides 2008; Opdenakker and Van Damme 2006; Scheerens and Bosker 1997; Teddlie and Reynolds 2000) and can be used to analyse differential effects of classroom factors (Campbell et al. 2004; Strand 2010).

Explanatory variables at school level

At the end of the school year 2010–2011, data regarding the school-level factors included in the dynamic model of educational effectiveness were collected. School factors were measured by asking all the teachers of the school sample to complete a questionnaire which was designed in such a way that information about the school-level factors of the dynamic model on school policy for teaching and on policy for improving the SLE could be collected. To capture school policy, we have not only investigated the formal school policy as defined in the school plan. Teachers were asked to provide information about a number of activities that take place in their school to clarify the expected outcomes/actions to teachers, parents and students in relation to the aspects of policy for teaching and policy for SLE mentioned in the previous section of the paper. For example, to measure the aspect of school policy on quantity of teaching, we used items related to issues discussed during staff meetings (e.g. dealing with teacher and student absenteeism, amount and type of homework). Teachers were also asked to refer to the extent to which these issues were discussed in documents and other materials which are distributed by the school management team to school stakeholders (i.e. teachers, students and parents). Teachers were not only asked whether these issues were covered in the policy documents, but also whether the documents made explicit to the teachers what they are expected to do. Finally, teachers were asked whether the school management team provides support to the teachers in order to help them implement the policy. The items measuring this factor and all the other factors discussed above have been used in previous studies testing the validity of the dynamic model of educational effectiveness. Through these studies, support to the construct validity of the teacher questionnaire has been provided (see Creemers and Kyriakides 2010a). Although the adapted version of the questionnaire can be found on the web page of the project (see www.ucy.ac.cy/esf), a representative item for each subscale is also given in Table 2.

A Likert scale was used to collect data on teachers' perceptions of the school-level factors. Data on school factors are based on teacher questionnaires only and the limitations of using perceptual methods to measure school factors should be acknowledged. Nevertheless, using the G theory the generalisability of the data was found to be appropriate (see Kyriakides, Creemers, and Panayiotou 2012). Using Mplus (Muthén and Muthén 2001), the intra-class correlations of the subscales were also computed. The intra-class correlations, which indicate the amount of variance of the teacher questionnaire situated at the between-level (i.e. teachers within the same school), were found to be relatively high. In addition, reliability was computed for each subscale measuring school policy for teaching, policy for SLE and school evaluation by calculating multilevel λ (Snijders and Bosker 1999) and Cronbach alpha for data aggregated at the school level. The findings of these analyses provided further support to the reliability and generalisability of the data emerged from the teacher questionnaire.

To test the validity of the questionnaire both within and across-country SEM analyses were conducted and evidence supporting the construct validity of the questionnaire

Table 2. Indicative items used to measure each subscale in regard the school factors of the dynamic model.

Scales	Indicative items per subscale
<i>Scale 1: School policy on teaching</i>	
Quantity of teaching ($n = 8$)	Discussions at staff meetings help me to improve my practice in making good use of teaching time
Provision of learning opportunities ($n = 12$)	There is material on notice-boards in the school relevant to provision of learning opportunities beyond the ones provided by the formal curriculum
Quality of teaching ($n = 14$)	At school staff meetings we discuss and take decisions on issues concerned with methods to effectively teach pupils (e.g. questioning, application, modelling)
<i>Scale 2: Policy on the school-learning environment (SLE)</i>	
Student behaviour outside the classroom ($n = 4$)	In my school, we have taken the decision to organise fun activities during break time that may help students to achieve specific learning goals (e.g. games, dance, sports)
Teacher collaboration ($n = 4$)	The teachers in my school cooperate with each other by exchanging ideas and material when teaching specific units or series of lessons.
Partnership: relation with the school community and parents ($n = 15$)	In parent–teacher meetings organized by our school, we discuss ways in which parents can help to deal with the following issues: (a) homework, (b) ...
Provision of learning resources to students and teachers ($n = 4$)	There is material on notice-boards in the school relevant to: The use of different educational tools for teaching provided by the school
<i>Scale 3: Evaluation of the school policy on teaching</i> ($n = 11$)	The principal and/or other members of the school staff observe the way the teaching policy is put into practice and presents the results of their observations to staff
<i>Scale 4: Evaluation of the SLE</i> ($n = 9$)	My school keeps systematic records concerned with: (a) the use of educational tools for teaching supplied by the school (e.g. maps, software etc.), (b) ...

was generated. Specifically, separate SEM analyses were conducted for the three overarching factors: (1) School policy on teaching; (2) Policy on the SLE and (3) Policy on Evaluation. The first overarching factor is School policy on teaching and consists of the factors measuring quantity of teaching, quality of teaching and provision of learning opportunities. The second overarching factor is Policy on the SLE and consists of the factors measuring teacher collaboration, partnership policy, provision of sufficient learning resources and relation with the community. Finally, the third overarching factor is Policy on Evaluation and consists of the factors measuring evaluation of the school policy on teaching and evaluation of the learning environment. Separate within-country SEM analyses showed that these models fit well to the data emerged by each country separately. The fit indices of the across-country models are shown in [Table 3](#).

Additionally, for each of the three overarching factors (school policy on teaching, policy on the SLE and school evaluation) another model was tested in order to compare its fit to the data with the three proposed models. In these alternative models (Models 2), all the items that were used for the SEM analyses in each of the three overarching factors were considered as belonging to a single factor. These models were an attempt to test whether the questionnaire items refer to a social desirability factor and thereby the questionnaire is not valid at all. The results indicate that Model 1 is the model that was found to best fit the data for each of the overarching factors. If the one-factor models (Models 2) were found to fit to the data, this would cause doubts on whether we could have scores per each factor separately. The fit indices of each model are shown in [Table 3](#) where it can be seen that Model 1 was found to best fit the data and that the fit indices of Model 1 were satisfactory. The same findings emerged from the within-country SEM analyses (for further information on the fit indices emerged from the

Table 3. Fit indices of the models emerged from the across-country SEM analyses of the teacher questionnaire used to measure each overarching school factor.

Models	χ^2	df	χ^2/df	p	CFI	RMSEA	Range RMSEA
<i>A. School Policy on teaching</i>							
Model 1	143	16	8.9	.001	0.984	0.052	0.045–0.060
Model 2 (one-factor model)	484	20	24.2	.001	0.943	0.090	0.083–0.097
<i>B. Policy on the school-learning environment</i>							
Model 1	669	96	6.9	.001	0.963	0.045	0.042–0.049
Model 2 (one-factor model)	3879	135	28.7	.001	0.759	0.098	0.095–0.101
<i>C. School Evaluation</i>							
Model 1	585	57	10.2	.001	0.967	0.057	0.053–0.061
Model 2 (one-factor model)	1600	65	24.6	.001	0.905	0.090	0.087–0.094

within-country analyses see the report in the web page of the project). Thus, based on the results of Models 1, the factor scores were estimated based on the loadings of the items that occurred from the SEM analyses. These factor scores were aggregated at the school level and were used for the multilevel analyses in order to identify the impact of the school factors on student achievement in mathematics and science.

Results

To test the effect of the school factors on students' achievement in mathematics and science, multilevel modelling techniques (Goldstein 2003; Snijders and Bosker 1999) were used to analyse the data. Multilevel analyses were used since the data are nested, namely, students within classrooms, classrooms within schools and schools within countries. Due to the fact that most of the sample's schools in the participating countries comprised only one classroom per year group, it was not possible to distinguish the two levels (i.e. classroom and school). Since this paper is concerned with the impact of school factors, the school level was used for the analyses instead of the classroom level. Moreover, the country level was not used as an additional level in the models as the number of countries participating in this study was very small. Tables 4–7 present the results of the across-country multilevel analyses concerned with the impact of school factors on mathematics and science student achievement, respectively. For the analysis of the data, the first step was to run a two-level model (school level and student level) without any explanatory variables (empty model) to determine the variance at each level (see Model 0). The variance for mathematics was 23.7% at the school level and 76.3% at the student level and was statistically significant in each level. The variance for science was 30.9% at the school level and 69.1% at the student level and was statistically significant in each level. The variance at each level was statistically significant and this implies that multilevel analysis can be carried out in order to identify the impact of each factor. Moreover, a comparison of the empty models in mathematics and science reveals that the effect of the school level is more pronounced on achievement in science rather than in mathematics. In Model 1, the context variables were added to the empty model. Both students' prior achievement and average prior achievement at the school level had a statistically significant effect at .05 level on each outcome. Model 1 was found to explain approximately 48% of the total variance of student achievement in mathematics and 43% in science and most of the explained variance is at the student level.

Table 4. Parameter estimates and (standard errors) for the analysis of student achievement in mathematics (students within schools) (Models 0, 1, 2a–2i).

School factors	Model 0	Model 1	Model 2a	Model 2b	Model 2c	Model 2d	Model 2e	Model 2f	Model 2g	Model 2h	Model 2i
Fixed part (intercept)	330.5 (1.9)	33.7 (9.9)	31.9 (12.6)	34.1 (14.4)	29.5 (13.5)	29.8 (13.3)	32.2 (12.1)	26.5 (13.04)	39.1 (12.2)	37.1 (13.5)	30.6 (12.8)
<i>Student level</i>											
Prior achievement		0.7 (0.01)	0.7 (0.01)	0.7 (0.01)	0.7 (0.01)	0.7 (0.01)	0.7 (0.01)	0.7 (0.01)	0.7 (0.01)	0.7 (0.01)	0.7 (0.01)
<i>School level</i>											
Prior achievement		0.32 (0.03)	0.22 (0.04)	0.23 (0.04)	0.23 (0.04)	0.23 (0.04)	0.22 (0.04)	0.22 (0.04)	0.23 (0.04)	0.23 (0.04)	0.23 (0.04)
Eval. of teaching			11.2 (3.4)								
Eval. of SLE				9.3 (4.2)							
Teacher collab.					12.3 (4.1)						
Resources						10.6 (3.4)					
Relation with community							11.3 (2.9)				
Partnership								14.6 (3.9)			
Quantity of teaching									8.04 (3.1)		
Learning opp.										6.9 (3.1)	
Quality of teaching											9.7 (2.9)
<i>Variance components, %</i>											
School	23.7	4.9	3.2	3.3	3.2	3.2	3.4	3.2	3.2	3.3	3.2
Student	76.3	47.5	45.3	45.3	45.4	45.3	45.3	45.3	45.3	45.3	45.3
Explained		47.6	51.5	51.4	51.4	51.5	51.3	51.5	51.5	51.4	51.5
<i>Significance test</i>											
Loglikelihood	103,307	98,607	77,846	77,852	77,847	77,847	77,842	77,843	77,850	77,851	77,845
Reduction		4700	20,761	20,755	20,760	20,760	20,765	20,764	20,757	20,756	20,762
Degrees of freedom		2	1	1	1	1	1	1	1	1	1
p-value		.001	.001	.001	.001	.001	.001	.001	.001	.001	.001

Note: For each alternative Model 2 (i.e. Models 2a up to 2i) the reduction is estimated in relation to the deviance of Model 1.

Table 5. Parameter estimates and (standard errors) for the analysis of student achievement in mathematics (students within schools) (Models 0, 1, 3a–3c).

School factors	Model 0	Model 1	Model 3a	Model 3b	Model 3c
Fixed part (intercept)	330.5 (1.9)	33.7 (9.9)	30.5 (13.6)	24.2 (14.0)	30.6 (13.3)
<i>Student level</i>					
Prior achievement		0.7 (0.01)	0.7 (0.01)	0.7 (0.01)	0.7 (0.01)
<i>School level</i>					
Prior achievement		0.32 (0.03)	0.23 (0.04)	0.22 (0.04)	0.2 (0.04)
Overarching evaluation			11.8 (4.1)		
Overarching SLE				17.6 (5.2)	
Overarching policy teaching					10.9 (3.5)
<i>Variance components, %</i>					
School	23.7	4.9	2.7	2.4	2.6
Student	76.3	47.5	45.3	45.3	45.3
Explained		47.6	52.0	52.3	52.1
<i>Significance test</i>					
Loglikelihood	103,307	98,607	77,848	77,845	77,847
Reduction		4700	20,759	20,762	20,760
Degrees of freedom		2	1	1	1
<i>p-value</i>		.001	.001	.001	.001

Note: For each alternative Model 3 (i.e. Models 3a up to 3c) the reduction is estimated in relation to the deviance of Model 1.

At the next step of the analysis, for each student outcome (mathematics and science), different versions of Model 2 were established. In each version of Model 2, the first-order factor scores of the SEM models which refer to the school-level factors of the dynamic model were added one by one to Model 1. In [Tables 4–7](#), only the factors which were found to have a statistically significant effect on achievement are included and thus the factor concerning policy on quantity of teaching which was not found to have a statistically significant effect in science was not included in [Tables 6 and 7](#). Thus, the fitting of each of these models was tested against Model 1, and the likelihood statistic (X^2) shows a significant change between Model 1 and each version of Model 2 ($p < .001$). This implies that variables measuring the school factors mentioned in each table have significant effects on student achievement in mathematics and science. Each version of Model 2 (Models 2a–2i and 2a–2h, respectively), explains approximately 51% of the total variance of student achievement in mathematics and approximately 49% of the total variance of student achievement in science.

Finally, in Models 3a–3c, the three overarching factors were added separately in Model 1 to see their impact on student achievement. All three overarching factors were found to be associated with student achievement in each subject. The fitting of each version of Model 3 (Models 3a–3c) was tested against Model 1, and the likelihood statistic shows a significant change between Model 1 and each version of Model 3 ($p < .001$). Each version of Model 3 explains approximately 52% of the total variance of student achievement in mathematics and approximately 50% of the total variance of student achievement in science. As can be seen in [Tables 4–7](#), Models 3a–3c have a better fit to the data than the respective Models 2 in which only a first-order factor score was included, as they explain more of the variance. This indicates that more than one first-order factor score are necessary to explain variance on student achievement. Moreover, when more than one first-order factors were included in Model 1, the model was found to fit better to the data than each version of Model 2. For example, when the two factors of the SLE concerned with the relations with the community and the school's partnership policy were added together

Table 6. Parameter estimates and (standard errors) for the analysis of student achievement in science (students within schools) (Models 0, 1, 2a–2h).

School factors	Model 0	Model 1	Model 2a	Model 2b	Model 2c	Model 2d	Model 2e	Model 2f	Model 2g	Model 2h
Fixed part (intercept)	318.03 (2.1)	40.4 (10.2)	29.7 (13.1)	35.6 (15.4)	28.4 (14.1)	34.5 (13.9)	34.7 (12.0)	31.3 (13.8)	38.9 (3.5)	34.1 (12.9)
<i>Student level</i>										
Prior achievement		0.54 (0.01)	0.56 (0.01)	0.56 (0.01)	0.56 (0.01)	0.56 (0.01)	0.56 (0.01)	0.56 (0.01)	0.56 (0.01)	0.56 (0.01)
<i>School level</i>										
Prior achievement		0.39 (0.04)	0.32 (0.04)	0.34 (0.04)	0.32 (0.04)	0.34 (0.04)	0.31 (0.04)	0.32 (0.04)	0.33 (0.04)	0.32 (0.04)
Eval. of teaching			12.6 (3.9)							
Eval. of SLE				8.7 (4.8)						
Teacher collaboration					13.5 (4.7)					
Resources						8.8 (3.8)				
Relation with community							11.9 (3.5)			
Partnership								12.5 (4.6)		
Learning opportunities									6.5 (3.5)	
Quality of teaching										9.3 (3.3)
<i>Variance components, %</i>										
School	30.9	7.8	4.8	5.0	4.8	5.0	4.7	4.9	5.0	4.9
Student	69.1	48.9	46.2	46.2	46.2	46.2	46.2	46.2	46.2	46.2
Explained		43.3	49.0	48.8	49.0	48.8	49.1	48.9	48.8	48.9
<i>Significance test</i>										
Loglikelihood	99,395	95,962	75,645	75,652	75,647	75,650	75,644	75,648	75,652	75,647
Reduction		3433	20,317	20,310	20,315	20,312	20,318	20,314	20,310	20,315
Degrees of freedom		2	1	1	1	1	1	1	1	1
p-value		.001	.001	.001	.001	.001	.001	.001	.001	.001

Note: For each alternative Model 2 (i.e. Models 2a up to 2h) the reduction is estimated in relation to the deviance of Model 1.

Table 7. Parameter estimates and (standard errors) for the analysis of student achievement in science (students within schools) (Models 0, 1, 3a–3c).

School factors	Model 0	Model 1	Model 3a	Model 3b	Model 3c
Fixed part (intercept)	318.03 (2.1)	40.4 (10.2)	29.5 (14.3)	24.7 (14.5)	36.1 (13.7)
<i>Student level</i>					
Prior achievement		0.54 (0.01)	0.56 (0.01)	0.56 (0.01)	0.56 (0.01)
<i>School level</i>					
Prior achievement		0.39 (0.04)	0.33 (0.04)	0.32 (0.04)	0.33 (0.04)
Overarching eval.			12.5 (4.6)		
Overarching SLE				18.5 (6.1)	
Overarching teaching					8.9 (4.1)
<i>Variance components, %</i>					
School	30.9	7.8	3.9	3.5	4.2
Student	69.1	48.9	46.2	46.2	46.2
Explained		43.3	49.9	50.3	49.6
<i>Significance test</i>					
Loglikelihood	99,395	95,962	75,648	75,646	75,650
Reduction		3433	20,314	20,316	20,312
Degrees of freedom		2	1	1	1
<i>p-value</i>		.001	.001	.001	.001

Note: For each alternative Model 3 (i.e. Models 3a up to 3c) the reduction is estimated in relation to the deviance of Model 1.

in one model to test their effect in mathematics achievement, the model was found to have a better fit to the data in comparison to the models where these two factors were added separately (i.e. Models 2e and 2f). Specifically, the likelihood statistic of the model with the two first-order factors had a significant reduction in comparison to Model 2e and model 2f ($X^2 = 77,839$) and the model explained 52.1% of the variance.

To search for the extent to which each school factor is associated with student achievement gains in each country, separate within-country multilevel analyses (students within schools) were conducted. For each subject, prior achievement and student background variables were, initially, added to the empty model (i.e. Model 1). By following the same approach as above, the first-order factor scores of the SEM models which refer to the school-level factors of the dynamic model were added one by one to Model 1. Due to space limitations, the within-country analyses are not presented but are available in the web page of the project (see www.ucy.ac.cy/esf). However, in order to estimate the relative importance of each factor, the effect sizes of each factor on student achievement in mathematics and science emerged from both the across- and within-country analyses were estimated (see Tables 8 and 9). Specifically, the fixed effects obtained with multilevel analysis were converted to standardised effects or 'Cohen's d' by following the approach proposed by Elliot and Sammons (2004) which describes the change on the outcome measure that will be produced by +/- one standard deviation on the continuous predictor variable, standardised by the within school standard deviation adjusted for covariates in the model. Thus, the relative strength of the effects of each factor can be compared more easily across the two outcome measures and across the participating countries. The following observations arise from Tables 8 and 9.

First, it is shown that the school factors of the dynamic model were found to have an effect ranging from 0.13 to 0.21. Even though the values of the average effect sizes of the school effectiveness factors can be considered as small, they correspond to the average effect sizes that were demonstrated through two recent meta-analyses searching for the impact of school factors on student outcomes (see, Kyriakides et al. 2010; Scheerens et al. 2005).

Table 8. Effects of each school factor on student achievement in mathematics (as expressed by Cohen's d) in each country and across countries.

Scales	Across countries	Belgium	Cyprus	Germany	Ireland	Slovenia
<i>Scale 1: School policy on teaching</i>						
(1) Quantity of teaching	.14	.14	.15	.12	N.S.S	.11
(2) Provision of learning opportunities	.13	.11	N.S.S	.13	.12	N.S.S
(3) Quality of teaching	.18	.15	.17	.16	N.S.S	.14
<i>Scale 2: Policy on the school-learning environment (SLE)</i>						
(1) Partnership policy	.18	N.S.S.	.16	.15	.15	N.S.S
(2) Relation with the school community	.19	N.S.S	.19	.18	.17	.17
(3) Teacher collaboration	.15	.10	.13	.12	.14	.13
(4) Provision of learning resources to students and teachers	.16	N.S.S	.18	.17	.15	.16
<i>Scale 3: Evaluation of the school policy on teaching</i>	.16	.13	.14	.16	N.S.S	.15
<i>Scale 4: Evaluation of the SLE</i>	.13	N.S.S	.12	.14	.12	.11

Second, these effect sizes also seem to support the argument that the school factors included in the dynamic model can be considered generic since only small differences in the effect sizes of the factors can be found in mathematics and science achievement. Namely, slightly higher effect sizes were observed in regard to science which, however, can be attributed to the fact that the variance at the school level was more pronounced in science (see empty models of Tables 4–7) and was thus in a position to allow for a better identification of the effect of the school factors.

Third, the generic nature of these factors could also be supported by comparing the effect sizes of each factor emerged from data in each country separately. In general, the reported effect sizes for each factor do not vary across the five participating countries (see Tables 8 and 9). However, for a few factors it was not possible to identify statistically significant effects in all countries. Nevertheless, all factors were found to be associated with achievement in at least three out of the five participating countries. Moreover, in those few cases that no statistically significant effects of factors are reported, one can see that the variance in the functioning of the factors in the respective countries was extremely small. One could therefore claim that this study provides some support to the generic nature of these factors at least in five European countries.

Table 9. Effects of each school factor on student achievement in science (as expressed by Cohen's d) in each country and across countries.

Scales	Across countries	Belgium	Cyprus	Germany	Ireland	Slovenia
<i>Scale 1: School policy on teaching</i>						
(1) Quantity of teaching	N.S.S	.12	N.S.S.	.11	N.S.S	.10
(2) Provision of learning opportunities	.14	.11	.13	.12	N.S.S	.12
(3) Quality of teaching	.18	.16	.19	N.S.S	.18	.17
<i>Scale 2: Policy on the school-learning environment (SLE)</i>						
(1) Partnership policy	.19	.15	.17	.18	.17	N.S.S
(2) Relation with the school community	.20	N.S.S	.17	.18	N.S.S	.17
(3) Teacher collaboration	.19	.09	.12	.11	.10	.10
(4) Provision of learning resources to students and teachers	.15	N.S.S	.13	.14	.12	.11
<i>Scale 3: Evaluation of the school policy on teaching</i>	.21	.17	N.S.S	.18	.19	.17
<i>Scale 4: Evaluation of the SLE</i>	.14	N.S.S	.12	.13	.13	.11

Finally, some factors were found to have a slightly greater effect on student achievement, such as school policy on the quality of teaching, partnership policy and policy on the relation with the school community. These differences in the effect sizes were small (not greater than 0.07), but imply that effective schools should develop a policy on teaching as well as a policy on establishing a learning environment in both subjects (i.e. mathematics and science).

Implications

This paper contributes to existing knowledge on school effectiveness by exploring the impact of school policy on teaching and the SLE on student progress in mathematics and science across five countries with very different educational systems. Previous research testing the dynamic model of educational effectiveness had focused on a single country but analyses presented in this paper show the value of using the model for comparative research. Although this comparative study was not in a position to have a precise measure of the school effect and the reported variances at school level in both subjects were much smaller than those reported in national studies (see Reynolds et al. 2014; Muijs et al. 2014), school factors concerned with policy for teaching, the SLE and the school evaluation were able to explain student achievement gains in each subject. Thus, implications of findings for policy and practice in these countries can be drawn.

Since the factors included in the dynamic model were found to be associated with student achievement gains, one could claim that schools should develop strategies and action plans aiming to improve the functioning of these factors and through that to promote student learning outcomes (Creemers and Kyriakides 2012). This argument could also be attributed to the fact that most schools in each country were found to perform below the midpoint of the scale. For example, the factors that were found to underperform in Cyprus referred to the establishment of a policy regarding partnership and collaboration with the community as well as to school policy on the quantity of teaching, while in Germany weaknesses were found in school policy on teacher collaboration. (More information on the functioning of school factors per country can be found in the web page of the project). These country differences in the functioning of school factors may also assist policy makers in each country to identify areas that need to be addressed at national level. For example, policy makers in Cyprus may have to take actions to assist schools in improving their policy for maximising the use of teaching and learning time rather than focusing on improving the policy on providing opportunities for learning since schools in Cyprus were found to perform better in this factor than the policy on quantity of teaching. Similarly, the results of this study seem to reveal that policy makers in Slovenia may have to support schools in taking actions to improve their policy on quality of teaching rather than the policy on quantity of teaching since schools in this country were found to perform less well in relation to policy on quality rather than quantity of teaching.

It should also be acknowledged that in each country a between-school variation in the functioning of school factors has been identified. This implies that the management team of each school should collect data on the functioning of these factors and identify those factors that may perform less well in their own school in order to develop strategies and action plans to improve the functioning of these factors and through that to promote

student learning. By demonstrating that specific school-level factors are associated with student gains, the results of this study may, therefore, assist the development of school improvement policies in regard to the factors included in the dynamic model that were found to perform less well. School evaluation data may also reveal which aspects of these factors need to be improved and develop a more focused improvement strategy and action plans to enhance these specific aspects of the factors (Muijs and Reynolds 2000). For example, school evaluation data may reveal that actions on improving policy on quantity of teaching should be more focused on how to handle student and teacher absenteeism rather than any aspect of the factor on quantity of teaching. In this context, an approach to school improvement could be developed that takes into account the results of school evaluation to identify improvement priorities and use the knowledge base of educational effectiveness research to design improvement strategies and action plans (Creemers and Kyriakides 2015).

Implications of the findings of this study for research can also be drawn. It should first of all be acknowledged that this study was not in a position to generate measures of each dimension per school factor. This finding could be attributed to the difficulties which were faced in producing a teacher questionnaire addressing the functioning of these factors in a quite diverse context. By removing items that were not in line with actions that are familiar to all the participating countries, the final specification table of the questionnaire did not cover the five dimensions of each factor. It may also be possible that due to this decision we were not in a position to pick up the variance in the functioning of factors that may exist in each country. As a consequence, in few cases the effect sizes of school factors were not found to be statistically significant (see Tables 8 and 9). Nevertheless, the construct validity of the final questionnaire was demonstrated through conducting both within- and across-country SEM analyses. This implies that the instrument which was developed can be used as a starting point for further international studies which may try to measure all five dimensions of the school factors. By initially conducting group interviews with headteachers in each country, we may find out how to cover all five dimensions of these factors in a way that is in line with the context of all countries and pick up the variance in the functioning of factors in each country. This finding can also be seen as an indication of the difficulties that we face in testing a complex model of educational effectiveness through an international study rather than through quantitative syntheses of national studies (see Kyriakides et al. 2010).

We also need more longitudinal and experimental studies to search for the impact of school organisational factors such as the SLE and the school policy on teaching. The study reported here was in a position to search for only direct effects of school factors whereas the dynamic model is based on the assumption that school factors have mainly indirect effects. By conducting longitudinal studies which will take place for more than one school year, one may see the impact of school factors on changing the SLE and improving the teaching practice and through that on promoting student learning outcomes (Heck and Moriyama 2010; Hendriks 2014). Moreover, longitudinal and experimental studies may investigate the impact of changes in the functioning of the school factors upon changes in the effectiveness status of schools (see Creemers and Kyriakides 2010b). Finally, we need further research aiming to support schools in their attempt to improve their SLE and their policy on teaching. These studies may not only help us to model school effectiveness through understanding the impact of school factors upon

student achievement but also to establish a dynamic approach towards improving school effectiveness.

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