Journal of Science Education

ISSN 0124-5481

Influencing Factors of PISA Science Performance: a Qualitative Meta-analysis

ZiLong Wang[a†], Xinyu Song[b†], Qianqian Xiu[c†], Song Gao[*d], Jingying Wang[*c]

[a] *People's Government of Xiaozhi Town, Pingyin County, Jinan, China*

[b] *High School Affiliated to Shandong Normal University, Jinan, China*

[c] *Normal College, Qingdao University, Qingdao, China*

[d] *School of Physics and Electronics, Shandong Normal University, Jinan, China*

A R T I C L E I N F O

Keywords:
PISA
Scientific achievements
Influencing factors

A B S T R A C T

This study takes a qualitative meta-analysis method to conduct a more comprehensive analysis and integration of 16 studies from 2010 to 2017. From the five dimensions of country, society, school, class and student, this paper summarizes the influencing factors of PISA scientific performance. Major findings include that most studies of the influencing factors of PISA scientific performance focus on the relationship between the variables of school level, class level and student level and PISA science performance, especially the relationship between students' level and PISA science performance. Hierarchical linear modeling (HLM) and the analysis of regression equation were used as the primary research methods. These findings may provide insights for researchers and educators into research trends in the influencing factors of PISA scientific performance.

1. Theoretical framework

1.1. Literature Review

In the Program for International Student Assessment (hereafter PISA) of 2006, science was a major field of assessment. The studies found the influencing factors of PISA science performance are diverse.

The influencing factors of science performance have always been a hot topic for researchers. For instance, Jing-Wen et al. (2016) explored the conceptual changing factors that affect most students' science learning process and learning outcomes by accessing the ERIC and using content analysis methods and came to the following conclusions: 1) balance the relationship between teaching intervention and personal characteristics; 2) reexamine the role of teachers and the epistemology of students; 3) strengthening the link between disciplines and teaching methods. Ömer et al. (2015), based on the regression analysis model, studied the impact of cognitive and motivational factors on science achievement of eighth-grade students in Turkey and gender differences on factors which significantly contributed significantly to the science achievement model. The study shows that girls outperform boys in science. In addition, based on the regression analysis model, as independent variables, the initial concept knowledge, scientific reasoning and the value of science can best help predict students' performance in science. The results also show that there is no difference between boys and girls in the initial concept knowledge and scientific reasoning, but there are differences in the practical value of science. Sandra & Hsien-Yuan (2013) analyzed three variables i.e. family, school and student with an aim of helping the youth in New Zealand and promote their PISA science performance. The study shows that family socioeconomic status (SES), the motivation of young people to learn science and the general value of science are important factors of influencing students' science achievement. The study also shows that there is a statistically significant interaction between SES and the first generation of immigrant families, but no significant interaction between SES and the second generation of immigrant families. In addition, although parents' views on the universal value of science have a positive impact on students' science performance, their predictive power is relatively limited. Odom et al. (2011) sampled 294 seventh-grade students who are enrolled in science-oriented schools across four different school districts and two charter schools and researched the relationship between the variables of students' attitudes towards science, student-centered teaching practices, computer use and traditional teaching practices and students' science performance based on the multiple regression analysis. The study shows that the attitudes towards science and student-centered teaching practices are both positively related to students' scientific achievement, and that student-centered teaching practices are positively related to the attitudes towards

---

†Zilong Wang , Xinyu Song and Qianqian Xiu are first authors,*Song Gao and Jingying Wang are corresponding authors.

* Corresponding author: Song Gao; Jingying Wang
Email: gaosong@sdnu.edu.cn; wangjingying8018@126.com

Accepted 2 October 2021, Available online 31 December 2021

science, while computer use and students' scientific achievement impact on students' scientific achievement.

In addition to the study of the influencing factors of scientific achievement, research on the influencing factors of PISA science performance has always been a topic for researchers. For instance, based on the structural equation model, Duygu (2011) carried out a study in Turkey and found that among the variables that can help predict and determine students' scientific achievement, the most important one is time, followed by the factor of environment, then by teaching, and a low positive correlation was identified between science performance and students' attitudes towards science. In the study of 10 regions with the best performance in PISA, Kwok-chi and Terence (2017) explored the relationship between teaching practices and science performance based on hierarchical linear modeling and it was found that teaching factors such as teachers' guidance are positively correlated with science performance in all regions. Milan and Katerina (2010), based on secondary analysis, studied students in Czech and found that those with some knowledge in information and communication technology (ICT) had better science performance in PISA. In addition, compared with those students who are not involved in ICT activities and educational processes, students who are involved had higher scores. Up to now, there are many studies centering on the influencing factors of science performance in PISA, but there is no study that systematically describes the influencing factors of science performance in PISA.

By analyzing the literature on the influencing factors of science performance, we found that the research samples in the literature are relatively simple, and the research results are not very consistent. The use of PISA data to study the factors of affecting science performance solves the problems in previous research and makes the research more comprehensive. Moreover, much of the previous research adopted the method of literature review, while in this study we adopted the ideas of Hattie, J. (2009) and used the qualitative meta-analysis method to analyze the literature collected, so as to systematically clarify and summarize the influencing factors of PISA science performance.

1.2.Research questions

Although many researchers carried out their study on the influencing factors of PISA science performance, the specific relationship between PISA science literacy and the influencing factors needs to be analyzed and summarized in depth. Therefore, the research questions of this study are as follows:

(1) What is the research status of previous studies on PISA science literacy and the influencing factors (study design, publication time, country involved, variables, etc.)?

(2) What are the characteristics of the previous studies (data sources, data processing methods, etc.)?

(3) What are the specific research results of these studies?

2. Research methods

2.1. Literature collection

First, we accessed the Web of Science database, focused on its core collection and entered the key terms PISA and science. The screening criteria at this stage are: 1) the title contains the key terms PISA and science; 2) the document type is article; 3) publication language is English; 4) the categories on the Web of Science are EDUCATION and EDUCATIONAL RESEARCH. At this stage, 36 articles were obtained. Then, at the second stage, the title, abstract or full text of the above-mentioned 36 articles were read and sorted again based on the following criteria: 1) the research objects includes PISA science performance; 2) the research must involve the influencing factors of PISA science performance. At this stage, 17 articles were obtained. Then, at the third stage, the full text of the above 17 articles were carefully read, and the articles were further sorted according to the following criteria: the articles must be in consistency with our classification framework of the influencing factors of PISA science literacy. Therefore, the final number of valid articles is 16.

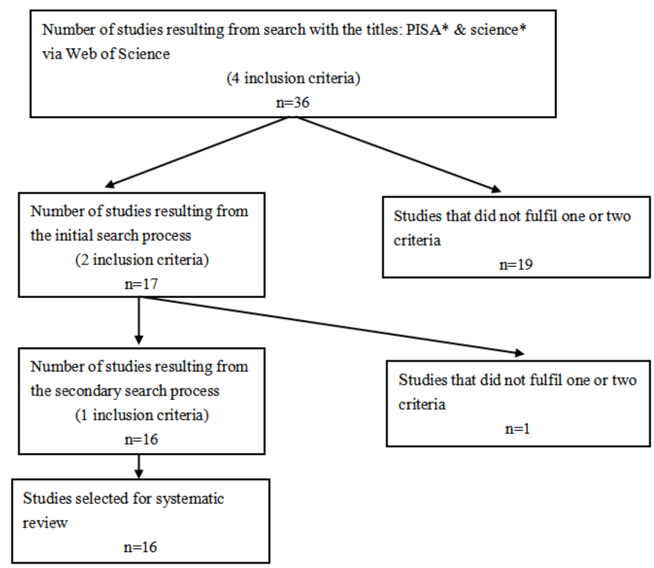

Fig. 1. Literature search and sorting flow chart.

2.2 The influencing factors of PISA science performance

This study classified the influencing factors of PISA science performance into five major categories, namely, national level, social level, school level, class level and student level (Terence and Kwok, 2014; Kwok-chi and Terence ,2017; Danhui and Luman, 2015). Specific categories are detailed below.

3. Analysis of the research

Based on the ideas put forward by Petticrew and Roberts (2006), we designed a table containing the information about the research (author, publication year, sample description, country involved, database and research methods; see Table 1), summarized and compared these studies and researched some relevant variables as described in the following subsections, hoping to clarify the theoretical basis for the influencing factors of PISA science literacy.

Table 1. Overview of the included studies.

Study	Sample	Country	Large-scale data base	Method,analysis
Andrew et al. (2014)	170 schools, 4,823 students (New Zealand) 356 schools, 14,216 students (Australia) 896 schools, 22,646 students (Canada)	Australia, United kingdom	PISA 2006 (Australia,Canada,New Zealand)	Quantitative, retrospective (secondary) analysis

Table 1. Continue

Study	Sample	Country	Large-scale data base	Method,analysis
Duygu (2011)	160 schools, 4,942 students (Turkey)	Turkey	PISA 2006 (Turkey)	Mixed methods, structure equation modelling
Danhui and Luman (2015)	1,241,031 students	China	PISA 2000 2003 2006 2009 2012	Quantitative, three-level hierarchical linear model
Esther (2010)	146 schools, 4,645 students (Hong Kong)	Honk Kong, China	PISA 2006 (Hong Kong)	Quantitative, hierarchical linear modelling
Feng and William F. (2015)	191,702 Students	United States of America	PISA 2006	Quantitative, marginal mean weighting through stratification (MMW-S) approach
Jari and Seppo (2009)	155 schools, 4,514 students (Finland)	Finland	PISA 2006 (Finland)	Quantitative, analysis of regression equation
Jaan et al. (2015)	470,000 students	Estonia	PISA 2009	Quantitative, multilevel analysis, multilevel regression analysis
Kwok-chi and Terence (2017)	4,000-20,000 students	Hong Kong, China	PISA 2015	Quantitative, hierarchical linear modelling analyses (HLM analyses)
Lorraine et al. (2010)	4,184 students	United Kingdom	PISA 2006 (Ireland)	Quantitative, multilevel model
Letao et al. (2012)	146 schools, 4,645 students	United States of America	PISA 2006 (Hong Kong)	Quantitative, multilevel modelling (MLM)
Marit and Svein (2011)	students from 60 countries	Norway	PISA 2006	Quantitative, Large-scale studies, international comparisons
Mustafa et al. (2014)	158 schools, 4,935 students (PISA 2006) 160 schools 4,964 students (PISA 2009)	Turkey	PISA 2006 2009 (Turkey)	Quantitative, hierarchical linear modeling (HLM)
Milan and Katerina (2010)	5,932 students (Czech Republic)	Czech Republic	PISA 2006 (Czech Republic)	Quantitative, the secondary analysis, one-way analyses of variance
Richard et al. (2010)	Students from New Zealand and Thailand	New Zealand, Thailand	PISA 2006 (New Zealand and Thailand)	Qualitative, comparative method
Rodger and Barry (2011)	Students from 20 countries or areas	Australia	PISA 2006	Quantitative, non-contextualisted students questionnaire, contextualized questions
Terence and Kwok (2014)	146 schools, 4,645students	Hong Kong, China	PISA 2006 (Hong Kong)	Quantitative, hierarchical linear modeling

3.1 Research Design

Of the 16 articles, there are 14 quantitative studies, accounting for 87.5% of the total; 1 qualitative study, accounting for 6.25% of the total and 1 mixed study, accounting for 15.79% of the total.

3.2 Country involved in the research

From the country involved in the research of the influencing factors of PISA science literacy, Hong Kong, China is an intensively studied area, followed by Turkey, Australia, the United States and the United Kingdom, each with 2 articles. Considering the continents, Asian researchers (represented by those from Hong Kong, China) and European ones (represented by those from the United Kingdom) are the most active, with 7 articles respectively.

3.3 Data sources

In terms of data sources, 12 of the 16 studies (accounting for 75%) researched the data of the 2006 PISA, among which 4 researched the comprehensive data of the 2006 PISA, and the remaining 8 researched the PISA data involving one country/region, or several countries/regions. Among these 8 studies, 3 studies researched the PISA data of Hong Kong and the other 5 studies researched the PISA data of Finland, Ireland, Turkey, the Czech Republic, Australia, Canada and New Zealand. In addition, 2 studies (accounting for 12.5%) researched the PISA data in 2009 and 2015, respectively. 1 study (accounting for 6.25%) researched the PISA data in 2006 and 2009 of the Czech Republic. In the study carried out by Danhui & Luman (2015), the comprehensive PISA data from 2000 to 2012 was analyzed.

3.4 Statistical analysis of data

In terms of statistical methods, 5 studies adopted hierarchical linear modeling (HLM). 2 studies adopted the following four statistical methods respectively: multilevel modelling (MLM), international comparisons, retrospective (secondary) analysis, multilevel regression analysis (analysis of regression equation). Another 3 studies used structure equation modelling, marginal mean weighting through stratification (MMW-S) approach, noncontextualized students questionnaire and contextualized questions, respectively.

3.5 Studied variables

This study is to explore the influencing factors of PISA science literacy scores, so the dependent variable is PISA science literacy scores. In different articles, the representation of this dependent variable is also different, as shown in Table 2. In most of the articles (10 in total), science literacy scores or science achievement scores were adopted as the representation of this dependent variable.

In the study carried out by Andrew et al. (2014), besides the science literacy performance, there were another two dependent variables: interest in learning science and students' levels of engagement in science (students' general interest in science, enjoyment of science, personal and general valuing of science, science self-efficacy and science self-concept).

In the study carried out by Feng and William F. (2015), besides the science achievement, interest in science and support for scientific inquiry were another two dependent variables studied.

In the study by Esther (2010), the specific indicators of cognitive and affective performance from PISA 2006, i.e. the scale that represents the overall achievement of knowledge and skills of science and self-efficacy in science were studied as dependent variables.

Another two studies (Terence and Kwok, 2014; Kwok-chi and Terence, 2017) focused on the dependent variable the cognitive component of scientific literacy.

Lorraine et al. (2010) categorized students into low, middle and high achievers based on PISA proficiency levels and focused on this dependent variable.

Most of the variables concerning students' levels of engagement in science (students' general interest in science, enjoyment of science, personal and general valuing of science, science self-efficacy and science self-concept.) were studied as independent variables of affecting PISA science literacy except in the study by Andrew et al. (2014) in which they were considered as dependent variables. Esther (2010) also studied the variable of science related self-efficacy as a dependent variable.

Except for two studies (Andrew et al, 2014; Feng and William F., 2015) in which interest in learning science was researched as a dependent variable, the rest of the studies researched this variable as an independent variable of influence PISA science literacy scores.

The categorization and analysis of the independent variables are discussed in the following sections.

Table 2. Dependent variables.

Study	Dependent variables
Andrew et al. (2014)	Science literacy performance, Interest in learning science, Students' levels of engagement in science, (students' general interest in science, enjoyment of science, personal and general valuing of science, science self-efficacy and science self–concept.)
Duygu (2011)	Science achievement scores
Danhui and Luman (2015)	Science literacy scores
Esther (2010)	Specific indicators of cognitive and affective performance from PISA 2006: the scale that represents the overall achievement of knowledge and skills of science and self-efficacy in science.
Feng and William F. (2015)	Science achievement, Interest in science, Support for scientific inquiry
Jari and Seppo (2009)	Science literacy scores
Jaan et al. (2015)	Science achievement scores
Kwok-chi and Terence (2017)	The cognitive component of scientific literacy
Lorraine et al. (2010)	Students were categorized into low, middle and high achievers based on PISA proficiency levels
Letao et al. (2012)	Science literacy test scores
Marit and Svein (2011)	Science literacy test scores
Mustafa et al. (2014)	Science literacy test scores
Milan and Katerina (2010)	The sore in the science knowledge test
Richard et al. (2010)	Science literacy scores
Rodger and Barry (2011)	Science literacy scores
Terence and Kwok (2014)	The cognitive component of scientific literacy

4. Research results

We summarized the relationship between the influencing factors and PISA science literacy. We refer to our results as "effects" to distinguish between findings based on statistically meaningful tests and the qualitative or descriptive analyses supplementing and explaining quantitative results. Table 3-7 shows the relationship between the influencing factors and PISA science performance (Sarah et al., 2018).

4.1 National level

Table 3 presents the country level factors' effects on PISA science performance. Country level factors include variables concerning science education reform, education management and Ln GDP.

Science education reform was researched in one study, which used a qualitative research approach.

The study shows that if investment is not made for scientific research and other scientific activities, or if there is no great investment in private sectors of health, economics, etc. the improvement of science education is unlikely to have effects.

Education management was researched in one study, which used a qualitative research approach.

Ln GDP was researched in one study, which used a quantitative research approach.

Table 3. Relationships between country level and PISA science performance.

National level	Effect (PISA science performance)	Study
Science education reform	+ (science literacy score in Thailand and New Zealand)	Richard et al. (2010)
Education management	+ (science literacy score in Thailand and New Zealand)	Richard et al. (2010)
Ln GDP	n.s. (science literacy scores)	Danhui and Luman (2015)

notes: effect directions marked with an asterisk are based on statistically significant results. insignificant effects revealed by significance tests are marked with n.s. effect directions without an asterisk are not based on statistically significant results but were revealed either by descriptive analyses (percentages or frequencies) or have been indicated by qualitative means (e.g. interviews).

4.2 Social level

Table 4 presents the social level factors' effects on PISA science performance. Social level factors are concerning culture.

Culture variables were researched in one study, which used a quantitative research approach.

This study shows that in assessing the role of culture and social values in science teaching, care should be taken in attributing the best performance of these regions to specific teaching practices, and then attributing these practices to specific cultural and social values (Kwok-chi and Terence, 2017).

Table 4. Relationships between social level and PISA science performance.

Social level	Effect (PISA science performance)	Study
Culture	n.s. (the cognitive component of scientific)	Kwok-chi and Terence (2017)

notes: the same as above

4.3 School level

Table 5 presents the school level factors' effects on PISA science performance. School level factors include variables of the teacher-student relations, teaching practices and curriculum.

School average SES was researched in six studies, all of which used a quantitative research approach.

Among them, four studies found a significant positive correlation between school average SES and PISA science performance.

Another study also found that school-level SES had a relationship with the classification of students based on their scientific performance in PISA. In the comparison of the two different levels, the correlation with school-level SES was significantly negative and not significant, respectively (Lorraine et al., 2010).

Another study found that school average SES has a significant positive impact on students' science performance. For each additional unit of average score, the students' scores were increased by approximately 54 points. These findings are consistent with the findings of Sun et al. (2012) and Ho (2010). However, Terence and Kwok (2014) found when the variable of students' academic ability was included, the impact of school SES became insignificant.

Girl school was researched in one study, which used a quantitative research approach.

The study found that girl school had no significant effects on PISA science performance in Hong Kong, Macao, China, Taipei, Singapore, Korea, Canada, Finland and Estonia, and there was even a negative correlation between girl schools and PISA science performance in Japan (Kwok-chi and Terence, 2017).

Boy school was researched in one study, which used a quantitative research approach.

The study found that there was a positive correlation between boy school and PISA science performance in Hong Kong, China, Taipei, Singapore, Japan, Korea, Canada, Finland and Estonia, but a negative correlation in Macao.

School types were researched in one study, which used a quantitative research approach.

At the school level, it was found both school type and school average SES showed a consistent significant positive correlation with students' scores in all the five PISA math and science literacy (Danhui and Luman, 2015).

Compweb index was researched in one study, which used a quantitative research approach.

It was found the COMPWEB index, which can show the use of Internet in schools, had a significant positive relationship with students' performance in maths and science. However, in 2012, it had a negative relationship with students' performance in these two subjects (Danhui and Luman, 2015).

Scmatedu was researched in one study, which used a quantitative research approach.

In contrast, it was found that SCMATEDU had a significant positive correlation with students' PISA scores in math and science, with the only exception in 2000 PISA (Danhui and Luman, 2015).

School enrolment size index was researched in 3 studies, all of which used a quantitative research approach.

Two studies found that school enrolment size was significantly positively correlated with PISA science performance, and another study found these two were significantly negatively correlated. In addition, in one of the former two studies, when the variables of school and student academic intake were included, the effects of school SES became insignificant and the effects of school enrollment size was also reduced by more than 60% (Terence and Kwok, 2014).

Location of school was researched in one study, which used a quantitative research approach.

Mustafa et al. (2014) found that among the school resources, the location of the school was the only factor that could explain the differences in PISA science performance in 2006 and 2009.

Shortage of science teachers was researched in one study, which used a quantitative research approach.

It was found that shortages of science teachers had a significant relationship with students' PISA science performance in 2006. (Mustafa et al., 2014).

Teacher-student ratio was researched in one study, which used a quantitative research approach.

Teacher-student ratio can help explain clearly the students' performance in PISA science in 2009. In schools with the small number of students per teacher, students scored significantly higher in science assessment. (Mustafa et al., 2014).

School student intake (medium) was researched in one study, which used a quantitative research approach.

It was found that school student academic intake (medium) had a strong correlation with the school's average science scores (Terence and Kwok, 2014).

School student intake (low) was researched in one study, which used a quantitative research approach.

It was found that school student academic intake (low) had a strong correlation with the school's average science scores (Terence and Kwok, 2014).

Table 5. Relationships between school level and PISA science performance.

School level	Effect（PISA science performance）	Study
School average SES	+* (the cognitive component of scientific)	Kwok-chi and Terence (2017)
	+* (science achievement and students' self-efficacy in science in Hong Kong)	Esther (2010)
	-* (L1 or below vs L2 to L4 in IRELAND) n.s. (L5 or L6 vs L2 to L4 in IRELAND)	Lorraine et al. (2010)
	+* (science literacy scores)	Danhui and Luman (2015)
	+* (science literacy test scores)	Letao et al. (2012)
	+* (The cognitive component of scientific literacy in Hong Kong) n.s. (The cognitive component of scientific literacy in Hong Kong when the variables of school student academic intake are included)	Terence and Kwok (2014)
Girl school	n.s. (the cognitive component of scientific in Hong Kong, Macao, China, Taipei, Singapore, Korea, Canada, Finland and Estonia) -* (the cognitive component of scientific in Japan)	Kwok-chi and Terence (2017)
Boy school	n.s. (the cognitive component of scientific in Hong Kong, China, Taipei, Singapore, Japan, Korea, Canada, Finland and Estonia) -* (the cognitive component of scientific literacy in Macao)	Kwok-chi and Terence (2017)
School type	+* (science literacy scores)	Danhui and Luman (2015)
COMPWEB	+* (science literacy scores in 2000 to 2009) -* (science literacy scores in 2012)	Danhui and Luman (2015)
SCMATEDU	-* (science literacy scores in 2000) +* (science literacy scores in 2003 to 2012)	Danhui and Luman (2015)
School enrolment size	+* (science literacy test scores in Hong Kong)	Letao et al. (2012)
	+* (science literacy test scores in PISA 2009 in Turkey)	Mustafa et al. (2014)
	+* (The cognitive component of scientific literacy in Hong Kong)	Terence and Kwok (2014)
Location of school	+* (science literacy test scores in PISA 2006 in Turkey) +* (science literacy test scores in PISA 2009 in Turkey)	Mustafa et al. (2014)
Shortage of science teachers	+* (science literacy test scores in PISA 2006 in Turkey)	Mustafa et al. (2014)
Teacher–student ratio	-* (science literacy test scores in PISA 2009 in Turkey)	Mustafa et al. (2014)
School student intake (medium)	-* (The cognitive component of scientific literacy in Hong Kong)	Terence and Kwok (2014)
School student intake (low)	-* (The cognitive component of scientific literacy in Hong Kong)	Terence and Kwok (2014)

notes: the same as above

4.4 Class level

Table 6 presents the effects of class level factors on PISA science performance. The factor of class level involves variables of teacher-student relationship, teaching practices and curriculum.

Teacher-student relationship was researched in one study, which used a quantitative research approach.

Several new ideas were put forward in the study:

1)The correlation between teacher-student relationship and PISA performance in different countries is different. The correlation between them is higher in more developed countries.

2)The correlation is slightly stronger at the class level than at the individual level, indicating that teachers should pay special attention to group activities.

3) At the national level, there are ecological fallacy effects of teacher-student relationship in all PISA countries, but if the geographically and culturally similar regions/countries are compared, there is no negative correlation between teacher-student relationship and PISA performance (Jaan et al., 2015).

The variables of teaching practices were researched in five studies, all of which used a quantitative research approach.

Four studies researched inquiry-based teaching practice. Surprisingly, it was found that most inquiry-based teaching practices had a significant negative correlation with PISA science performance. In addition, it was found that a small number of inquiry-based teaching practices were significantly positively correlated with PISA science performance..

The other variables of teaching practices had either significant positive or significant negative correlation with PISA science performance, as shown in Table 6.

Curriculum variables were researched in one study, which used a qualitative research approach.

Table 6. Relationships between class level and PISA science performance.

Class level	Effect（PISA science performance）	Study

a. Teacher-student relationship	+* (science achievement score at the school and students level) -* (science achievement score at the country level)	Jaan et al. (2015)
b. Teaching practices		
Perceived feedback	-* (the cognitive component of science)	Kwok-chi and Terence (2017)
Adaptive instruction	+* (the cognitive component of science in Hong Kong, Macao, China, Singapore, Japan, Korea, Canada, Finland and Estonia) n.s. (the cognitive component of science in Taipei)	Kwok-chi and Terence (2017)
Teacher−directed instruction	+* (the cognitive component of scientific)	Kwok-chi and Terence (2017)
Interactive Investigation (enquiry-based teaching)	-* (the cognitive component of scientific)	Kwok-chi and Terence (2017)
Interactive Application (enquiry-based teaching)	+* (the cognitive component of science)	Kwok-chi and Terence (2017)
Inquiry teaching	Level 0 -Level 4 (Student science achievement reached the highest point with Level 2 inquiry teaching) Level 0-Level 4 (student interest in science and support for scientific inquiry increased when the inquiry teaching level increased)	Feng and William F. (2015)
	-* (science literacy scores in Finland)	Jari and Seppo (2009)
	-* (science literacy performance) +* (interest in learning science, students' levels of engagement in science)	Andrew et al. (2014)
Student debate	-* (science literacy scores in Finland)	Jari and Seppo (2009)
Demonstration	+* (science literacy scores in Finland)	Jari and Seppo (2009)
Practical work	+* (science literacy scores in Finland)	Jari and Seppo (2009)
Student discussion	-* (science literacy scores in Finland)	Jari and Seppo (2009)
Students applying and modeling	n.s. (science literacy scores in Finland)	Jari and Seppo (2009)
Teachers' explaination (teaches)	n.s. (science literacy scores in Finland)	Jari and Seppo (2009)
Students' ideas and opinions are listened to	n.s. (science literacy scores in Finland)	Jari and Seppo (2009)
Quantity of instruction	+* (science literacy test scores in Hong Kong)	Letao et al. (2012)
c Curriculum variable		
Constructivist-based, learner-centred science curriculum	+ (science literacy score in Thailand and New Zealand)	Richard et al. (2010)
Curriculum assessment	+ (science literacy score in Thailand and New Zealand)	Richard et al. (2010)

notes: the same as above

4.5 Student level

Table 7 presents the effects of student level on PISA science performance. Student level involves variables concerning student background, students themselves and parents.

The factor of student background was researched in eight studies, seven of which used a quantitative research approach and 1 used a qualitative research approach.

Eight studies researched the factor of gender, and found most elements related with girl (relative to boy) had a significant negative correlation with PISA science performance. It was also found that only in Thailand that gender was positively correlated with PISA science performance (Richard et al., 2010). In the rest studies which researched the gender variable, gender was found not significantly associated with PISA science performance, as shown in Table 6.

Seven studies researched SES, and five of them found that there was a positive correlation between SES and PISA science performance. One of the remaining two also found SES was positively related to PISA science performance, but their relationship was insignificant. In the case of the increase in a standard deviation of SES, only 7 points increased. It was found that when the grade level was under control, the effect was no longer significant (Terence and Kwok, 2014). In another study, SES had a certain relationship with students' levels classified based on PISA science performance. In the comparison of the two different levels, it was found that SES had a significant negative correlation and a significant positive correlation with PISA science performance, respectively.

One study researched the first generation of immigrants, and found that children of first-generation immigrants tended to perform poorly in PISA except for Hong Kong, Macau and Singapore (Kwok-chi and Terence, 2017).

One study researched ethnicitiy and migrants in Thailand, which shows there was no significant relationship between ethnicity and PISA performance, for Thailand has never been colonized and has few migrants, but there was great relationship between gender and PISA performance. In New Zealand, the case is almost the opposite, there being not many gender-based differences considering PISA performance, but great differences in PISA performance occurred when race and immigration were taken into consideration (Richard et al., 2010).

Three studies researched the grade level, two of which found that the grade level was significantly positively correlated with PISA science performance..

One study researched students born in Chinese mainland (relative to those born in Hong Kong), and it found that students born in Chinese mainland had significantly lower scores than native students in PISA science performance (about 12 points lower than native students). Interestingly, this connection became positive after the variable of students' grade level was controlled, which means that the scores of students born in Chinese mainland were on average 24 points higher than those of students born in Hong Kong (Terence and Kwok, 2014).

Parental factors were researched in seven studies, six of which used a quantitative research approach and one used a mixed research approach.

Three studies researched parents' education and all found this factor was significantly positively correlated with PISA science scores.

Four studies researched culture (culture resources, cultural possession, cultural capital: low-medium, cultural capital: high-medium, log books index, possessions textbooks, possessions literature, possessions poetry and how many books at home), among which two studies found that culture had a significant positive correlation and no significant relationship with PISA science performance. Another study found that cultural capital: low-medium, cultural capital: high-medium and log books index have a relationship with student levels classified based on PISA science performance (Lorraine et al., 2010). Another study found that the culturally relevant factors mentioned above had either a significant positive correlation or a significant negative correlation with PISA science performance. (Mustafa et al., 2014).

Three studies researched material-related factors (material resources, how many computers, possessions dishwasher, how many cells phones, how many cars and environment). One study found the material resources had no significant relationship with PISA science performance. Another study researched four factors i.e. how many computers, possessions dishwasher, how many cell phones and how many cars and found that these factors either had a positive correlation or a negative correlation with PISA science performance, and even there were differences in the relationship between 2006 PISA and 2009 PISA. One study researched the environment which refers to the combination of educational resources and material resources, and found that it had a significant positive correlation with PISA science performance.

Two studies researched science activities at age 10. One study shows that when children were 10 years old, parental involvement in scientific activities of their children had the strongest positive correlation with PISA science performance of their children (Esther, 2010). The other study also found this factor had a significant positive correlation with PISA science performance. However, when the variable of students' attitude was under control, the impact of the scientific activities on 10-year-old students became insignificant (Terence and Kwok, 2014).

Two studies researched the factors related to communication and participation (educational and social communication, cultural communication, social and cultural communication, communication with school and participation in school). It was found that most of these factors had no significant relationship with PISA science performance, and a small number of them had a significant negative correlation with PISA science performance.

One study researched home language: other language-English or Irish and found that this factor had a certain relationship with student levels classified based on their PISA science performance.

One study researched parental views on science and found that parental views on science had a significant positive impact on PISA science performance.

One study researched parents' general value of science and found that parents' general value of science was significantly associated with their children's science performance. The general value of parents for science was a powerful predictor of students' science achievement. For each additional unit of parents' value, their children's scientific score increased accordingly by 11 points. However, when the variable of students' attitude was under control, the impact of parents' general value of science was reduced by about 50% (Terence and Kwok, 2014).

Student factors were researched in nine studies, eight of which used a quantitative research approach and one used a mixed research approach.

Three studies researched self-efficacy related to science and all identified a significant positive correlation between self-efficacy related to science and PISA science performance.

One study researched self-concept related to science and found that self-concept related to science had a significant positive impact on PISA science performance.

Two studies researched the four similar variables: their perception of the use of learning science for the future science job, their perception of the use of learning science for their future, future science job and future science orientation. All the variables have been found significantly negatively related to PISA science performance, except for the first variable.

Three studies researched the four similar variables: interest in science process, general interest in learning science, interest in science learning and interest in learning science topics, among which the first two variables had a significant negative correlation with PISA science performance, and the last two variables were significantly positively correlated with PISA science performance.

There are two studies that researched the general value of science to human beings and society. Both studies found that general value of science to human beings and society had a significant positive correlation with PISA science performance.

One study researched the variable of personal value of science and found that there was no significant relationship between personal value of science and PISA science performance. The variable of out-of-school science-related activities was also researched in a study which found this variable had no significant relationship with PISA science performance.

One study researched the three similar variables: Interest in physics and chemistry, interest in astronomy, interest in biology and geology. All the variables have been found significantly negatively related to PISA science performance, except for the first variable.

Two studies researched the variable of science enjoyment. One study found that the variable had no significant relationship with PISA science performance. The other found that the variable was significantly positively correlated with PISA science performance.

There was a relationship between student levels classified based on PISA science performance and their intent to leave school early: Yes-No and gender × intention to leave school early.

Two studies researched the influence of places for using a computer on PISA science performance.

One study researched students who used computers and the time on using computer, and they found both these two variables had a significant positive correlation with PISA science performance.

Two studies researched the reasons for using a computer. In the first study, most findings were expected. Students using ICT often got better test results. Only under three conditions when using ICT (i.e. playing games, educational software and creating programs), students got lower test scores (Milan and Katerina, 2010). In the second study, the different reasons for using a computer have different correlation with PISA science performance.

Two studies researched tasks on a computer. One explored the relationship between students' self-estimation of completing tasks and PISA science performance. The other study found that students' confidence in performing Internet tasks had always been beneficial to their performance in these two subjects. In terms of science, higher confidence was found to be an important positive factor in 2009 PISA (Danhui and Luman, 2015).

One study researched the variable time and found that it had a significant positive correlation with PISA science performance.

One study researched the factor attitude and found this factor had a significant positive correlation with PISA science performance.

Motivation was researched in one study and it was found that it had a positive impact on students' PISA science performance.

Table 7. Relationships between class level and PISA science performance

Students' levels	Effect (PISA science performance)	Study
a. Students' background		
GIRL (relative to boy)	-* (the cognitive component of scientific literacy)	Kwok-chi and Terence (2017)

Table 7. Continue

Students' levels	Effect (PISA science performance)	Study
	n.s. (science literacy scores in Finland)	Jari and Seppo (2009)
	-* (science achievement and students' self-efficacy in science in Hong	Esther (2010)

	Kong)	
	+ (science literacy scores in Thailand) n.s. (science literacy scores in New Zealand)	Richard et al. (2010)
	n.s. (L1 or below vs L2 to L4 and L5 or L6 vs L2 to L4 in IRELAND)	Lorraine et al. (2010)
	-* (science literacy scores in 2003 to 2012) n.s. (science literacy scores in 2000)	Danhui and Luman (2015)
	-* (science literacy test scores in Hong Kong)	Letao et al. (2012)
	-* (The cognitive component of scientific literacy)	Terence and Kwok (2014)
SES	+* (the cognitive component of scientific literacy in Hong Kong)	Kwok-chi and Terence (2017)
	+* (science achievement and students' self-efficacy in science in Hong Kong)	Esther (2010)
	+ (science literacy scores in Thailand and New Zealand)	Richard et al. (2010)
	-* (L1 or below vs L2 to L4 in IRELAND) +* (L5 or L6 vs L2 to L4 in IRELAND)	Lorraine et al. (2010)
	+* (science literacy scores)	Danhui and Luman (2015)
	+* (science literacy test scores in Hong Kong)	Letao et al. (2012)
	+* (The cognitive component of scientific literacy in Hong Kong) n.s. (The cognitive component of scientific literacy in Hong Kong when grade level is controlled)	Terence and Kwok (2014)
2nd generation of immigrants	+* (the cognitive component of scientific literacy in Macao, Taipei and Singapore) -* (the cognitive component of scientific literacy in Finland and Estonia) n.s. (the cognitive component of scientific in Hong Kong, Japan, Korea and Canada,	Kwok-chi and Terence (2017)
1st generation of immigrants	+* (the cognitive component of scientific literacy in Hong Kong, Macao and Singapore) -* (the cognitive component of scientific literacy in China, Korea, Canada, Finland) n.s. (the cognitive component of scientific literacy in Taipei, Japan and Estonia)	Kwok-chi and Terence (2017)
Ethnicitiy and migrants	n.s. (science literacy scores in Thailand) - (science literacy scores in New Zealand)	Richard et al. (2010)
Grade level	+* (the cognitive component of scientific literacy in Hong Kong, Macao, China, Taipei, Singapore, Korea, Canada, Finland and Estonia) n.s. (the cognitive component of scientific literacy in Japan)	Kwok-chi and Terence (2017)
	+* (The cognitive component of scientific literacy in Hong Kong)	Terence and Kwok (2014)
Grade: below grade9-Grade9	+* (L1 or below vs L2 to L4 in IRELAND) n.s. (L5 or L6 vs L2 to L4 in IRELAND)	
Grade: above grade9-Grade9	-* (L1 or below vs L2 to L4 in IRELAND) +* (L5 or L6 vs L2 to L4 in IRELAND)	
Born in mainland (relative to born in Hong Kong)	-* (The cognitive component of scientific literacy in Hong Kong) +* (The cognitive component of scientific literacy in Hong Kong when grade level is controlled)	Terence and Kwok (2014)
Born in other countries (relative to born in Hong Kong)	n.s. (The cognitive component of scientific literacy in Hong Kong)	Terence and Kwok (2014)
b.Parental factors		
Parents' education	+* (science literacy scores in Finland)	Jari and Seppo (2009)
	+* (science achievement score in Turkey)	Duygu (2011)
	+* (science literacy test scores in PISA 2006 in Turkey)	Mustafa et al. (2014)
Cultural resources	+* (science achievement and students' self-efficacy in science in Hong Kong)	Esther (2010)
cultural possession	n.s. (The cognitive component of scientific literacy in Hong Kong)	Terence and Kwok (2014)
Cultural capital: low-medium	n.s. (L1 or below vs L2 to L4 and L5 or L6 vs L2 to L4 in IRELAND)	Lorraine et al. (2010)
Cultural capital: high-medium	-* (L1 or below vs L2 to L4 in IRELAND) +* (L5 or L6 vs L2 to L4 in IRELAND)	Lorraine et al. (2010)
Log books index	-* (L1 or below vs L2 to L4 in IRELAND) +* (L5 or L6 vs L2 to L4 in IRELAND)	Lorraine et al. (2010)
possessions textbooks	-* (science literacy test scores in PISA 2006 in Turkey) +* (science literacy test scores in PISA 2009 in Turkey)	Mustafa et al. (2014)
Possessions literature	+* (science literacy test scores in PISA 2006 in Turkey) +* (science literacy test scores in PISA 2009 in Turkey)	Mustafa et al. (2014)
Possessions poetry	-* (science literacy test scores in PISA 2006 in Turkey) -* (science literacy test scores in PISA 2009 in Turkey)	Mustafa et al. (2014)
How many books at home	+* (science literacy test scores in PISA 2006 in Turkey) +* (science literacy test scores in PISA 2009 in Turkey)	Mustafa et al. (2014)
Educational resources	n.s. (science achievement and students' self-efficacy in science in Hong Kong)	Esther (2010)

Table 7. Continue

Students' levels	Effect（PISA science performance）	Study
Material resources	n.s. (science achievement and students' self-efficacy in science in Hong Kong)	Esther (2010)

How many computers	+* (science literacy test scores in PISA 2006 in Turkey) +* (science literacy test scores in PISA 2009 in Turkey)	Mustafa et al. (2014)
Possessions dishwasher	- * (science literacy test scores in PISA 2006 in Turkey)	Mustafa et al. (2014)
How many cell phones	+* (science literacy test scores in PISA 2009 in Turkey)	Mustafa et al. (2014)
How many cars	-* (science literacy test scores in PISA 2006 in Turkey) -* (science literacy test scores in PISA 2009 in Turkey)	Mustafa et al. (2014)
Environment (combination of educational and material resources)	+* (science achievement score)	Duygu (2011)
Science activities at age 10	+* (science achievement in Hong Kong) +* (self-efficacy in science in Hong Kong)	Esther (2010)
	+* (The cognitive component of scientific literacy in Hong Kong) n.s. (The cognitive component of scientific literacy in Hong Kong students' attitudinal factors are controlled)	Terence and Kwok (2014)
Educational and social communication	n.s. (science achievement in Hong Kong) n.s. (self-efficacy in science in Hong Kong)	Esther (2010)
Cultural communication	n.s. (science achievement in Hong Kong) n.s. (self-efficacy in science in Hong Kong)	Esther (2010)
Social and cultural communication	n.s. (The cognitive component of scientific literacy in Hong Kong)	Terence and Kwok (2014)
Communication with school	-* (science achievement in Hong Kong) n.s. (self-efficacy in science in Hong Kong)	Esther (2010)
Participation in school	-* (science achievement in Hong Kong) n.s. (self-efficacy in science in Hong Kong)	Esther (2010)
Home language: Other language-English or Irish	+* (L1 or below vs L2 to L4 in IRELAND) n.s. (L5 or L6 vs L2 to L4 in IRELAND)	Lorraine et al. (2010)
Parental views on science	+* (science literacy test scores in Hong Kong)	Letao et al. (2012)
Parents' general value of science	+* (The cognitive component of scientific literacy in Hong Kong)	Terence and Kwok (2014)
c. Student factors		
Self-efficacy related to science	+* (science literacy scores in Finland)	Jari and Seppo (2009)
	+* (science literacy test scores)	Letao et al. (2012)
	+* (The cognitive component of scientific literacy in Hong Kong)	Terence and Kwok (2014)
Self-concept related to science	+* (science literacy scores in Finland)	Jari and Seppo (2009)
Learning science is useful for the future science job	+* (science literacy scores in Finland)	Jari and Seppo (2009)
Learning science is useful for me from the point of view of my future	-* (science literacy scores in Finland)	Jari and Seppo (2009)
Future science orientation	-* (science literacy test score)	Marit and Svein (2011)
Future science job	-* (science literacy test score)	Marit and Svein (2011)
Interest in science process	-* (science literacy scores in Finland)	Jari and Seppo (2009)
Interest in science learning	+* (The cognitive component of scientific literacy in Hong Kong)	Terence and Kwok (2014)
General interest in learning science	-* (science literacy scores)	Rodger and Barry (2011)
Interest in learning Science topics	+* (science literacy scores)	Rodger and Barry (2011)
General value of science to human beings and society	+* (science literacy scores in Finland)	Jari and Seppo (2009)
	+* (The cognitive component of scientific literacy in Hong Kong)	Terence and Kwok (2014)
Personal value of science	n.s. (science literacy scores in Finland)	Jari and Seppo (2009)
Interest in physics and chemistry	+* (science literacy scores in Finland)	Jari and Seppo (2009)
Interest in astronomy	-* (science literacy scores in Finland)	Jari and Seppo (2009)
Interest in biology and geology	-* (science literacy scores in Finland)	Jari and Seppo (2009)
Out-of-school science-related activities	n.s. (science literacy scores in Finland)	Jari and Seppo (2009)
Science enjoyment	n.s. (science literacy scores in Finland)	Jari and Seppo (2009)
	+* (The cognitive component of scientific literacy in Hong Kong)	Terence and Kwok (2014)
Intend to leave school early: Yes-No	n.s. (L1 or below vs L2 to L4 and L5 or L6 vs L2 to L4 in IRELAND)	Lorraine et al. (2010)
Gender × Intention to leave school early	-* (L1 or below vs L2 to L4 in IRELAND) n.s. (L5 or L6 vs L2 to L4 in IRELAND)	Lorraine et al. (2010)
Places for using a computer	school (the highest mean score in Czech: once or twice a week the lowest mean score in Czech: never) home (the highest mean score in Czech: almost every day achieved the lowest mean score in Czech: never) other places (the highest mean score in Czech: once a month or less achieved the lowest mean score in Czech: almost every day)	Milan and Katerina (2010)

Table 7. Continue

Students' levels	Effect（PISA science performance）	Study
	-* (science literacy scores at school)	Danhui and Luman (2015)

	-* (science literacy scores at home in 2009) n.s. (science literacy scores at home in 2012)	Danhui and Luman (2015)
Students who used computers	+* (the score in the science knowledge test in Czech)	Milan and Katerina (2010)
The times on using computer	+* (the score in the science knowledge test in Czech)	Milan and Katerina (2010)
Reasons for using a computer	+* (the score in the science knowledge test in Czech except playing games, educational software, creating programmes)	Milan and Katerina (2010)
	-* (science literacy scores at program/software (PRGUSE) in 2000 to 2006)	Danhui and Luman (2015)
	+* (science literacy scores in Internet for fun (INTUSE) in 2012) -* (science literacy scores in Internet for fun (INTUSE) in 2003 to 2009) n.s. (science literacy scores in Internet for fun (INTUSE) in 2000)	Danhui and Luman (2015)
	-* (science literacy scores in Internet for education at school (SCHUSE) in 2009 to 2012)	Danhui and Luman (2015)
	-* (science literacy scores in Internet for education at home (HOMUSE) in 2009) n.s. (science literacy scores in Internet for education at home (HOMUSE) in 2012)	Danhui and Luman (2015)
Tasks on a computer	the highest mean score (I can do this very well by myself in every task except construct a web page in Czech) the lowest knowledge score (students who responded in all tasks I do not know what this means, except for the creating database task in Czech)	Milan and Katerina (2010)
	+* (science literacy scores in high-level tasks in 2009) -* (science literacy scores in high-level tasks in 2006) n.s. (science literacy scores in high-level tasks in 2003)	Danhui and Luman (2015)
	+* (science literacy scores in Internet tasks in 2003 to 2006)	Danhui and Luman (2015)
Time	+* (science achievement score in Turkey)	Duygu (2011)
Attitude	+* (science achievement score in Turkey)	Duygu (2011)
Motivation	+* (science literacy test scores in Hong Kong)	Letao et al. (2012)

notes: the same as above

5. Discussion

In terms of research contents, most of the studies researched the relationship between the variables of school level, class level and student level and PISA science performance, especially the relationship between students' level and PISA science performance. There are few studies on the variables of nation level and social level.

As far as the research results are concerned, there is a significant positive correlation between the variables of science education reform and education management at the national level and PISA science performance. The culture element at the social level has little effect on PISA science performance.

At the school level, except in one study, a significant positive correlation between school average SES and PISA science performance has been identified in most studies. So the factor of the school average SES needs to be paid attention to considering its important role. In addition, in all the studies a significant positive correlation has been identified between school enrolment size and PISA science performance.

At the class level, there is a certain ecological fallacy in the influence of teacher-student relationship on PISA science performance. When it comes to teaching practices, the relationship between inquiry-based teaching practice and PISA science performance is found complicated, and some studies even have identified a negative correlation between them, so teachers need to think more when they adopt the inquiry-based teaching practice, thus to make it have a positive impact on PISA science performance.

At the student level, except for in Thailand, the gender factor has a significant negative correlation with PISA science performance in all studies. Therefore, it is necessary to pay attention to the disadvantaged status of girls in scientific learning and try to help them. Meanwhile, it is found that SES also has a positive impact on PISA science performance. Therefore, it is necessary to pay more attention to families' economic situation and help those children with economic difficulties as much as possible. In addition, except for in Japan, there is a significant positive correlation between grade level and PISA science performance identified in all studies. Most studies have found a significant positive correlation between cultural and material resources and PISA science performance, except for science activities arranged at age 10, when most parental involvement in science activities is not related or negatively related to PISA science performance. Therefore, parents should focus on investment in education, rather than on involvement in education activities. In addition, all the studies have found a significant positive correlation between self-efficacy related to science and PISA science performance. Therefore, we should pay attention to the establishment of students' scientific self-efficacy.

Acknowledge

Fund for cultivating outstanding achievements in scientific research (Humanities and Social Sciences) colleges and universities of the Ministry of Education(RZ2100004649)

References

Petticrew, M., & Roberts, H. (2006). Systematic reviews in the social sciences: A practical guide. Malden: Blackwell.

Sarah R., Doris H., & Tina S. (2018). Encouraging a career in science: a research review of secondary schools' effects on students' STEM orientation

Sun, L., Bradley, K. D., & Akers, K. (2012). A multilevel modelling approach to investigating factors impacting science achievement for secondary school students: PISA Hong Kong Sample. International Journal of Science Education, 34(14), 2107–2125.

Ho, S. C. (2010). Family influences on science learning among Hong Kong adolescents: What we learned from PISA. International Journal of Science and Mathematics Education, 8(3), 409–428.

Ma, X. (2003). Measuring up: Academic performance of Canadian immigrant children in reading, mathematics and science. Journal of International Migration and Integration, 4(4), 541–576.

Zhang, D., & Liu, L. (2016). How does ict use influence students' achievements in math and science over time? evidence from pisa 2000 to 2012. Eurasia Journal of Mathematics Science & Technology Education, 12(9), 2431-2449.

Kubiatko, M., & Vlckova, K. (2010). The relationship between ict use and science knowledge for czech students: a secondary analysis of pisa 2006. International Journal of Science & Mathematics Education, 8(3), 523-543.

Mcconney, A., Oliver, M. C., Woods-Mcconney, A., Schibeci, R., & Maor, D. (2014). Inquiry, engagement, and literacy in science: a retrospective, cross - national

analysis using pisa 2006. Science Education, 98(6), 963–980.
Rodger Bybee, & Barry McCrae. (2011). Scientific literacy and student attitudes: perspectives from pisa 2006 science. International Journal of Science Education, 33(1), 7-26.
Topçu, M. S., Arıkan, S., & Erbilgin, E. (2015). Turkish student' science performance and related factors in pisa 2006 and 2009. Australian Educational Researcher, 42(1), 117-132.
Marit Kjærnsli, & Svein Lie. (2011). Students' preference for science careers: international comparisons based on pisa 2006. International Journal of Science Education, 33(1), 121-144.
Mikk, J., Krips, H., Ülle Säälik, & Kalk, K. (2015). Relationships between student perception of teacher-student relations and pisa results in mathematics and science. International Journal of Science & Mathematics Education, 14(8), 1437-1454.
Gilleece, L., Cosgrove, J., & Sofroniou, N. (2010). Equity in mathematics and science outcomes: characteristics associated with high and low achievement on pisa 2006 in ireland. International Journal of Science & Mathematics Education, 8(3), 475-496.
Dahsah, C. (2010). The influence of educational context on science learning: a cross‐national analysis of pisa. Research in Science & Technological Education, 28(1), 3-24.
Lavonen, J., & Laaksonen, S. (2010). Context of teaching and learning school science in finland: reflections on pisa 2006 results. Journal of Research in Science Teaching, 46(8), 922-944.
Lau, K., & Lam, T. Y. (2017). Instructional practices and science performance of 10 top-performing regions in pisa 2015. International Journal of Science Education, 39(15), 1-22.
Jiang, F., & Mccomas, W. F. (2015). The effects of inquiry teaching on student science achievement and attitudes: evidence from propensity score analysis of pisa data. International Journal of Science Education,37(3), 554-576.
Lam, T. Y. P., & Lau, K. C. (2014). Examining factors affecting science achievement of hong kong in pisa 2006 using hierarchical linear modeling. International Journal of Science Education, 36(15), 2463-2480.
Anil, D. (2011). Investigation of factors influencing turkey's pisa 2006 science achievement with structural equation modelling. Educational Sciences Theory & Practice, 11(3), 1261-1266.
Hattie, J. (2009). Visible learning: A synthesis of over 800 meta-analyses relating to achievement. New York: Routledge
Jing-Wen L., Miao-Hsuan Y., Jia-Chi L., Mei-Hung C., Chorng-Jee G. (2016). Examing the Factors That Influence Students' Science Learning Processes and Their Learning Outcomes:30 Years of Conceptual Change Research
Ömer A., Lütfullah T., Ahmet B. (2015). Examination of Gender Differences on Cognitive and Motivational Factors that Influence 8th Graders' Science Achievement in Turkey
Sandra T., & Hsien-Yuan H. (2013) Negotiating diversity: an empirical investigation into family, school and student factors influencing New Zealand adolescents' science literacy
Arthur L., Jacob M., Elizabeth R., & Jerzy M. (2011) Computers and Traditional Teaching Practices: Factors influencing middle level students' science achievement and attitudes about science