What Makes Students Perform in PISA? Science Teachers' Beliefs

Sofia Anastasiadou
Aikaterini Dimitriadou
University of Western Macedonia
Greece

Eleni Toda
Teacher of Physics in Secondary Education in Greece
Greece

Abstract

This research paper examines the educational requirements associated with students' response to Science issues included in PISA (Program for International Student Assessment) (OECD, 2010). Specifically, it attempts to detect the factors that may be responsible for Greek school 15 year old students' poor performance in Science competitions in PISA related to the teaching parameters applied in Greek school, as described by teachers themselves.

Keywords: educational requirements, PISA, Science, performance

School quality and student achievement

Students' performance in international assessment systems is important indicators of the quality of educational systems, as they refer to the characteristics of education related to the concept of effective schools (OECD, 2006; Sahlberg, 2007; Osborn & Dillon, 2008).

According to Hulpia & Valcke (2004), the starting point of school academic effectiveness is the school itself rather than students' background. Its criteria are clear statement of goals and ways of achieving them, purposeful teaching and learning opportunities provided to students, cooperation between those involved in the educational process, teachers' professional guidance by advisors, directors and academics, students' frequent assessment and positive reinforcement, as well as parental involvement in school processes (Sammons et al., 1995: 25-26). On this issue, Sammons et al. (1995: 10) suggest 11 factors, which are mainly associated with student performance in general examinations: professional leadership, shared vision and goals, a learning environment, concentration on teaching and learning, purposeful teaching, high expectations, positive reinforcement, monitoring progress, pupil rights and responsibilities, home-school partnership and a learning organization, aimed at school-based staff development.

Beyond education policies (Sahlberg, 2007), however, the most important factor in school effectiveness is the teacher (OECD, 2005; Darling-Hammond, 2000; Sammons et al., 1995: 7-9) although teacher quality is described in various and diverse ways within academic literature (Timmerling et al., 2010: 378-381).

Teachers differ with regard to the learning patterns they adopt, the quality of teacher learning and their professional development, which are associated with the obvious and non-obvious learning activities they implement (Vermunt and Endedijk, 2011). However, their beliefs, practices and attitudes, and the relationship between all those are related to the challenges teachers face at work and contribute to shaping the learning environment, climate, and school culture in general, affecting students' learning (OCED, 2009: 92; AAPT, 2009; Darling-Hammond, 2000; Bartholomew et al., 2004).

Teachers' practices and beliefs on teaching are related to their own qualities (age, gender, experience, education, training), as well as those of the class (AAPT, 2009). For example, female teachers tend to adopt greater use of structuring, student oriented practices and cooperative activities than their male counterparts (OCED, 2009: 113).

Great academic emphasis is on content knowledge, pedagogical knowledge, and pedagogical content knowledge as regards the curriculum (Darling-Hammond, 2000; Osborn & Dillon, 2008; AAPT, 2009), but also on constructive objectives, student-centered methods, and successful management of class problems. Moreover, structured teaching practices seem to ensure a good school climate, while student-centered practices are associated with the development of students' socialization (OECD, 2009: 91).

The lever of the school objectives achievement seems to be teachers' own satisfaction from their job (OECD, 2009: 119-120). Equally important is the cooperation between teachers, which is divided into two levels: exchange of educational material or discussion of students' learning problems, and the more general, innovative types of cooperation, such as peer teaching and feedback (OECD, 2009: 90). Research findings show that teachers' cooperation on peer teaching and reflection creates a climate of confidence. However, teachers do not feel comfortable in accepting colleagues in class, which shows insecurity at work (Postholm, 2008). Another important element is teachers' flexibility aiming at adapting teaching to students' learning abilities and developing appropriate strategies. However, there seems to be no particular teaching method that is considered to be better than others (Sammons et al., 1995).

Admittedly, however, contemporary teachers are expected to keep up with developments related to their own skills, knowledge and pedagogy (Osborn & Dillon, 2008), as well as students' learning readiness and diverse backgrounds with regard to perspectives of good teaching (Vermunt and Endedijk, 2011). These practices seem to shift from traditional, lecture based teaching to active, self-regulated student learning. As a result, teachers' pedagogic role demands their ability to apply student-centered learning approaches, to promote metacognitive regulative strategies for students, to design assignments, to coach project groups and to monitor and reflect on learning and thinking strategies of students (Bakkenes et al., 2010; Maclellan & Soden, 2011). An important element in the quality of their work is reflective feedback (Schon, 1983; Hulpia & Valke, 2004).

Teacher qualifications are related to student achievement (Darling-Hammond, 2000), which is not only limited to knowledge acquisition; it also includes metacognitive skills, which involve both information inquiry and elaboration, and other skills of understanding, checking and monitoring their learning process (Zimmerman, 2007; Osborn & Dillon, 2008; Molenaar et al., 2011).

Student achievement is also related to motivation, feedback, reflection, and development of critical thinking, aimed to confront students' epistemic beliefs (Sammons et al., 1995: 23; OECD, 2009: 118-119; Maclellan & Soden, 2011). In the same direction, student achievement assessment tools are used, such as the student portfolio (Arter & Spandel, 1992).

Assessing Students' Performance to PISA Science Items

Education policy orientation and planning of respective practices in each country are detected through international student assessment systems (OECD, 2006, 2007, 2009 & 2010). The aim is that information and comparative data on education systems internationally emerge, so that learning outcomes are monitored and reforms are implemented.

The Program for International Student Assessment (PISA), created in 1997, combines the assessment of domain-specific cognitive areas, namely science, mathematics and reading. Scientific literacy is the major domain being assessed (OECD, 2006: 20), as it focuses on 15 year old students' competences, knowledge and attitudes, assessing their knowledge of the natural world but also of science itself (OECD, 2006: 19-44 & 2007: 12-30; Dillon, 2009; Osborn & Dillon, 2008; Psalidas et al., 2008: 90-91; Pinto & Boudamoussi, 2009). It is worth noting that in this context there has been a strong negative correlation between students' interest in science and their achievement in science tests (Osborn & Dillon, 2008: 7).

Effective teaching of Science is primarily associated with students' engagement with science and scientific phenomena through investigative work and "hands-on" experimentation (Osborn & Dillon, 2008; Cunningham and Herr, 1994), aimed at the development of scientific thinking skills (Zimmerman, 2007).

Equally significant is teachers’ cognitive competence, their ability to collaborate with colleagues on issues related to science, use of open discussions with students, students' promotion to actively participate in the learning process and implementation of appropriate activities related to the subject they teach (Bartholomew et al., 2004).

However, in Finland, which notes outstanding performance in PISA (20% of all students in Finland are top performers in science, OECD 2009: 11), teachers are generally conservative and restrained in their relationships with students. And, while they have a high level of education, they are respected by society and parents and they do not undergo traditional types of control of their work, they themselves complain of increased pressure and workload. It is worth noting that they usually organize teaching in such a way that, after a short introduction, students work on their own or in teams under their supervision (Simola, 2005; Sahlberg, 2007). Education policies in Finland, however, give a strong emphasis on teaching and learning, encouraging schools "to craft optimal learning environments and establish instructional content that would best help students to reach the general goals of schooling" (Sahlber, 2007: 168).

It should be noted that research findings bring the advisability of publishing the PISA school results into question, and show that increasing competition between schools does not improve student achievement (Cobbold, 2010). Assessment techniques of student performance have also been questioned. It has been argued, for example, that "paper-and-pencil" tests in PISA in Science can not provide clear results on Greek students’ knowledge and capabilities, as students who were tested on the same subjects by use of an interview outperformed (Psalidas et.al., 2008). In general, PISA methods, however, enjoy international recognition by the educational community.
Greek school students’ performance in PISA are among the lowest in Europe: the 35th place among 57 countries worldwide in 2006 (OECD, 2007: 20), and 32nd place among 65 countries worldwide in 2009 (OECD, 2010: 15). This fact may be associated with both the curriculum and teachers’ perceptions and educational process. This paper attempts to detect the causes for Greek school students’ poor performance in Science in PISA, based on teachers’ beliefs.

The study

This study examines the educational requirements associated with students’ response to Science issues included in PISA (Program for International Student Assessment) (OECD, 2010). Specifically, it attempts to detect the factors that may be responsible for Greek school 15 year old students’ poor performance in Science competitions in PISA related to the teaching parameters applied in Greek school, as described by teachers themselves. It should be noted that in this study, students’ socio-economic characteristics are not the subject of investigation related to the topic, although PISA assessment allows considering performance differences between students and schools from varying socio-economic contexts (OECD, 2007: 31-37; Cobbold, 2010).

Next we present the research questions and research hypotheses formulated, our sample data, and the research method. Processing of results follows the method of implicative statistics (Gras, Peter, and Philippe, 1997; Bodin, Coutourier, Gras, 2000; Gras & Kountz, 2008), illuminating the parameters indicated by teachers as important for effective teaching, as well as the relationships between these parameters.

Research Questions

Having as a starting point the findings of international educational research on the factors influencing learning and teaching, the present study addressed the following research questions:

1. How important do teachers believe are the factors related to school characteristics for student performance in Science?
2. How important do they believe are the factors related to teachers’ characteristics?
3. How important do they believe is the factor of cooperation between teachers?
4. Which instructional practices do teachers believe are important for student performance in Science?
5. Which teaching approaches do teachers believe are important for student performance in Science?

To investigate the above factors we chose to study the factors that shape teaching, derived from the aforementioned theory. These parameters were organized on five thematic axes: school characteristics, teachers’ characteristics, cooperation between teachers, teaching practices applied in class, and educational approaches to Science teaching.

Thus, school characteristics include:

School Organization

- The small number of students in laboratory exercises;
- The approach to Science issues outside school;
- Curriculum reduction, and probing specific issues of Science;
- The institutionalization of a consecutive two-hour Science teaching in the curriculum;
- Reduction of students' Science homework;
- Cooperation with other schools.

The support system

- The use of different textbooks by students, which are to be selected by teachers;
- Operation of a fully-equipped Science lab at school;
- Existence of a library with Science books at school.

The school environment

- Students' esteem toward teachers;
- Trust and cooperation between parents and teachers;
- The financial support by the local government for courses out of school;
- Parents' involvement in school activities.

Teachers' characteristics examine:

The Teacher's Background
- Teachers' training in Science;
- Teachers' experience;
- Science teachers' pedagogical training;
- Evaluation of the teacher's work at school.

Teachers' self-efficacy

- Teachers' satisfaction from their job;
- Teachers' feeling of having a significant impact on their students' life;
- Teachers should feel successful in the classroom;
- Teachers should feel that they know how to handle their students.

As regards teachers' cooperation, the following are considered:
- Cooperation between teachers of the same specialty in teaching;
- Science teachers' support by mentors;
- Teachers should exchange teaching material;
- Teachers should attend other teachers' classes and reflect;
- Teachers should participate in joint projects of different classes and different age groups.

The practices which teachers apply regard:
Structured Teaching Practices
- Development of motivation from the part of students to attend the lesson;
- Explicit wording of goals of the daily lesson to students, and clear criteria for assessing student work;
- Examination/evaluation of errors as a means of feedback to students;
- Analysis of students' homework in class.

Constructive Teaching Practices
- Support students so that they learn to investigate;
- Support students so that they themselves find solutions to problems;
- Provide opportunities to students to think of solutions to practical problems before the teacher shows how they are solved.

Student-centred practices

• Support of diversity among students;
• Construction of teaching on problems of students' daily life;
• Students' work in small groups and common solution to the task they examine;
• Assignment by the teacher of different tasks to students who have difficulty from those who can work faster.

Supportive Practices

• Lesson elaboration by students using various techniques (use of diagrams, tables, images, etc.)
• Students' dealing with projects which require at least a week to complete;
• Students' facing issues on which they need to explain their thinking or justify their answer;
• Students\ practice in discussing and arguing on a particular point of view, even if it is not theirs.

Training approaches include:

• Implementation of interdisciplinary approaches to Science teaching;
• Use of multimodal texts in teaching;
• Implementation of educational techniques for the development of students' critical thinking;
• Use of new technologies in the learning process
• Students' evaluation through the "Portfolio";
• Implementation of differentiated instructional practices;
• Connection of Science with real life situations outside school.

Research Questions

In order to answer the above questions the following research hypotheses were set:

H01: All variables of the three sub-categories of the category School Characteristics interact by affecting Greek school students' successful response to PISA assessment in the same way.
H02: All variables of the three sub-categories of the category Teacher Characteristics interact by affecting Greek school students' successful response to PISA assessment in the same way.
H03: All variables of the category Teachers Cooperation interact by affecting Greek school students' successful response to PISA assessment in the same way.
H04: All variables of the four sub-categories of the category Teaching Practices interact by affecting Greek school students' successful response to PISA assessment in the same way.
H05: All variables of the category Pedagogical Approaches interact by affecting Greek school students' successful response to PISA assessment in the same way.

The research sample

The research sample was 207 Science teachers serving in high schools of Central and Western Macedonia, who completed the questionnaires. Out of them 117 (56.5%) were male and 86 (41.5%) female, and four (1.9%) gave no answer about gender. As regards their age, four (1.9%) were up to 30 years old, 32 (15.5%) were 31-40 years old, 89 (43%) were 41-50 years old, 81 (39.1%) were over 50 years old, and one did not respond (0.5%). As regards the years of service, 39 (18.8%) had 0-5 years of service, 68 (32.9%) had 6-15 years of service, 40 (19.3%) had 16-25 years of service, 48 (23 2%) had over 25 years of service, and 12 (5.8%) did not respond.

The research tool

The research tool was a questionnaire which included three demographic questions related to gender, age and years of service, and 49 Likert scale questions, in which the gradation of responses was in order of evaluation: 1 "not important", 2 " slightly important ", 3" somewhat important ', 4' very important ', 5' essential '. The questions were divided into five groups, which corresponded to the following factor categories: 1. School Characteristics; 2. Teacher Characteristics; 3. Teacher Cooperation; 4. Teaching Practices; 5. Educational Approaches.

School characteristics concern the school organization, the support system and the school environment. Teacher cooperation includes teaching, exchange of educational material, participation in joint projects, peer teaching, and educational support by mentors. As regards teachers' characteristics, they include their background and self-efficacy. Teaching practices concern structured and constructive teaching practices aimed at the student, and reinforced practices.

Moreover, teaching approaches examine interdisciplinary implementation, use of multimodal texts and New Technologies, use of educational techniques to develop students' critical thinking, implementation of different teaching practices, connection of Science with real conditions out of school, and use of Portfolio for students' evaluation.

Results

1. School characteristics

1.1. **Observations on the Similarity diagram**. The similarity diagram (Figure 1.1) shows the groups of variables based on Science teachers' attitudes and responses as regards School Characteristics. The similarities in bright red color are significant at a significance level of 99%. Based on this diagram we can make the following observations:

On the similarity diagram (Figure 1.1) there are three distinct clusters of similarity (Cluster A, Cluster B, Cluster C). The first cluster of similarity refers to similarity relationships among the variables (QB3-QB4-QB5, QA26-QA32) (Cluster A), which relate to the Support System and the School Organization, as they demonstrate the role of the Support System, which the school uses regarding the Curriculum of Science teaching, and cooperation with other schools. The similarity of the variables of the first cluster shows that Science teachers face the use of different textbooks by students (QB3), the operation of an equipped Science laboratory (QB4), the existence of a library with Science books at school (QB5), the conditions that relate to the System support, and the institutionalization of a consecutive two hour lesson in the Curriculum of Science (QA26) and cooperation with other schools (QA32), which refer to the School Organization, in the same way.

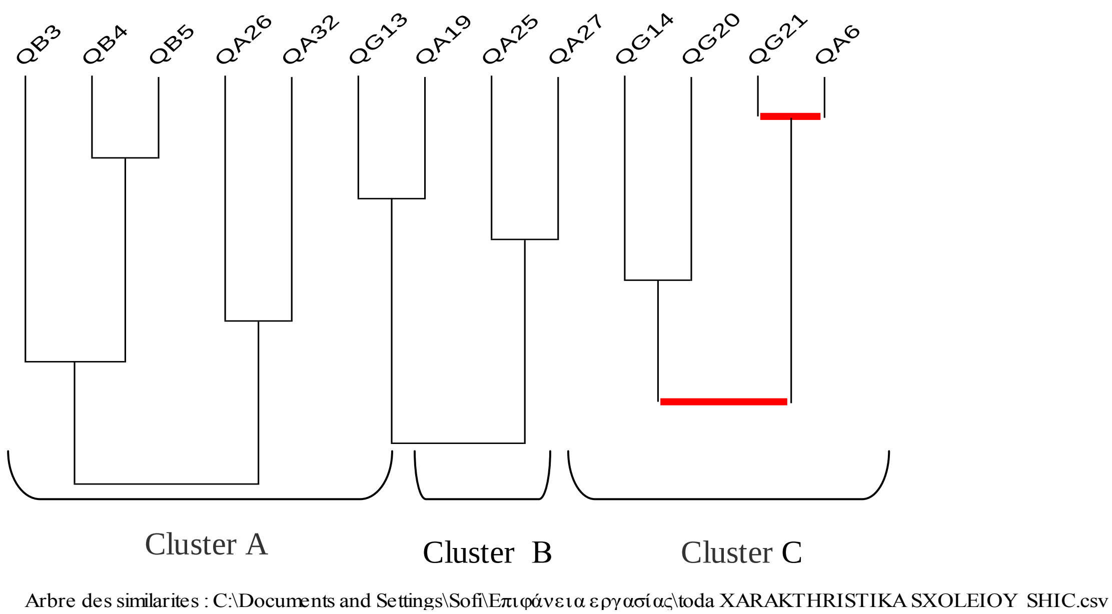


Figure 1.1: Similarity Diagram

The second cluster refers to similarity relationships between the variables (QG13-QA19, QA25-QA27) (Cluster B), which relate to the School Environment and Organization.

The similarity of the above variables demonstrates the firmness with which Science teachers recognize the school environment as an educational requirement for Greek school students' successful response to PISA assessment, especially the appreciation students have for teachers (QG13) who mark the School Environment and School Organization approaching Science out of school (e.g., with visits to museums, university, etc.) (QA19), curriculum reduction while deepening in specific Science issues (QA25), and thus of students' Science homework (QA27), which mark the School Organization.

Finally, the third cluster refers to similarity relationships between variables (QG14-QG20, QG21-QA6) (Cluster C), relating to trust and cooperation between parents and teachers (QG14), financial support by local government for courses out of school (QG20), parents' involvement in school activities (QG21), which mark the School Environment, and the small number of students in laboratory activities (not more than 15) (QA6), which marks the School Organization.

This finding shows that the School Environment and Organization are approached in the same way. In particular, the most pronounced similarity (similarite: 0.751018) is between the variables (QG21-QA6) (Figure 1), which were the most important requirements, and they confirm the previous claim. The similarity of these variables to variables QG14 and QG20 demonstrates the firmness with which Science teachers face the School Environment. Equally significant is also the similarity (QB4-QB5) (similarite: 0.712091), relating to the Support System and the similarity (QG13-QA19) (similarite: 0.664509), which marks the School Environment and School Organization, whereas the similarity which relates to all the sub-questions ((QB3-(QB4-QB5)), (QA26-QA32))) is not high (similarite: 0.108621 0,779). In addition, the similarity (QA25-QA27) (similarite: 0.608283) is also very important.

The similarity diagram shows that the first cluster of similarity (Cluster A) is not strongly associated with the other two clusters of similarity (Cluster B) and (cluster C), which indicates that all the sub-questions of the variables QA (School Organization), i.e., QA26, QA32 (Cluster A), QA13, QA19, QA25, QA27 (Cluster B), QA6 (Cluster C), all the sub-questions of QG (School Environment), QG13 (Cluster B) and QG14 , QG20, QG21) (Cluster C) are not interrelated. That means that there is no communication between all the areas of the School Characteristics, i.e., the different sub-questions, which relate to the School Organization and Environment, but only between the similarity clusters.

1.2. Observations on the hierarchical diagram. The hierarchical diagram (Figure 1.2) shows the implicative relations between the variables in order of significance. In addition, we can see the direction of this relationship on the hierarchical diagram. The implications in bold are significant at a significance level of 99%.

As regards the first hierarchical cluster, which refers to the variables QB3-QB4 (cohesion: 0.614), it suggests that a necessary requirement for Greek school students' successful response to PISA assessment is the use of different textbooks by the students, chosen by teachers (QB3) implies the view of the operation of a fully-equipped Science lab at school (QB4).

As regards the variables QG21-QA6 (cohesion: 0,657), we can claim that the view that the achievement of educational goals - which is based on parent involvement - on school activities (QG21) implies the necessity of a small number of students in laboratory activities (not more than 15) (QA6). In short, the School Environment e prioritizes the School Organization.

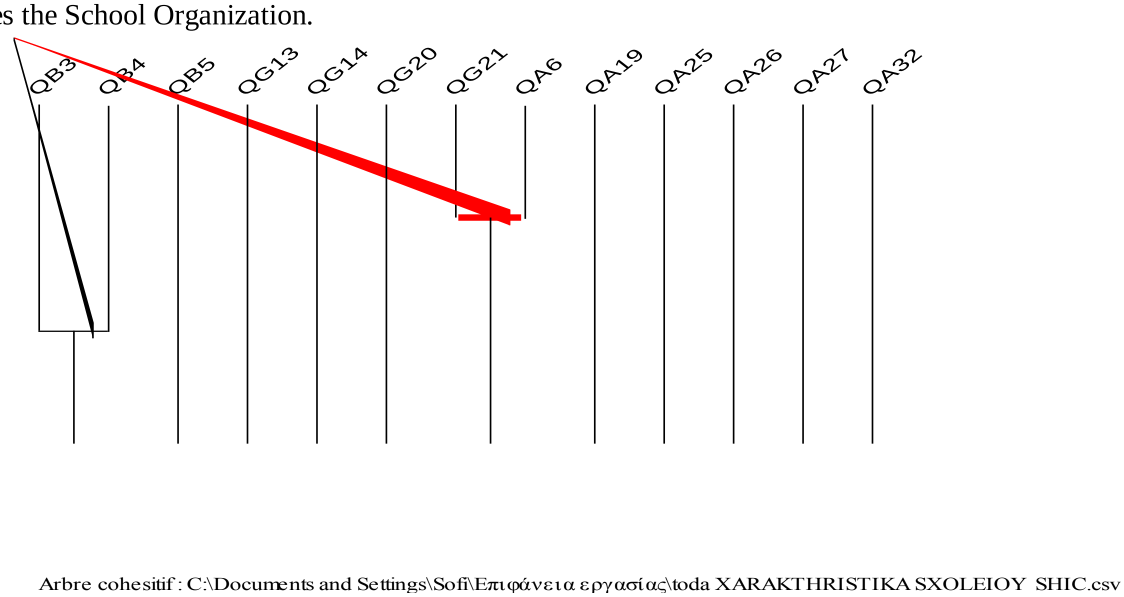


Figure 1.2: Hierarchical Diagram

1.3. Observations on the implicative diagram. The implicative diagram highlights the relationships between the variables (Figure 1.3).

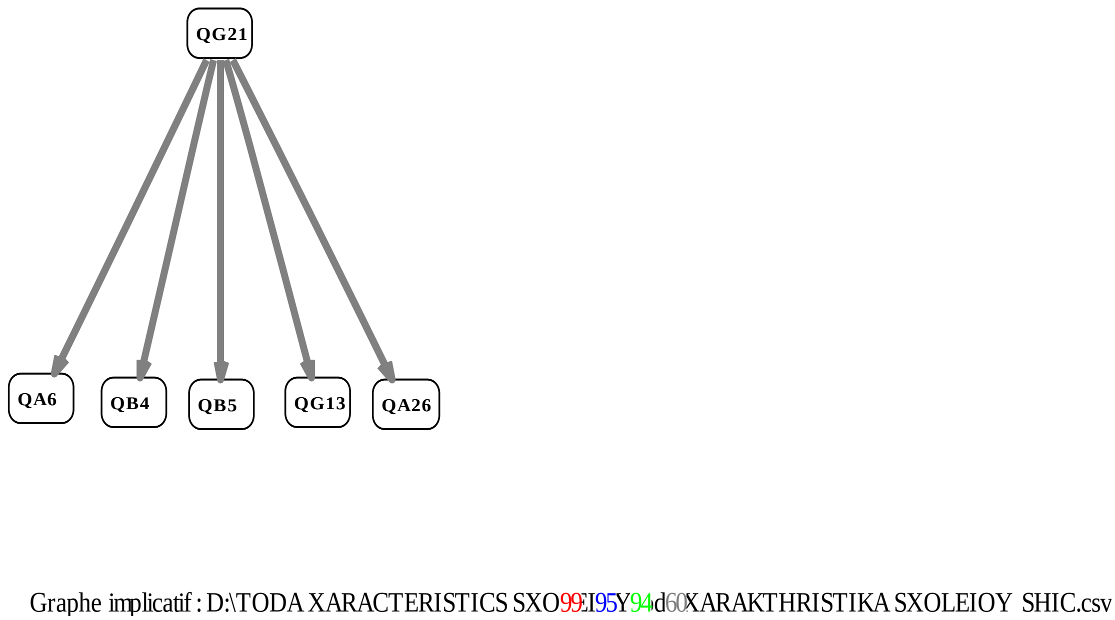


Figure 1.3: Implicative Diagram

In particular, on the implicative chain (QG21→QA6, QB4, QB5, QG13, QA26) the variable QG21 is most significant since the adoption of the view that the achievement of specific goals and objectives pursued by Science teaching in Secondary Education - especially of the educational requirements for Greek school students' successful response to PISA assessment - depends on parents involvement in school activities (QG21), i.e., the School Environment, leads to the adoption of the view that a prerequisite for Greek school students' successful response to PISA assessment is the small number of students in laboratory activities (not more than 15) (QA6), the operation of a fully-equipped lab at school (QB4), the existence of a library with Science books at school (QB5), the appreciation students have for the teacher (QG13), and finally the institutionalization of a consecutive two hour lesson in the Science curriculum (QA26). This implicative chain (QG21→ QA6, QB4, QB5, QG13, QA26) makes it clear that the *School Environment* entails the *School Organization* and the *Support System* of the Course.

1.4. Summary of Results. This analysis attempted to investigate Science teachers' views aimed at detecting educational requirements, which relate to School Characteristics, for Greek school students' successful response to PISA assessment. Parents' involvement in school activities and the requirement for a small number of students in the laboratory exercises (not more than 15) are very important for teachers. The operation of a fully equipped Science laboratory and the existence of a library with Science books at school are of a particular importance.

The analysis of the results shows that there is no communication between all the different areas of the School Characteristics, i.e., the different sub-questions related to the *School Organization*, *Support System* and *Environment*. It should be noted that the *School Environment* involves data/requirements from the *Organization* and *Support System.* Furthermore, the above results show that the null hypothesis (H01), which argues that all variables of the three sub-categories of the category of School Characteristics interact by affecting the Greek school students' successful response to PISA assessment in the same manner, is not acceptable.

2. Teachers' Characteristics

2.1. Observations on the Similarity diagram. The similarity diagram (Figure 2.1) develops the clusters of opinions based on Science teachers' views on the educational requirements for Greek school students' successful response to PISA assessment as regards Teachers' Characteristics. The similarities in bright red color are significant at a significance level of 99%. Based on this diagram we can make the following observations:

The similarity diagram (Figure 2.1) shows two distinct clusters of similarity (Cluster A, Cluster B).

The first similarity cluster (Cluster A) refers to the similarity relationships among the variables which consider teachers' training in Science (e.g., master's degree) (EA7), Science teachers' pedagogical training (EA10), their experience (EA8) related to the Teacher's Background, the satisfaction they take from their job (EV9) related to Teachers' Self-efficacy, and finally, the evaluation of the work they offer to school (EA12), which relates to the Teacher's Background, to be essential requirements.

The second similarity cluster (Cluster B) (EV47-(EV48-EV49)) refers to the similarity relationships among the variables, which refer exclusively to teachers' self-efficacy. In particular, Cluster B (Figure 2.1) consists of those similarity relationships that reveal broad consistency of the responses of the teachers who participated in the research as regards the requirements for Greek school students' successful response to PISA assessment, and they are related to whether teachers feel they have a significant impact on their students' life (EV47), and feel successful in the classroom (EV48), and also whether they know how to handle their students (EV49). The most significant similarity between the variables is identified in Cluster B, particularly between the variables EV48 and EV49 (similarite: 0.755057). Moreover, the whole similarity cluster B (EV47-(EV48-EV49)) shows excellent similarity (similarite: 0.702918).

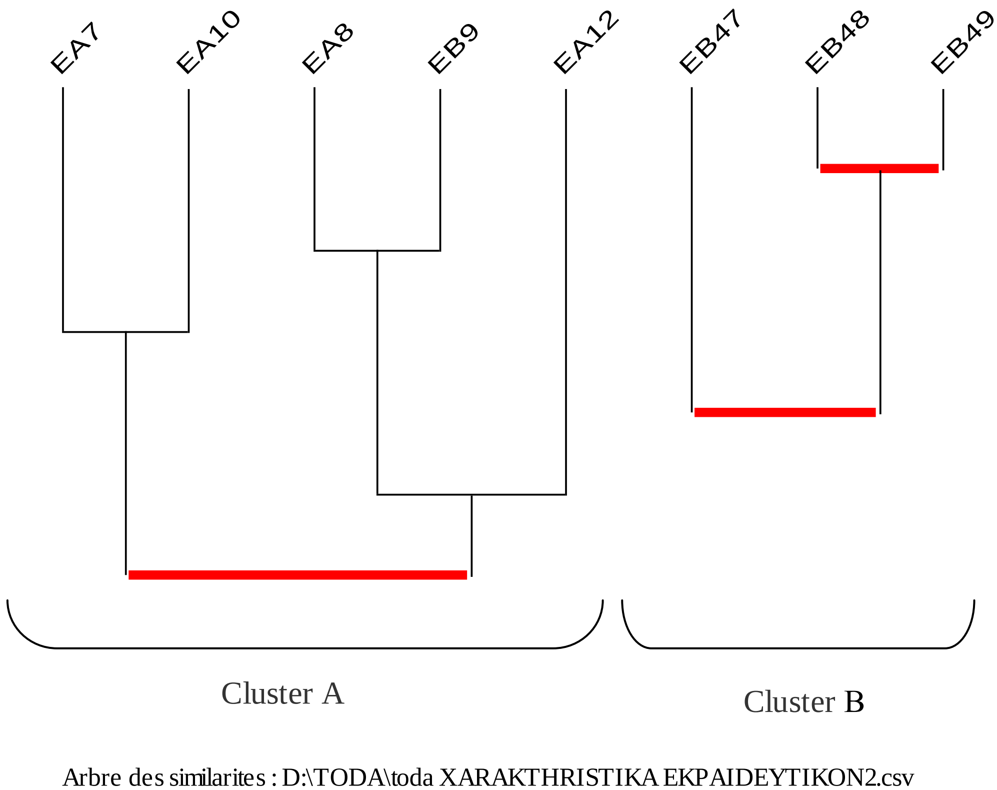
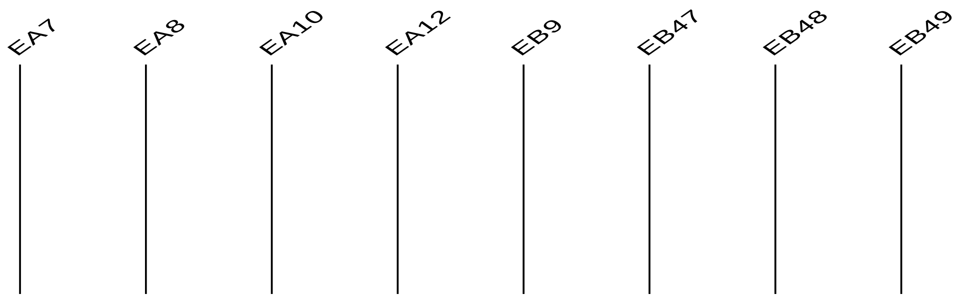


Figure 2.1: Similarity Diagram

It should be noted that significant similarity is identified in cluster A, and particularly in the variable sub-clusters (EA8-EB9) (similarite: 0.682997) and (EA7-EA10) (similarite: 0.660273). However, the whole cluster ((EA7-EA10) - ((EA8-EB9)-A12)) (similarite: 0.0949825) has low similarity.

2.2. Observations on the hierarchical diagram. The hierarchical diagram (Figure 2) shows the hierarchies/hierarchical relationships between the variables in order of significance.



Arbre cohesitif : D:\TODA\toda XARAKTHRISTIKA EKPAIDEYTIKON2.csv

Figure 2.2: Hierarchical Diagram

In this case there was no hierarchical relationship between the variables related to teachers' characteristics.

2.3. Observations on the implicative diagram. The implicative diagram shows the relationships between the variables. In this case there was no implicative relationship between the variables related to teachers' characteristics.

2.4. Summary of results. The analysis of the category Teachers' Characteristics demonstrated that there is no communication between all its different areas, and more specifically Teachers' Background and Self-efficacy with the exception of the variable (EV9), which refers to the satisfaction they take from their job, and concerns teachers' self-efficacy. The most crucial variables that constitute Greek school students' successful response to PISA assessment are related to whether teachers feel successful in the classroom and they know how to handle their students. Teachers' experience and job satisfaction also act resolutely and decisively on students' success. It should be noted that the null hypothesis, according to which the variables of the three sub-categories of the Category Teacher's Characteristics interact by affecting Greek school students' successful response to PISA assessment (H02), is not accepted.

3. Teachers' Cooperation

3.1. Observations on the Similarity diagram. The similarity diagram (Figure 1) shows the groupings of works based on Science teachers' attitudes related to the educational requirements for Greek school students' successful response to PISA assessment, in terms of Teachers' Cooperation. The similarities in bright red color are significant at a significance level of 99%. Based on this diagram we can make the following observations:

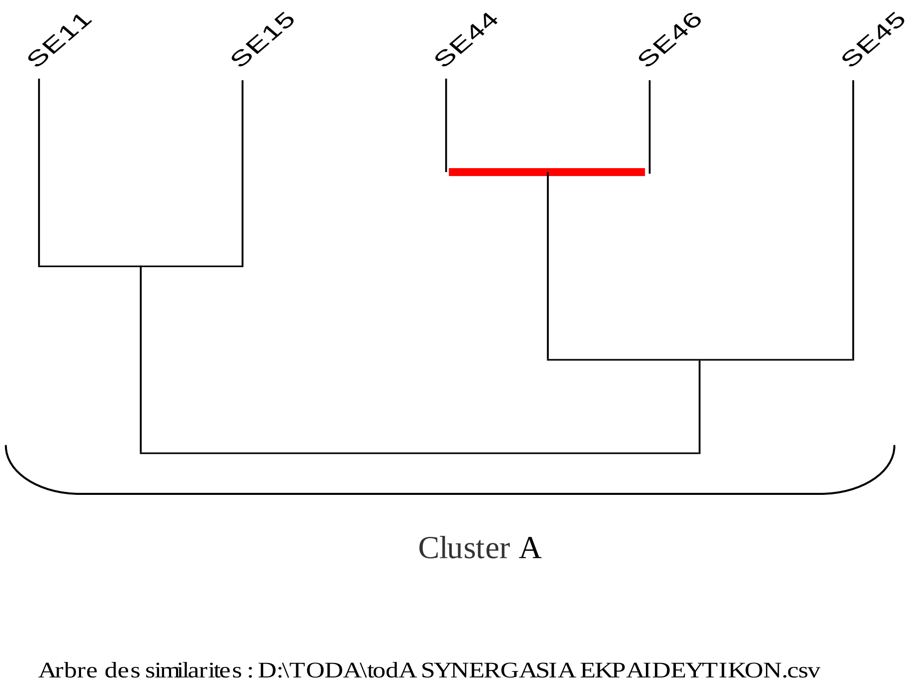
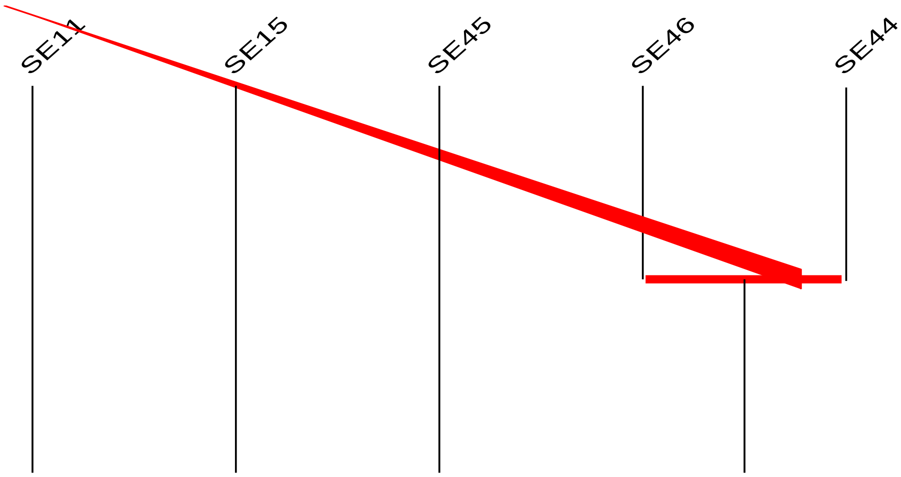


Figure 3.1: Similarity Diagram

The similarity diagram (Figure 1) shows a distinct similarity (Cluster A). This similarity cluster refers to similarity relationships among the variables (SE11-SE15, SE44-SE46-SE45) (Cluster A) which concern Teachers' Cooperation. This similarity of the variables of cluster A shows teachers' agreement on the importance of cooperation between teachers of the same specialty in teaching (SE11), Science teachers' support by mentors (e.g., School advisors, University professors, etc.) (SE15), exchange of teaching material between colleagues (SE44), participation in joint projects of different classes and different age groups (e.g., projects) (SE46), and finally, peer teaching and reflection (reflect, i.e., critics) (SE45).

In particular, the most pronounced similarity (similarite: 0.648882) is between the variables (SE44-SE46) (Figure 3.1), indicating exchange of teaching materials among colleagues (SE44) and participation in joint projects of different classes and different age groups (e.g., projects) (SE46). The similarity between variables (SE11-SE15) (similarite: 0.610036) is also important.

3.2. Observations on the hierarchical diagram. The hierarchical diagram (Figure 3.2) presents the implicative relations between the variables in order of significance. In addition, on the hierarchical diagram we can see the direction of these relations. The implications in bold are significant at a significance level of 99%. The only hierarchical cluster refers to variables SE46-SE44 (cohesion: 0,741), and demonstrates that the adoption of participation in joint projects of different classes and different age groups (e.g. projects) (SE46) leads to the exchange of teaching materials among colleagues (SE44).

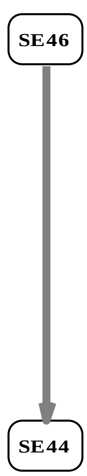


Arbre cohesitif : D:\TODA\todA SYNERGASIA EKPAIDEYTIKON.csv

Figure 3.2: Hierarchical Diagram

3.3. Observations on the implicative diagram. The implicative diagram shows the implicative relations between the variables (Figure 3.3).

The implicative diagram consists of an intro-relational and essentially one-direction relation (SE46→ SE44), which is particularly instructive of the aforementioned, and is in perfect alignment with the hierarchical relation on the hierarchical diagram (Figure 3.2).



Graphe implicatif 99 D 95 C 90 / 50 odA SYNERGASIA EKPAIDEYTIKON.csv

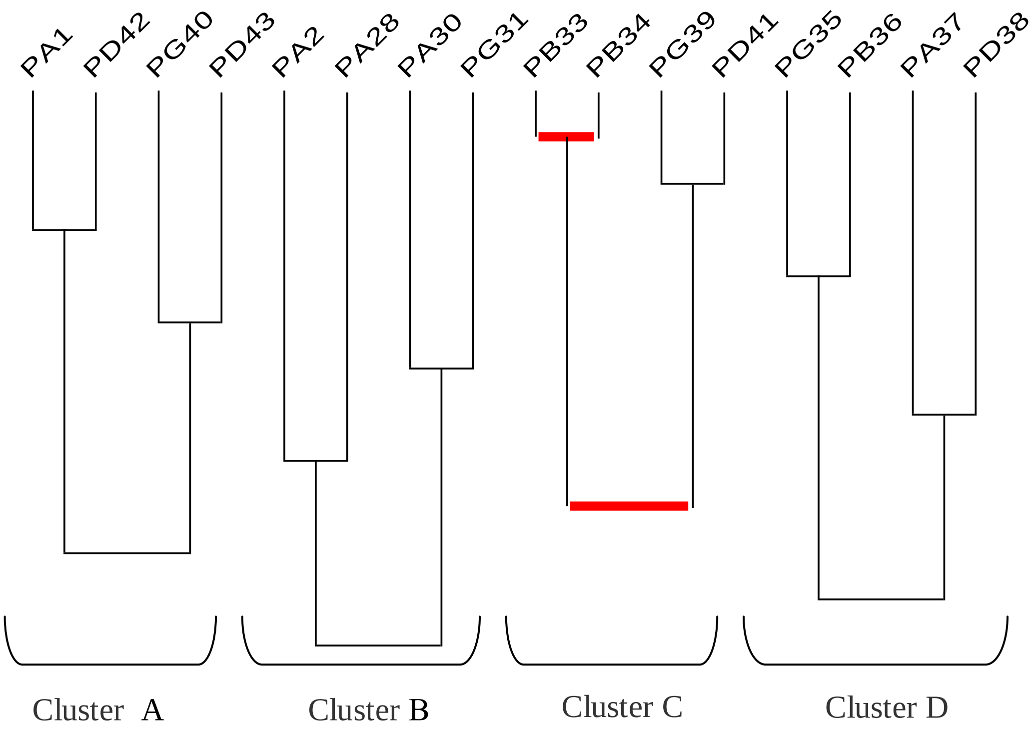
Figure 3.3: Implicative Diagram

3.4. Summary of results. The analysis of similarity results confirmed that all variables belong to a single cluster, the cluster of Teachers' Cooperation. The exchange of teaching material between fellow Science teachers, and their participation in joint projects of different classes and different age groups are the most crucial variables that constitute Greek school students' successful response to PISA assessment compared with the others that are in the category of Teachers' Cooperation. It becomes clear from the above results that although all the variables interact with each other, they do not act in the same way. Therefore, the null hypothesis H03, which claims that all variables of the category of Teachers' Cooperation interact by acting the same way on Greek school students' successful response to PISA assessment, is not accepted.

4. Teaching Practices

4.1. Observations on the Similarity diagram. The similarity diagram (Figure 4.1) shows the grouping variables based on Science teachers' attitudes to the educational requirements for Greek school students' successful response to PISA assessment as regards teaching practices.

The similarities in bright red color are significant at a significance level of 99%. Based on this diagram 4.1 we can make the following observations: four distinct similarity clusters (Cluster A, Cluster B, Cluster C, Cluster D) are presented. The first similarity cluster refers to similarity relations among the variables ((PA1-PD42) - (PG40-PD43)) (Cluster A) related to students' motivation to attend the lesson (PA1) and face issues in which they need to explain their thoughts or justify their answers (PD42). The respondent Science teachers argue that the teacher should assign a different task to students with difficulties from those who can work faster (PG40), so that students learn to discuss and argue on a particular point of view, even if it is not theirs (PD42).



Arbre des similarites : D:\TODA\toda PRAKTIKES DIDASKALIAS.csv

Figure 4.1: Similarity Diagram

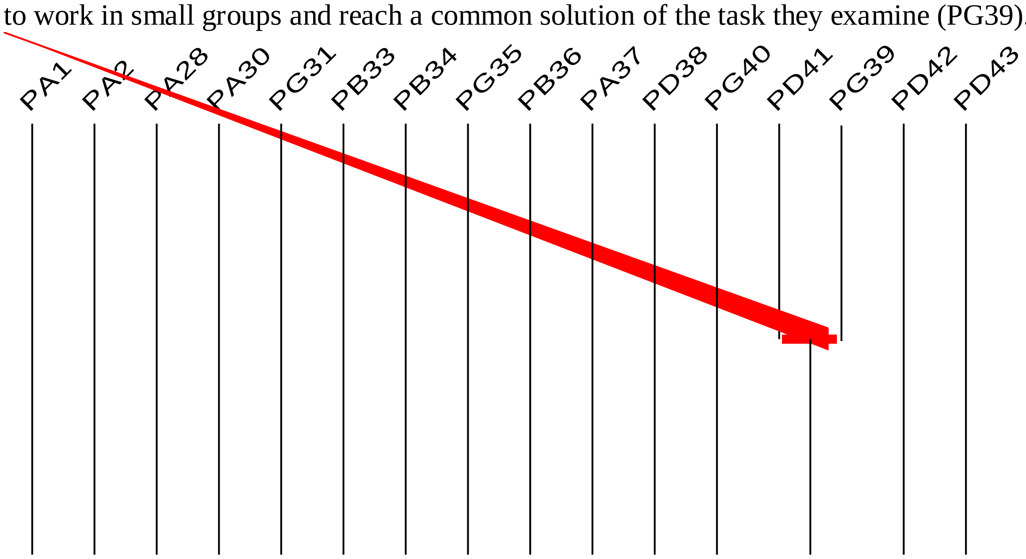
The second cluster refers to similarity relations between variables ((PA2-PA28) - (PA30-PG31)) (Cluster B), which relate to the explicit wording of the objectives of everyday lesson to students (PA2), clarity of criteria of assessing students' work (PA28), the examination/assessment of errors as a means of feedback to students (PA30), and they mark Structured Teaching Practices and finally, support for diversity among students (PG31), signifying Student-centered practices. Therefore, this similarity of variables of the second cluster shows that Science teachers connect Structured Teaching Practices with Student-centered practices.

The third cluster refers to similarity relationships between variables ((PB33-PB34) - (PG39-PD41)) (Cluster C) related to supporting students to learn to investigate (PB33) and find their own solutions to problems (PB34), and they mark Constructive Teaching Practices, and additionally, to learn to work in small groups and reach a common solution to the task they examine (PG39), which marks Student-centered practices, and finally, to be engaged in projects that require at least a week to complete (PD41), which marks Supporting Practices. Therefore, this similarity of the second cluster variables shows that Science teachers link Constructive Teaching Practices and Student-centered to Supporting Practices.

Finally, the fourth cluster refers to similarity relationships between variables ((PG35-PB36) - (PA37-PD38)) (Cluster D) related to teaching construction on problems of students' every day life (PG35), which marks Student -centered practices, provision of opportunities for students to think of solutions to practical problems before the teacher shows them how they are solved (PB36), which marks Constructive Teaching Practices, analysis of students' homework in class (PA37), which marks Structured Teaching Practices, and finally, elaboration of the lesson by the students using various techniques (use of diagrams, tables, images, etc.) (PD38) which marks Supporting Practices. Therefore, this similarity of the second cluster variables shows that Science teachers connect Student-centered Practices with Constructive Teaching Practices, Structured Teaching Practices, and finally, Supporting Practices.

Moreover, the most pronounced similarity (similarite: 0.707231) is among the variables (PB33-PB34) (Figure 1), highlighting the opportunities given to students to learn to investigate (PB33) and find their own solutions to problems (PB34) as the most important. Equally significant is the similarity (PG39-PD41) (similarite: 0.678907). The similarities (PA1-PD42) (similarite: 0.646128), (PG35-PB36) (similarite: 0.618312) and (PG40-PD43) (similarite: 0.600945) are also at the same level of significance.

4.2. Observations on the hierarchical diagram. The hierarchical diagram (Figure 4.2) shows the hierarchical relations between the variables in order of significance. In addition, on the hierarchical diagram we can see the direction of this relationship. The implications in bold red are significant at a significance level of 99%. The only hierarchical cluster refers to variables PD41-PG39 (cohesion: 0,732), which demonstrates that the adoption of students' involvement in projects, which require at least a week to complete (PD41), leads to students' necessity to work in small groups and reach a common solution of the task they examine (PG39).



Arbre cohesitif : D:\TODA\toda PRAKTIKES DIDASKALIAS.csv

Figure 4.2: Hierarchical Diagram

4.3. Observations on the implicative diagram. The implicative diagram shows the relationships between the variables (Figure 4.3). In detail, on the implicative chain (PD41→PB34, p A1, PB33, PG35, PA30, PD42, PD43, PD38, PD41 PG39, PA37, PG40), the variable (PD41) is the most significant one because the adoption of the view that students should be involved in projects that require at least a week to complete (PD41) implies the views that there should be one to support the students to find their own solutions to problems (PB34), have motives to attend the lesson (p A1), and learn to investigate (PB33); also teaching should be structured on students' every day life (PG35); examination/evaluation of errors should be a means of feedback to students (PA30); students should face issues on which they need to explain their thinking or justify their answer (PD42); students should learn to discuss and argue on a particular point of view, even though it is not theirs (PD43), elaborate on the lesson using various techniques (use of diagrams, tables, images, etc.) (PD38), work in small groups and reach a common solution of the issue they examine (PG39), analyze their homework in class (PA37), and finally, the teacher should give a different task to students who have difficulty from those who can work faster (PG40). This implicative chain (PD41→PB34, p A1, PB33, PG35, PA30, PD42, PD43, PD38, PG39, PA37, PG40), makes it clear that Support Practices entail Constructive Teaching Practices, Structured Teaching Practices and Student-centered Practices.

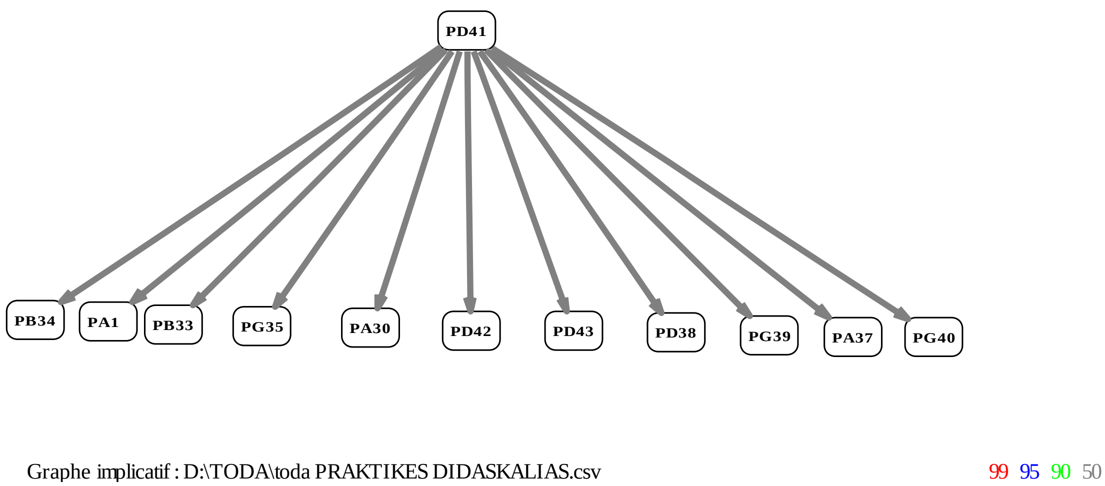
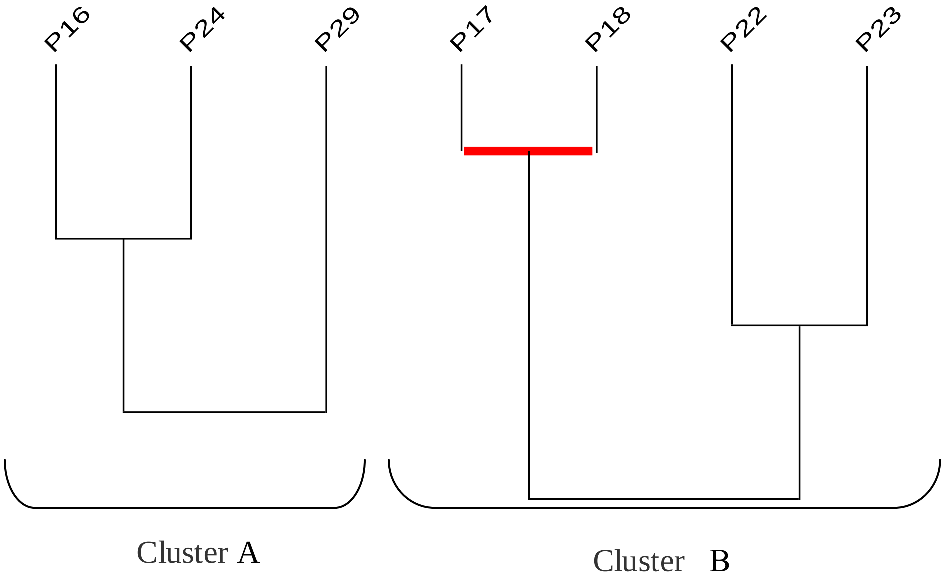


Figure 4.2: Implicative Diagram

4.4. Summary of results. Similarity analysis of results showed that all variables of the four sub-categories of the category Teaching Practices, *Structured Teaching Practices*, *Constructive Teaching Practices*, *Student-centered Practices*, *Enhanced Practices*, do not belong to each subcategory separately but they are involved in one way or another, without the clusters which they belong to being linked. The view of supporting students, so as to learn to investigate and find their own solutions to problems is highlighted as very important. Therefore, the null hypothesis H04, which suggests that all the variables of the four sub-categories of the category Teaching Practices interact, by acting on Greek school students' successful response to PISA assessment in the same way, is rejected.

5. Pedagogical Approaches

5.1. Observations on the Similarity diagram. The similarity diagram (Figure 5.1) shows the groupings of works based on the views of Science teachers on educational requirements for Greek school students' successful response to PISA assessment, as regards teaching approaches. The similarities in bright red color are significant at a significance level of 99%. Based on this diagram we can make the following observations:



Arbre des similarites : C:\Documents and Settings\Sofi\Τα έγγραφά μου\toda2DIDAKTIKES PROSSEGGISEIS.csv

Figure 5.1: Similarity Diagram

The similarity diagram (Figure 5.1) shows two distinct clusters of similarity (Cluster A, Cluster B). The first similarity cluster refers to similarity relations among the variables (P16-P24-P29, P17-P18-P22-P23) (Group A) related to the implementation of interdisciplinary approaches on Science teaching (P16), the connection of Science with real life conditions outside school (P24), and the implementation of differentiated teaching practices (P29). The second cluster refers to similarity relationships between variables (P17-P18-P22-P23) (Cluster B), which concern the implementation of educational techniques on the development of students' critical thinking of (P18), by use of multimodal texts in teaching (P17), new technologies in the learning process (P22), and students' assessment through the "Portfolio" (P23).

In particular, the most pronounced similarity (similarite: 0.684708) is among the variables (P17-P18) (Figure 5.1) highlighting these variables as most significant, according to Science teachers' views as regards the requirements for Greek school students' successful response to PISA assessment.

Equally important is the similarity between variables (P16-P24) (similarite: 0.678527), as well as the similarly between variables (P22-P23) (similarite: 0.672436).

However, the overall similarity of the variables of cluster A ((P16-P24)-P29) (similarite: 0.430628) is low, and there is an extremely low similarity in Cluster B ((P17-P18) - (P22-P23)) (similarite: 0.193201).

5.2. Observations on the hierarchical diagram. The hierarchical diagram (Figure 2) shows the hierarchical relationships between the variables in order of significance.

Moreover, on the hierarchical diagram we can see the direction of this relationship. The implications in bold are significant at a significance level of 99%.

Figure 5.2: Hierarchical Diagram

As regards the unique hierarchical cluster, it refers to variables P23-P22 (cohesion: 0,802) where the student's assessment through the "Portfolio" (P23), as a requirement for Greek school students successful response to PISA assessment, involves use of new technologies in the learning process (P22). Here, we must emphasize that there is no other hierarchical relationship between the rest variables which examine Science teachers' views as regards Greek school students' successful response to PISA assessment.

5.3. Observations on the implicative diagram. The implicative diagram shows the implicative relationships between variables (Figure 3), and more specifically of (P23), (P24) and (P22)..

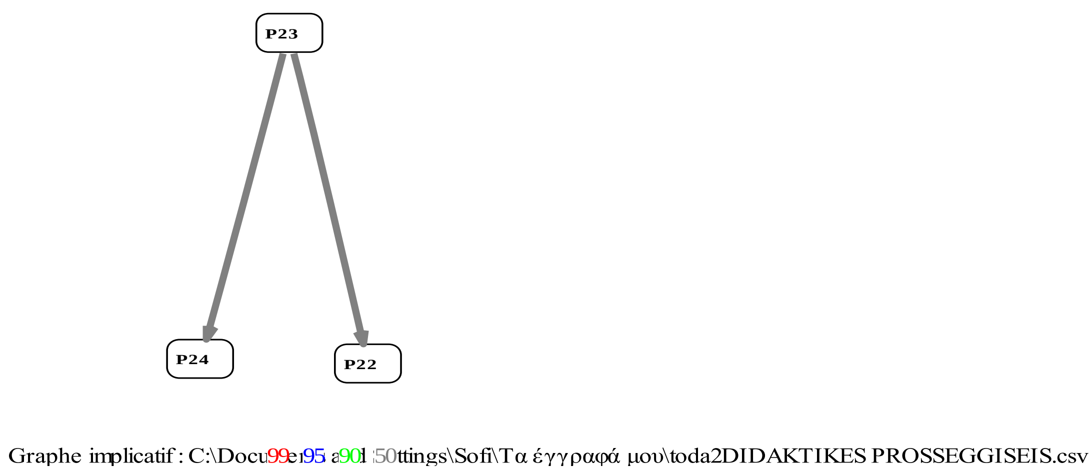


Figure 5.3: Implicative Diagram

In detail, on the implicative chain (P23→ P24, P22), which is unique, we observe that the variable (P23) is significant because the adoption of the view that the student's assessment through the "Portfolio" (P23) is an important requirement for Greek school students' successful response to PISA assessment, leads to the view that both the connection of Science with real life situations outside school (P24) and use of new technologies in the learning process (P22) are equally important

5.4. Summary of results. Analysis of the similarity results showed that all the variables do not belong to a single cluster of the cluster Pedagogical approaches but they are two different sub-clusters. The most important views which contribute to Greek school students' successful response to PISA assessment suggest implementation of interdisciplinary approaches in Science teaching, and the connection of Science with real life situations outside school. Therefore, the null hypothesis H03, which claims that all variables of the category Pedagogical Approaches interact, by acting on Greek school students' successful response to PISA assessment in the same way, is rejected.

Discussion and conclusions

1. School Characteristics

Teachers relate school organization to its structural characteristics, as derived from the institutional arrangements of the state (timetable books, number of students, laboratory equipment) rather than to organizing activities by the teachers themselves and the school director on operation issues, such as, for instance, approach of Science issues outside school, cooperation with other schools, use of different textbooks, school support by local organizations etc. Thus, the responsibility for students' performance in Science seems to be on the institutions of school organization, rather than on any school initiatives for action taking in specific areas related to its operation.

2. Teachers' Characteristics

Teachers refer to personal characteristics which show dedication to the idea of the authority of the teacher (students' manipulation) or occupational prestige (successful), but they do not associate these characteristics with specific pedagogical conditions which they could ensure them on teachers' professional profile (e.g. pedagogical subject knowledge, in service training etc). Therefore, they are limited to those as if they were something separated from teachers' overall efficiency in teaching. So, they do not seem to recognize teachers' responsibility on ensuring the requirements for gaining their influence on students, and feeling successful. In Finland, however, teachers are considered to "respond to their traditional mission to be model citizens and transmitters of knowledge" and apply "an authoritarian pedagogy" (Simola, 2005: 466).

3. Teaches' cooperation

Teachers regard the exchange of educational material as important, and they link it with projects development, but they do not correlate them with cooperation between teachers of the same specialty or support by mentors. Neither do they consider that peer teaching of the same specialty and reflection, which research highlights as an effective "vehicle" for teaching quality, are significant elements for students' better performance in Science. These findings agree with findings of earlier research (Postholm, 2008).

4. Teaching practices

As regards students' successful response to PISA, teachers think course matter-centered structured teaching is important, but they connect it with student-centered practices. They also emphasize the exploratory nature of teaching in order to find solutions to problems. The variable which they consider to be more important is the development of projects, since they recognize the importance of students' cooperation in groups. It should be noted that project was introduced as a distinct unit of the curriculum in the first grade of Senior High School in the school year 2011-12.

5. Pedagogical approaches

Teachers believe that multimodal texts encourage the implementation of techniques for the development of students' critical thinking. However, they do not connect use of multimodal texts with New Technologies, interdisciplinary or differentiated teaching, as one would expect. They connect use of New Technologies with students' assessment through portfolios, and not with the substantial support of the Science subject.

Summarizing, we could say that teachers of Science recognize school responsibility of students' performance in PISA only at an institutional level, and not at the school level. They associate teachers' successful professional profile with the feeling of success in teaching and the ability of "handling" students, but not with parameters identified in the literature as important for the effectiveness of the course (knowledge base of teaching, mentoring, reflective feedback, connection between the school organization, the learning environment and the support system of the subject of Science, as well as investigative work and "hands-on" experimentation). They emphasize the value of projects and they state their need to have support material at their disposal.

They connect them with students' experience on Science issues outside school. Furthermore, they link use of New Technologies to support the lesson only with the field of evaluation through portfolios.

Comparing the results of our research with the results of a corresponding research conducted by OECD (2009) to develop policies for effective schooling (Creating Effective Teaching and Learning Environments: TALIS), we would conclude to the following common findings: teachers consider student participation in the process of knowledge acquisition is important, but they prefer to apply structured learning methods in class, rather than student-centered teaching. Moreover, in all countries teachers work together to exchange and coordinate ideas and information, but they avoid cooperative teaching (OECD, 2009: 90).

Greek teachers' beliefs can be used for the development of education and training programs for teachers and educational changes aimed at improving student achievement in Science (Osborn & Dillon, 2008; AAPT, 2009; Zimmerman, 2007) and the scientific literacy of students (Dillon, 2008). However, the results presented here provide a starting point to explore how Greek schools could attain quality in Science education. The research challenge is to refine the conclusions, identify gaps and to gather further evidence about the potential of ameliorating the Greek school students' achievement in PISA. Moreover, provided that policy investments in the quality of schools are related to improvements in student performance (Sahlber, 2007), the findings of our research are expected to be used so that Greek schools become learning organizations, where learning is school wide and is built on cooperation, planning and practice of ideas for improving teaching (Sammons et al., 1995: 27).

References

AAPT (2009). The Role, Education, Qualifications, and Professional Development of Secondary School Physics Teachers. College Park, MD: American Association of Physics Teachers. Available at www.aapt.org (6.4.2012).

Arter, J. & Spandel, V. (1992). NCME Instructional Module: Using portfolios of student work in instruction and assessment. *Educational Measurement: Issues and Practice, 11(1), 36-44*.

Bakkenes, I., Vermunt, J., Wubbels, T. (2010). Teacher learning in the context of educational innovation: Learning activities, and learning outcomes of experienced teachers. *Learning and* Instruction 20, 533-548.

Bartholomew, H., Osborne, J., Ratcliffe, M. (2004).Teaching Students ''Ideas-About-Science": Five Dimensions of Effective Practice. *Science Education, 88,* 655–682.

Bodin, A., Coutourier, R. et Gras, R. (2000). *CHIC : Classification Hiérarchique Implicative et Cohésitive. Version sous Windows – CHIC 1.2.* Rennes: Association pour le Recherche en Didactique des Mathématiques.

Cobbold, T. (2010). *Reporting School Results and Student Achievement*. Retrieved from www.saveourschools.com.au (available at 9.4.2012.

Cunningham, J. and N. Herr (1994). *Hands-On Physics Activities with Real-Life Applications.* New York: Simon & Schuster

Darling-Hammond, L. (2000). Teacher Quality and Student Achievement: A Review of State Policy Evidence. *Education Policy Analysis Archives, 8 (1),* 1-44.

Dillon, J. (2009). On Scientific Literacy and Curriculum Reform. *International Journal of Environmental & Science Education* 4 (3), 201-213.

Gras, R., & Kountz, P. (2008). An overview of the Statistical Implicative Analysis (SIA) development. In R. Gras, E. Suzuki, F. Guillet & F. Spagnolo (Eds), *Statistical Implicative Analysis*. Berlin: Springer-Verlag.

Gras R., Peter P., and Philippe J. (1997). Implicative statistical analysis. *Proceedings of IFCS 96*. Tokyo: Springer-Verlag.

Hamilton, S. L. (2009). *Using PISA Data to Measure School and System Characteristics and Their Relationships with Student Performance in Science.* RAND Corporation

Hulpia, H. & Valcke, M. (2004). The use of performance indicators in a school improvement policy: The theoretical and empirical context. *Evaluation & Research in Education, 18,* 102-120.

Lumpe, A., Haney, J., Czerniak C.(2000). Assessing Teachers' Beliefs about their Science Teaching Context. *Journal of Research in Science Teaching, 37 (3), 275–292.*

Maclellan, E., & Soden, R. (2011). Psychological knowledge for teaching critical thinking: the agency of epistemic activity, metacognitive regulative behaviour and (student-centred) learning. *Instructional Science* (25 July), 1-16. doi:10.1007/s11251-011-9183-4.

Maclellan, E., & Soden, R. (2004). The importance of Epistemic Cognition in Student-Centred Learning. *Instructional Science, 32*, 253–268.

Molenaar, I., Van Boxtel, A. M. C., & Sleegers, J. C.P. (2009). Metacognitive Scaffolding in an Innovative Learning Arrangement, *Instructional Science: An International Journal of the Learning Sciences, 39 (6),* 785-803.

Molenaar, I., Van Boxtel, A. M. C., Sleegers, J. C.P. (2009). Metacognitive Scaffolding in an Innovative Learning Arrangement, *Instructional Science: An International Journal of the Learning Sciences*, *39 (6)*, 785-803.

OECD (2009). *Creating Effective Teaching and Learning Environments: First Results from TALIS* Retrieved from http://www.oecd.org/dataoecd/17/51/43023606.pdf

OECD. (2005). *Teachers Matter: Attracting, Developing and Retaining Effective Teachers. Education and Training Policy. Overview.* Retrieved from *http://www.oecd.org/dataoecd/39/47/34990905.pdf*

OECD. (2006). *Assessing Scientific, Reading and Mathematical Literacy: A Framework for PISA 2006.* Retrieved from *http://www.oecd.org/dataoecd/63/35/37464175.pdf*

OECD. (2007). *Executive Summary PISA 2006: Science Competencies for Tomorrow's World* Retrieved from http://www.oecd.org/dataoecd/15/13/39725224.pdf

OECD. (2009). *Top of the class – High Performers in Science in PISA 2006* Retrieved from http://www.oecd.org/dataoecd/44/17/42645389.pdf

OECD. (2010). *PISA 2009 Results: What Students Know and Can Do – Student Performance in Reading, Mathematics and Science (Volume I)* Retrieved from http://www.oecd.org/dataoecd/10/61/48852548.pdf

OECD. (2010). *Trends Shaping Education 2010*. Retrieved from http://www.keepeek.com/Digital-Asset-Management/oecd/education/trends-shaping-education-2010_trends_edu-2010-en

Osborn, J. & Dillon, J. (2008). Science Education in Europe: Critial Reflections. A Report of the Nuffield Foundation. London: The Nuffield Foundation.

Pinto, R.E. & Boudamoussi, S. (2009). Scientific Processes in PISA Tests Observed for Science Teachers. *International Journal of Science Education,* 31 (16), 2137-2159

Postholm, M.B. (2008), Teachers developing practice: Reflection as key activity. *Teaching and Teacher Education, 24, 1717–1728.*

Psalidas A., Apostolopoulos C., Hatzinikita V. (2008). Investigating Factors affecting Students' Performance to PISA Science Items. *Journal of engineering Science and Technology*, 1, 90-97.

Sahlberg, P. (2007). Education policies for raising student Learning: the Finnish approach *Journal of Education Policy, 22,(2),pp. 147–171.*

Sammons, P., Hillman, J., & Mortimore, P. (1995). *Key Characteristics of Effective Schools: A Review of School Effectiveness Research for the Office of Standards in education (OFSTED).* London: Institute of Education.

Simola, H. (2005). The Finnish miracle of PISA: Historical and sociological remarks on teaching and teacher education. *Comparative Education, 41*(4), 455–470.

Timmerling, L., Snoek, M. & Dietze, A. (2010). Identifying Teacher Quality: Structuring Elements of Teacher Quality. In: M. Montaneé & J. Salazar (ed.), *ATEE 2009 Annual Conference Proceedings,* 376-388. <http://www.atee1.org/uploads/atee_2009_conference_proceedings_final_version.pdf> (Available at …)

Vermunt, J., & Endedijk, M. (2010). Patterns in teacher learning in different phases of the professional career. *Learning and Individual Differences, 21 (3),* 294–302. Zimmerman, C. (2007). The development of scientific thinking skills in elementary and middle school. *Science Direct Developmental Review, 27 (2007),* 172–223.