INVESTIGATING THE IMPACT OF INTERNATIONAL GENERAL CERTIFICATE OF SECONDARY EDUCATION SCORES AND GENDER ON THE DIPLOMA PROGRAMME SCORES IN MATHEMATICS AND SCIENCE

A MASTER'S THESIS

BY

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THE PROGRAM OF CURRICULUM AND INSTRUCTION

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BURCU YAĞIZ

May 2014

I certify that I have read this thesis and have found that it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Arts in Curriculum and Instruction.

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ABSTRACT

INVESTIGATING THE IMPACT OF INTERNATIONAL GENERAL CERTIFICATE OF SECONDARY EDUCATION SCORES AND GENDER ON THE DIPLOMA PROGRAMME SCORES IN MATHEMATICS AND SCIENCE

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M.A., Program of Curriculum and Instruction

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Inspired by their goal for a well-rounded education in a world that has become more globalized, an increasing number of schools in the United States, Europe and other parts of the world have been adapting the philosophy and curricula of international schools. While there have been several studies to support Diploma Program as an established curriculum at the senior high school level, there has been little evidence that would support any particular curriculum at the junior high school level. The purpose of this study was to investigate the relationship between external examination scores of International General Certificate of Secondary Education and those of Diploma Program. A purposive sample was drawn from high school students who attended a private international school in a major metropolitan city in Turkey (N = 250). Data were analyzed with a multiple regression approach. Statistically significant and relatively strong relationships were found between external examination scores, both in mathematics and science.

Key Words: International schools, International Baccalaureate, Diploma Program, International General Certificate of Secondary Education, mathematics education, science education.

ÖZET

ULUSLARARASI ORTAÖĞRETİM GENEL SERTİFİKASI MATEMATİK, FEN SINAV PUANLARI VE CİNSİYETİN DİPLOMA PROGRAMI SINAV PUANLARI ÜZERİNE ETKİSİ

Burcu Yağız

Yüksek Lisans, Eğitim Programları ve Öğretim

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Giderek küreselleşen dünyada çok yönlü eğitim sunma hedefinden yola çıkan Amerika, Avrupa ve dünyanın diğer bölgelerinden birçok okul; uluslararası okulların felsefesini ve eğitim programlarını benimsemeye başlamıştır. Diploma Programı'nın çok yönlü bir eğitim sağladığı sonucuna varan birçok çalışma olmasına rağmen, 9. ve 10.sınıf düzeyinde belirli bir eğitim programını destekleyen çalışma sayısı oldukça azdır. Bu çalışmanın amacı, Uluslararası Ortaöğretim Genel Sertifikası sınav puanları ile Diploma Program sınav puanları arasındaki ilişkiyi matematik ve fen bilimleri üzerinde araştırmaktır. Bu çalışmanın örneklemi Türkiye'deki büyük şehirlerden birinde yer alan özel bir uluslararası okula giden lise öğrencilerinden seçilmiştir (N = 250). Öğrencilerin sınav puanlarından oluşan veri çoklu regresyon yöntemi kullanılarak analiz edilmiştir. Hem matematik hem de fen bilimleri derslerinde sınav puanları arasında istatistiksel olarak anlamlı ve güçlü bir ilişki bulunmuştur.

Anahtar Kelimeler: Uluslararası okullar, Uluslararası Bakalorya, Diploma Program, Uluslararası Ortaöğretim Genel Sertifikası, matematik eğitimi, fen bilimleri eğitimi.

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CHAPTER 1: INTRODUCTION

The world economies demand a workforce that is composed of individuals who are prepared to live and work efficiently in an interconnected world. This preparation requires individuals to become effective communicators, knowledgeable inquirers, risk-takers and problem solvers (National Research Council, 2010; International Baccalaureate Organization [IBO], 2013). Individuals with these 21st century skills have the potential to become successful in today's interconnected world.

Background of the study

International schools are one of the major facilitators that provide students with such skills. International schools offer a multicultural K-12 education to a particular group of students whose parents are mobile due to their work; mostly at international companies or organizations (Bunnell, 2007; Eidse & Sichel, 2004; Lee, Hallinger & Walker, 2012). In the dynamic and multicultural environment of international schools, these students learn how to communicate confidently and creatively in a variety of languages. They also learn how to work collaboratively with cultures different than their own (Banks & Banks, 1995; Lauder, 2007). The overall number and geographic coverage of international schools has experienced a rapid increase with the recognition of international school diplomas in several countries around the world (Dunne & Edwards, 2010; Roberts, 2003). This wide recognition enabled international school students to continue their international education when they move from one country to another.

There is no consensus among scholars and organizations about the definition of international education. According to the IBO, a Switzerland based organization that supports international schools; international education is defined as the development of international-minded individuals (IBO, 2013a). Some scholars advocated that the focus of international education is to build peace among nations with different cultures; this focus is based on the view that some of the earliest international schools were founded following major historical events or large-scale aftermaths, such as Balkan Wars or World Wars (Roberts, 2003; Harrington, 2008; Walker, 2009). According to other scholars, providing a uniformly accepted education is the main purpose of international education; this view stems from the increasing mobility of students to and from different countries (Harwood & Bailey, 2012; Hayden & Thompson, 1998).

There are two major institutions that provide support to international schools: IBO and Cambridge International Examinations (CIE). Although the IBO has headquarters in Switzerland, their curricular program is designed by a group of international educators from different parts of the world (IBO, 2013a). The CIE, which is a division of Cambridge Assessment, was founded in the United Kingdom and their curricula are widely used by British international schools (CIE, 2014). The policy makers, curriculum designers, and researchers affiliated with these programs collaborate to support international schools and international education (CIE, 2014; IBO, 2013a). It is possible to suggest that two institutions compete as both institutions claim that they establish a level of excellence in international education with a high-quality curricula, rigorous assessment of student skills and extensive support for practitioners.

There are three IBO programs designed for students aged 3 to 19: the International Baccalaureate Primary Years Program (PYP), the International Baccalaureate Middle Years Program (MYP), and the International Baccalaureate Diploma Program (DP) (IBO, 2013). As a senior high school program for students aged 16 to 19, the DP is widely popular at international schools. The DP certifies high school students through external examinations in several subjects (IBO, 2013b).

There are four CIE programs for students aged 5 to 19: Cambridge International Primary Program, Cambridge Lower Secondary Program, Cambridge International General Certificate of Secondary Education (IGCSE), and Cambridge Advance Level. As a junior high school program for students aged 14 to 16, the IGCSE is particularly popular among international schools (British Broadcasting Corporation, 2009; CIE, 2013). The IBO's DP and CIE's IGCSE are the most popular curricular programs at junior and high school levels, respectively.

Problem

As the oldest of the international programs, DP has established itself as the premium university preparatory curriculum for students in grades 11 and 12 (Hayden, 2006). Schools need to give a critical decision on the program that would best prepare students for rigor of the DP (Corlu, 2013). The decision of many schools to choose IGCSE seems to be arbitrary because the body of literature providing evidence for selecting IGCSE as a well-established DP preparatory curriculum is scarce. Therefore, there is a need to explore whether IGCSE is compatible with DP in international school contexts and whether there is empirical evidence that supports the choice of many international schools around the world.

Purpose

The purpose of the current study is to explore IGCSE-DP compatibility in terms of student scores in external examinations. Specifically, the research investigated the impact of IGCSE scores and gender on DP outcome scores in mathematics and science.

Research questions

The specific research questions of the current study were:

1) To what extent do IGCSE mathematics scores and gender explain variance in DP mathematics scores?
2) To what extent do IGCSE coordinated science scores and gender explain variance in DP science scores?

The alternative hypotheses for both tests: $H_A : R^2 \neq 0$.

3) What are the best predictors of DP mathematics scores?
4) What are the best predictors of DP science scores?

Intellectual merit & broader impact

The intellectual merit of the study materializes in its contribution to our knowledge base on continuity in school mathematics and science; particularly in how students can be better prepared in junior high school level for the challenges of senior high school curriculum when tests for college placement becomes high-stakes for students. At the local level, this study advances our knowledge regarding international education in the Turkish context and its impact on national education. The findings of the study may have a broader impact on international school students, teachers, and administrators. For example, teachers can evaluate how successful factors, such as IGCSE examination scores are in predicting DP scores. Thus, the study enables teachers to become aware of such students, who are potentially at risk to succeed at the DP.

Definition of key terms

CIE: Cambridge International Examinations is a division of Cambridge Assessment, developed in the UK and is mostly used by British schools. There are four CIE programs for students aged 5 to 19 (CIE, 2014).

DP: As a senior high school program for students aged 16 to 19, the Diploma Program is widely used at international schools as an academically challenging program with final examinations that qualify students for higher education (IBO, 2013b).

IB-IBO: International Baccalaureate or International Baccalaureate Organization, a recognized leader in the field of international education (IBO, 2013a).

International mindedness: International mindedness is a world view that captures a set of skills, understanding, awareness and actions thought to be necessary for being a good national and international citizen (Harwood & Bailey, 2012, p.7).

IGCSE: International General Certificate of Secondary Education is the world's most popular international curriculum for 14-16 year olds (grades 11 to 12), leading to globally recognized and valued Cambridge IGCSE qualifications (CIE, 2014)

MYP: The Middle Years Program of IB is designed for students aged 11 to 16 (grades 6 to 10). It provides a framework of learning that encourages students to become creative, critical and reflective thinkers (IBO, 2013).

PYP: The Primary Years Program of IB is a curriculum framework designed for students aged 3 to 12 (grades 1 to 5). It focuses on the development of the whole child as an inquirer, both in the classroom and in the world outside (IBO, 2013).

CHAPTER 2: REVIEW OF RELATED LITERATURE

Introduction

In this chapter, the theoretical framework of the study is presented through a synthesis of theory and research on international education, international schools, and international curricula. First, several perspectives with regard to international education were presented after an analysis of relevant documents, research and expert opinions. Second, research on international schools was further investigated. Third, mathematics and science curricula of international schools were critically explored. The general information about two mainstream curricula, namely International Baccalaureate Diploma Program (IB-DP) and International General Certificate of Secondary Education (IGCSE) were the focus of this investigation: their philosophy, scope, assessment schemes; for continuum consistency and alignment with a special focus on mathematics and science. The chapter concludes with an brief investigation of international education practices in Turkey.

Perspectives with regard to international education

Several authors have written about their understanding of international education according to their world views and personal philosophies of education. Based on these understandings, four approaches were developed as they defined international education by setting up its scope and explaining its significance. These approaches were idealistic, historic, global and pragmatic (Cambridge & Carthew, 2007; Cambridge & Thompson, 2004; Corlu, 2013; Dale, 2000; James, 2005; Walker, 2012). However, it should be noted that these perspectives are not mutually exclusive and that the adoption of a particular perspective by international schools can be a volatile decision because of the high mobility rate of students and high turnover rate of teachers or school administrators (Corlu, 2014). See Table 1 for a detailed interpretation of these approaches.

Table 1

Four approaches to the notion of international education

	Idealistic Approach	Historic Approach	Global Approach	Pragmatic Approach
Scope and Boundaries	moral & social development of individuals	reaction to historically significant incidents, wars or large-scale devastating events.	the need for a global workforce. individuals with skills to help them work efficiently at global organizations or companies.	recognition of diploma
Significance	building peace within and among individuals.	building peace among nations and learning how to resolve conflicts.	to be qualified to work in multicultural environments.	continuity in education from one country to another (minimize the disadvantage due to mobility)

Scholars, whose ideas have been influenced by the idealistic approach, claimed that the aim of international education was to foster the moral and social development of the individual (Cambridge & Carthew, 2007; James, 2005). In this approach, moral development was defined in terms of developing positive attitudes towards and acting to promote peace by educating students as responsible citizens of the world (Cambridge & Thompson, 2004). The social development referred to all learning processes in a multicultural environment in which students respect and appreciate other cultures, beliefs, and values (Fail, 2007; Hill, 2000).

Scholars, whose ideas have been influenced by the historic approach emphasized that our current understanding of international education has been deeply influenced by several examples of schooling in history (Corlu, Burlbaw, Capraro, Corlu, & Han, 2010; Walker, 2009; Walker; 2012). These scholars came to their conclusions by analyzing several school systems in Western and Eastern parts of the world. They observed that international education eliminated the effect of nationalistic prejudices. One early example was Enderun, which was founded in Constantinople during the 16th century. Enderun provided an exemplary education for ordinary students coming from different ethnic backgrounds in the multicultural Ottoman Empire. The school educated potential leaders of their communities by promoting a sense of coexistence within the Empire (Corlu et al., 2010).

Other scholars who interpreted international education with a historic approach claimed that international education emerged as a reaction to the destruction brought by devastating wars or large-scale events (Allan, 2002; Hill, 2001; Sylvester, 2002; Walker, 2009). One example was the Ecole Internationale de Genève, Ecolint. The school was founded after the First World War (1914-1918) as a non-selective international school, admitting students from all nationalities. Its aim was to create a multicultural school environment that would promote peace among nations (Walker, 2009). Another example was the United World Colleges (UWC) which was founded after the Second World War (1935-1945). The UWC sought to create an international intellectual force for promoting peaceful coexistence among world nations (Hill, 2002; Walker, 2012). A former deputy headmaster of one of the Colleges explained that "education [in UWC] must be used as a tool to break down the barriers of race, religion and class which separate our students" (Jonietz, 1991, p. 222). In conclusion, these scholars believed that the purpose of international schools is to build peace among nations.

Scholars whose ideas have been influenced by the global perspective believed that international education has emerged as a reaction to the need for a global workforce (Cambridge, 2012; Dale, 2000; Hill, 2012). In particular, international companies needed people with effective communication, problem solving, creative thinking and responsibility skills that would help them act and think globally. Moreover, these individuals needed to be able to efficiently work in a foreign country or with people from different countries and cultural backgrounds (Cambridge & Thompson, 2004).

Scholars whose ideas have been influenced by the pragmatic perspective stated that the true purpose of international education was to provide a set of academic qualifications that would be recognized across the world (Bates, 2011). Development of these academic qualifications required a continuity of education across nations and a recognized diploma at the end. The continuity of education would ensure that students could continue their education in different countries without any gap in their learning (Lee, Hallinger, & Walker, 2012). The international curricula, including those developed by institutions such as IBO and CIE, established themselves as recognized programs serving this perspective. Some claimed that the pragmatic perspective was the reason behind the rapid growth of international schools around the world (Walker, 2012). Pragmatic perspective emphasized the need of continuity in education for students who needed to relocate from one country to another by minimizing disadvantage caused by regular mobility.

International-mindedness

Several scholars expressed their understanding of international education according to their view of the world and their ideologies. The common idea of the four approaches (idealistic, historic, global and pragmatic) approaches was that they all emphasized the education of individuals with an international mindset (Cambridge & Carthew, 2007; Cambridge & Thompson, 2004; Corlu, 2013; Dale, 2000; James, 2005; Walker, 2012). This international mindset concept or international-mindedness view was understood as a way of developing students' understanding of the multiculturalism and to act in a multicultural environment (Cambridge & Thompson, 2000).

According to the idealistic and historic approaches to international education, internationally-minded citizens regard themselves as a caring member of the community; they do not only understand, respect and appreciate different cultures they also act to find solutions to the local and global problems (Cambridge & Carthew, 2007; Haywood, 2005; Skelton, 2007; Walker, 2012). The global and pragmatic perspectives refer to international-mindedness as promoting the development of inquiring, knowledgeable, and global youth. These young individuals develop an international outlook in their profession lives (Harwood & Bailey, 2012). It should also be noted that some scholars claimed that "international schools share no recognized philosophical foundation. There are no deeply held, publicly declared beliefs and values to bind them, to bond them into a coherent system" (Bartlett, 1998, p.77).

International schools & communities

Students choose to study at international schools for mainly two reasons. One reason is that students leave their home countries for a quality education that is not available in their home countries (Walker, 2000). One characteristic that they share in common is that they are of high socio-economic status (Bryceson & Vuorela, 2002). A second reason is that students have to move to another country because of their parent's employment (Eidse & Sichel, 2004). Their parents may be international business people, missionaries, military personnel, faculty members at universities or members of foreign diplomatic missions.

International schools employ teachers from different nationalities. Host-country nationals, local hire expatriates or overseas hire expatriates and teachers living abroad prefer to work in international schools for several reasons (Garton, 2000; Merryfield, 2000). First, the teachers may be attracted to the financial and professional benefits or they may consider that conditions and facilitates of international school are better than national schools at home (Garton, 2002). Some teachers may perceive international teaching as a career choice (Magee, Keeling, 2011; Richards, 1998; Snowball, 2007). Third, teachers may want to see and experience the adventure of living in another country (Sylvester, 2002). Finally, teachers may not be the citizens of the host country, but because of family situations (e.g., marriage), they need to find employment in the country (Garton, 2000).

Curricular issues and perspectives

The IB curriculum has attracted the attention of a growing number of national schools in the United States, Europe and at other parts of the world (Lewis, 2012; Roberts, 2012). In fact, IB (2014) reported that the number of international school has doubled in ten years since the millennium (Lee, Hallinger & Walker, 2012).

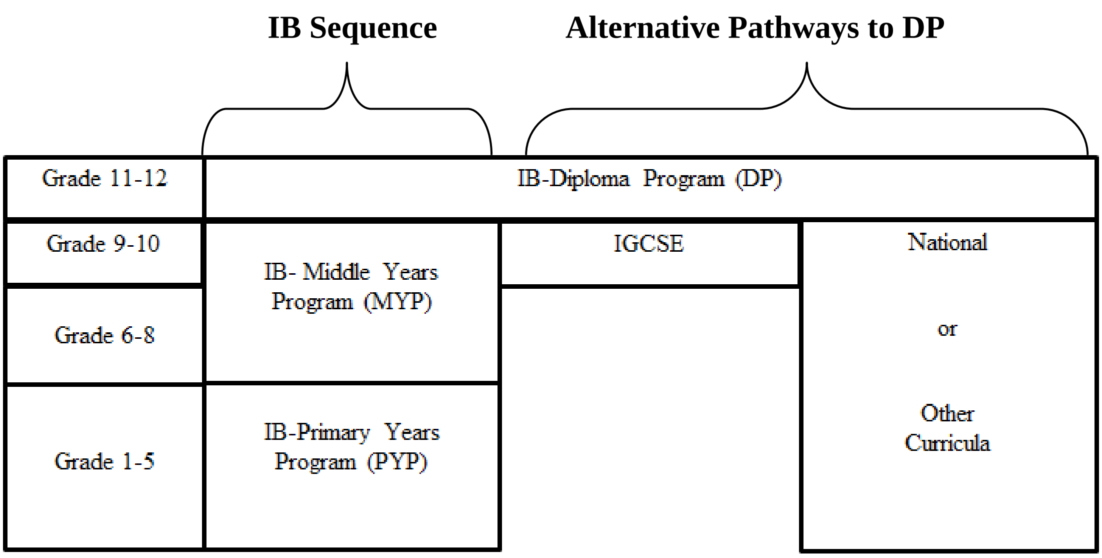

Figure 1. IB sequence and alternative pathways to DP.

As the oldest of the international programs, DP has established itself as the premium university preparatory curriculum for students in grades 11 and 12 (Hayden, 2006). However, which preparation program is best for DP is a controversial issue. Some schools follow the IB sequence (PYP-MYP-DP) while other schools use IGCSE as a pre-DP course. Some schools prefer a combination of one or more alternative programs before DP. See *Figure 1*.

Worldwide, over 3,748 international and national schools in 147 countries across Africa/Europe/Middle East, Asia-Pacific and Americas are offering one or more of the IB programs. These schools enroll over 1,173,000 students and the numbers have been increasing steadily during the last decade (Barnes, 2014). Over 3,700 schools offer the IGCSE syllabi (CIE, 2014). Table 2 shows the total number of IB schools that implement the IB programs.

Table 2
Number of schools that implement the IB programs

Regions	Countries	Schools
Africa/Europe/Middle East	86	888
Asia-Pacific	29	588
Americas	32	2163
Total	147	3639

Over the past ten years, the average annual growth rate of the number of programs is 12.19% (Barnes, 2014). Figure 2 shows the strong growth of the three IB programs.

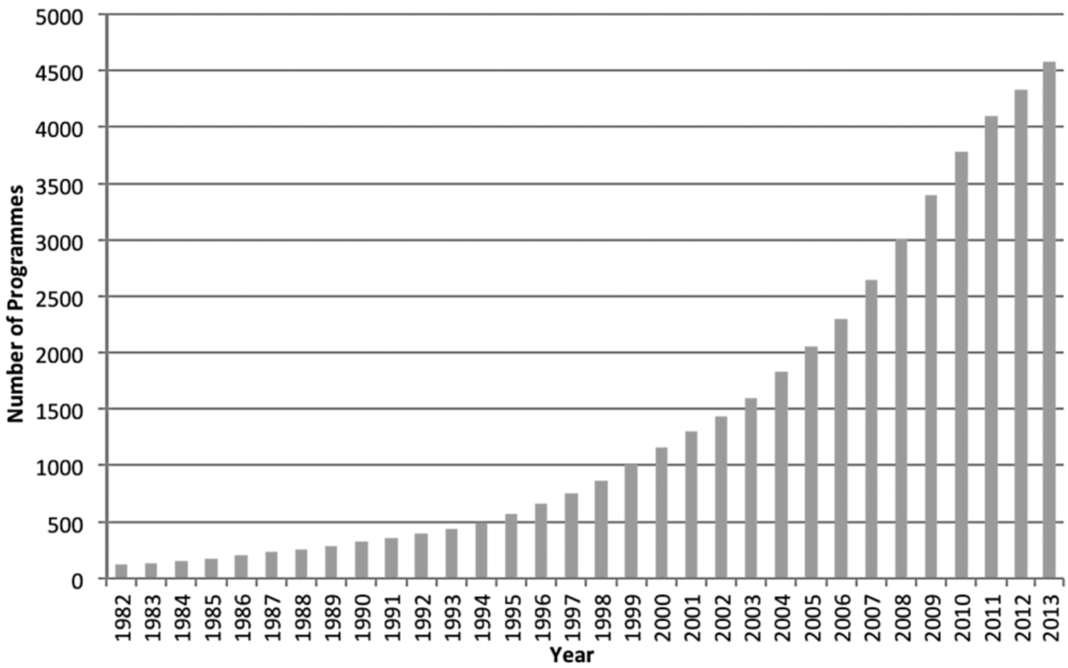

Figure 2. Annual growth rates for IB programs.

Mainstream international curricula

The DP is designed as a two-year university preparatory course for secondary school students between the ages of 16 and 19 (Culross & Tarver, 2011; Stewart, 2010). During their DP studies, students are expected to be enrolled in at least one subject from each of the following five subject groups: (a) language acquisition, (b) studies in language and literature, (c) individuals and societies, (d) experimental sciences, (e) mathematics and computer science. In addition to this subject specific academic preparation, DP students take three other courses; Theory of Knowledge (diverse ways of knowing and areas of knowledge), Extended Essay (an essay of approximately 4,000 words about a topic of interest written as a result of independent research), and participation in Creativity, Action, and Service (CAS) activities (IBO, 2013b). At the senior high school level, DP has been a popular curriculum in schools. One reason behind the widespread use of DP across the globe is the academically challenging nature of its diploma requirement while preparing students for an increasingly global world (IBO, 2013c).

The IGCSE is designed as a two-year course for secondary school students between the ages of 14 and 16 (CIE, 2014). Within IGCSE, the core subjects groups are mathematics, language and science. Each core subject has an individual differentiated syllabus. IGCSE students can choose to take these individual syllabi according to their needs and interest (CIE, 2014). Some claimed that IGCSE has gained a certain level of popularity because of the coherence of its learning content (Nashman-Smith & Taylor, 2004; Richardson, 2010). Some believed that the choice of schools to implement IGCSE indicated that their pragmatic need of a formal curriculum which offers internal and external examinations (Hayden & Thompson, 1998).

Mathematics and science in international curricula

Mathematics and science in IGCSE

Both mathematics and science courses in IGCSE are designed as a comprehensive syllabus that offers a variety of levels and assessment schemes. The levels of mathematics and science curricula are divided into core and extended and this devision allows students to choose a particular level according to their abilities and needs.

IGCSE mathematics course focuses on number, algebra, functions, geometry, transformations, trigonometry, sets, probability, and statistics. Mathematics grades range from A to G, with A being the highest. IGCSE mathematics external examination includes two papers; while students cannot use a calculator in Paper 1, they can use their calculators in Paper 2. External assessments are graded by external examiners. Students' portfolios and projects are assessed internally by teachers (CIE, 2014a).

The IGCSE science course, which is also called the coordinated science, contains content from all individual science subjects including biology, chemistry and physics. Students in IGCSE science take three of the six papers, depending on their interest and level: Paper 1 (multiple choice questions); either paper 2 or paper 3 (short or extended response questions); either papers 4, 5 or 6 (practical assessments such as coursework, and practical test including experimental and observational skills). Coordinated science grades range from A to G, with A being the highest (double award system). Similar to the assessment in mathematics, written examinations in science are also graded by external examiners and moderated externally by Cambridge Examination Board (CIE, 2014b).

Mathematics and science in DP

Both mathematics and science in the DP offer a variety of levels and rigorous assessment schemes. While there are four different levels of DP mathematics: mathematical studies, mathematics standard level, mathematics higher level, and further mathematics standard level, there are two different levels of DP science: standard level and higher level. Students choose one of these levels according to their individual needs, interests, and abilities (IBO, 2013c).

The DP mathematics includes the following topics: algebra, functions and equations, circular functions and trigonometry, matrices, vectors, statistics and probability, and calculus (IBO, 2014a). DP science includes the following six topics: biology, computer science, chemistry, design technology, physics, and sports, exercise and health science (IBO, 2014b). There are two assessment types: external and internal assessments with both short and extended response questions. While students are assessed internally by their teachers, they are assessed externally by IB examiners. External mathematics assessment includes two papers: Paper 1 and paper 2. Students are not allowed to use calculators in paper 1, but they may use in paper 2. Students' portfolios are internally assessed. DP assessment grades range from 1 to 7 (highest). Total score is 45 points, and students need to take at least 24 points to qualify for the DP diploma (IBO, 2013c).

International curriculum context in Turkey

International curricula are widespread across Turkey; especially the DP is popular among private schools (Halıcıoğlu, 2008). As of 2014, there are 48 schools that implement one or more of the IB programs, 34 of which implement the DP and eight of which implement the MYP. Including the two schools that are authorized to offer all three IB programs, there are four schools in total that offer the MYP and DP sequence. These figures show that 30 out of the 34 DP schools follow an alternative pathway to IBO's MYP-DP sequence (See Figure 1) (IBO, 2013c). There are at least 15 Cambridge schools in Turkey, but there is no information about the exact number of schools that offer IGCSE (CIE, 2014).

Because of the centralized placement system of higher education in Turkey, universities cannot admit students based on their DP scores. However, several private universities offer scholarship to DP graduates and exempt them from first year core courses, given that students had a high score during their DP studies of these subjects (Tarsus American College, 2014; Türkiye'de Uluslararası Bakalorya Diploma Programı (IBDP) uygulayan okullar, n.d).

CHAPTER 3: METHOD

Introduction

The current research investigated the impact of student scores in International General Certificate of Secondary Education (IGCSE) scores and gender on the International Baccalaureate Diploma Program (DP) scores in mathematics and science. First, the researcher investigated whether the IGCSE mathematics scores and gender (independent variables) were statistically significant predictors of DP mathematics scores (dependent variable). Second, the study explored whether the IGCSE science scores and gender (independent variables) were statistically significant predictors of DP science scores (dependent variable). This chapter included the research design used to address these research questions, the sampling procedure, how data were collected, and how data were analyzed.

Research design

For the current study, multiple regression analysis was conducted to answer the research questions. In multiple linear regression analysis, the researcher investigates the relationships between a single outcome (dependent) variable and at least two or more predictor (independent) variables (Creswell, 2003). As for data scale of variables, the independent variables can be measured at any level (i.e., nominal, ordinal, interval or ratio); however, the dependent variable must be measured at the interval or ratio level (Huck, 2011).

Participants

The sample was drawn from high school students who attended a private international school in a major metropolitan city in Turkey. Students could be described as of a high socioeconomic status and according to the school registrar's office, they were mostly children of faculty members from nearby universities or members of foreign diplomatic missions in the city. The school had a tradition of sending its graduates abroad for higher education. For example, between the years 2010 and 2012, approximately two thirds of the graduating students chose to attend universities in the United States or in Europe. The medium of instruction at this school was English and over 60% of the faculty members held international teaching qualifications.

Two of the three International Baccalaureate Organizations (IBO) programs were offered at this school. The school followed the Primary Years Program (PYP) for grades 1 through 5, the Turkish Ministry of National Education (MONE) curriculum for grades 6 through 8, the IGCSE for grades 9 and 10 and DP for grades 11 and 12. The school was one of the 34 schools in Turkey that was authorized to offer DP courses, and the school was one of the 30 DP schools that did not implement the MYP (IBO, 2014). In fact, it was one of 15 Cambridge schools (CIE, 2014).

The participants (*N* = 250, 132 female) were students of the school who met the following criteria: (a) They were enrolled in DP mathematics standard or high level courses and at least one DP science course between the years 2005 and 2012; (b) they had taken for the IGCSE mathematics and science examinations while at this particular school between the years 2003 and 2010. Sixty-seven students who did not meet these criteria were excluded from further analysis, which was not unusual given that a high mobility rate would be expected among international school students.

Participants in the sample consisted of mostly Turkish citizens (*n* = 231) while a small minority of the students had non-Turkish passports (*n* = 19).

Table 3 presents participants' enrollment in each DP science course, either standard or high level. Because some students opted to take a high level science course in two or more subjects, the total percentage in each subject group did not add up to 100. All students in the sample took the DP mathematics.

Table 3
Student enrolment in DP science courses

	Physics	Chemistry	Biology
Standard Level	24%	18%	31%
Higher Level	54%	21%	14%

Data collection

With regard to the first research question, the dependent variable of the study was the DP mathematics scores (*dpmath*), while the independent variables were the IGCSE mathematics external examination scores (*imath*) and *gender*. With regard to the second research question, the dependent variable of the study was the average DP science scores in physics, chemistry and biology (*dpscience*), while the independent variables were the IGCSE science scores external examination scores in science (*iscience*) and *gender*. The data scales of each variable are explained as follows:

- *dpmath:* This variable was measured at the interval level and the range was from 1 to 7 (highest).

- *dpscience*: This variable was composed of mean scores in biology, chemistry and was measured at the interval level. The range of *dpscience* was from 1 to 7 (highest).
- *imath:* The *imath* variable was measured at the interval level and the marks of *imath* were awarded on a seven point scale of grades range from 1 indicated with a letter grade of *G*) to 7 (highest, indicated with a letter grade of A).
- *iscience:* The *iscience* variable was measured at interval level and the marks of iscience were awarded as a seven point scale of grades.
- *gender*: The *gender* variable was measured on a nominal scale. Data were dummy coded as females = 0 and males = 1.
- Interaction variables: The interaction between IGCSE mathematics and gender was shown with a new variable, named *g_imath.* The interaction between IGCSE science and gender was shown with *g_iscience*.

Data analysis

Data were first analyzed descriptively by computing the means and standard deviation for each continuous variable. Correlations between two continuous variables were estimated by Pearson's product-moment correlation coefficient *r* to describe the isolated relationship between the intervally-scaled variables (Huck, 2011).

Data were then explored with respect to assumptions of multiple linear regression and one-sample *t*-test in order to provide accurate estimates of regression coefficients (Thompson, 2008). The primary assumptions were as follows:

- normality of residuals,
- linearity,
- homoscedasticity,
- multicollinearity threat.

Any violations were checked by means of graphical and statistical measures, such as histograms, standardized scores, scatter plots, and skewness-kurtosis estimates (Tabachnick & Fidell, 2007). There was no multicollinearity threat. The detailed information about assumptions and how data met the assumptions was explained in Appendix 1 and Appendix 2. No outliers or missing scores were detected in the sample.

A one-sample *t*-test (alpha level = .01) was used to find out whether the student scores in our sample was statistically significant better than scores of students worldwide. The regression results were interpreted by using *a* (constant), *b* (unstandardized), β (standardized) weights and structure coefficients (r_s) in order to determine the strength of the relationship between dependent and independent variables (Courville & Thompson, 2001). A detailed explanation of the unstandardized and standardized weights was given in Appendix 3. The detailed information of structure coefficients was given in Appendix 4.

Thus, the general form of a regression equation can be given by *Equation 1*:

$$Y_i \leftarrow Y_{i}\_hat = a + b_i\,(X_i) \tag{1}$$

,where (X_i) represents the set of all predictor variables, while *a* denotes the constant and *b* shows the unstandardized weights. In this equation, Y_i is the measured variable, consisting of actual scores and Y_i_hat is the predicted variable, indicating the estimated scores (Thompson, 2008).

The results were given symbolically through equations by using standardized β (beta) and unstandardized regression (*b*) weights. The independent variables were centered to minimize the multicollinearity threat. Subtracting the sample mean from each observed value has been recommended as a potential solution to multicollinearity problems in multiple regression analysis (Cronbach, 1957). This process is called the mean centering. The centralized independent variables were renamed as:

imath → *c_imath*

iscience → *c_iscience*

g_imath → *g_c_imath*

g_iscience → *g_c_iscience*

Thus, the regression equations with unstandardized and standardized weights are presented in *Equation 2* and *Equation 3,* respectively for mathematics and in the *Equations 4* and *Equation 5,* respectively for science:

$$dpmath = a + b_1 * c\_imath + b_2 * g\_c\_imath + b_3 * gender \quad (2)$$

$$Z_{dpmath} = \beta_1 * Z_{c\_imath} + \beta_2 * Z_{g\_c\_imath} + \beta_3 * Z_{gender} \quad (3)$$

$$dpscience = a + b_4 * c\_iscience + b_5 * g\_c\_iscience + b_6 * gender \quad (4)$$

$$Z_{dpscience} = \beta_4 * Z_{c\_iscience} + \beta_5 * Zg\_c\_iscience + \beta_6 * Z_{gender} \quad (5)$$

In addition to the symbolic representations, the American Psychological Association (APA) suggested that researchers include visual representations in their reports (Cumming, Fidler, Kalinowski, & Lai, 2012). Thus, the results were visually represented by path diagrams, as well. All the analyses of data were conducted by using Predictive Analytics Software (PASW-SPSS) 20.

Model fit

The amount of variance, which is explained through an investigation is named as $SOS_{explained}$ (sum of squared deviation scores), while the part of the total variance which is unexplained is called $SOS_{unexplained}$. The total variance, which is denoted by SOS_{total} provides "*information about both the amount and the origins of individual differences*" (Thompson, 2008, p. 60) . Thus,

$$SOS_{EXPLAINED} + SOS_{UNEXPLAINED} = SOS_{TOTAL} \quad (6)$$

It was strongly recommended that researchers report effect sizes (Cumming, Fidler, Kalinowski, & Lai, 2012). As much as the value of Pearson product-moment coefficient *r*, indicated the bivariate relationship; multiple *R* indicated the multivariate relationship. Thus, R^2, which is an effect size by itself, indicated how much of the SOS_{total} was explained by independent variables. The regression effect size (R^2) was computed by using *Equation 7* or *Equation 8*.

$$R^2 = \frac{\text{SOSexplained}}{\text{SOSTOTAL}} \tag{7}$$

$$R^2 = \beta_1 (r_{yx1}) + \beta_2 (r_{yx2}) + \ldots \tag{8}$$

, which r_{yx1} denotes the bivariate correlation between the dependent *y* variable and the first independent *x* variable.

Chapter 4: RESULTS

Introduction

In this chapter, results from the analysis of chapters on the impact of International General Certificate of Secondary Education scores and gender on the Diploma Program scores in mathematics and science were reported to address the following research questions:

1) To what extent do IGCSE mathematics scores and gender explain variance in DP mathematics scores?
2) To what extent do IGCSE coordinated science scores and gender explain variance in DP science scores?

Descriptive statistics

Data were first analyzed descriptively in terms of means and standard deviations for the continuous variables. See Table 4.

Table 4
Descriptive statistics

	Mean	*SD*
dpmath	4.98	1.25
dpscience	4.45	1.28
imath	5.14	1.26
iscience	4.50	1.34

Note. SD = Standard Deviation.

Based on the descriptive statistics, the participants in the sample scored better than the global averages, which were reported for all students taking the exam worldwide between the years 2006 and 2012. See Table 5. Hence, students in this study's sample scored about 0.68 standard deviations better (Cohen's *d*) in mathematics (t = 5.47; df = 249, p < .01) and about 0.30 standard deviations better in science (t = 2.40; df = 249, p = .02), when compared to the mean of global scores (Mean = 4.55, SD = 0.05 of mathematics group; Mean = 4.26, SD = 0.06 of science group). The limited dispersion in both global averages of mathematics and science scores indicated that the global scores could be considered to consistently be around these reported point estimates.

Table 5
Global averages of student scores in DP mathematics and science

Year of the Examination	Mathematics Group	Science Group
2006	4.66	4.32
2007	4.53	4.21
2008	4.53	4.24
2009	4.50	4.21
2010	4.56	4.22
2011	4.51	4.31
2012	4.53	4.34
Mean	4.55	4.26
SD	0.05	0.06

Correlations

The bivariate relationship between the variables was described in terms of correlation coefficients. Table 4 indicates that there was a statistical significant correlation between DP science and IGCSE science scores ($r_{\text{dpscience}-\text{iscience}}$ = 0.68, *p* < .01) as well as between DP science and DP mathematics scores ($r_{\text{dpscience}-\text{dpmath}}$ = 0.64, *p* < .01). These relatively strong correlations implied that students, who were more successful in DP science, were also successful in IGCSE science and in DP mathematics. None of the variables were in correlation with *gender* (*p* > 01), indicating that males and females were not likely to differ in terms of their achievement in mathematics or science.

Table 6
Bivariate correlation matrix

	dpscience	*dpmath*	*imath*	*iscience*	*gender *imath*	*gender *iscience*	*gender*
dpscience	1	.64*	.61*	.68*	.26*	.30*	.11
dpmath		1	.54*	.53*	.15*	.16*	0
imath			1	.79*	.24*	.23*	0
iscience				1	.26*	.35*	.06
*gender*imath*					1	.97*	.94*
*gender*iscience*						1	.92*
gender							1

Note. * Correlation is statistically significant (*p* < .01).

Table 6 shows that the strength of the linear relationship between *imath* and *iscience* (r = .79, r^2 = .62, p < .01) is greater than the strength of the linear relationship between *dpmath* and *dpscience* (r = .64, r^2 = .41, p < .01). This may show that DP mathematics and science curricula are more departmentalized than IGCSE mathematics and science curricula. This finding is not surprising because research showed that as year progresses; both mathematics and science include more specialized knowledge due to the nature of these subjects (Bong, 2001; Sagun & Corlu, 2014). The nature of the relationship between variables did not change when the independent variables were centered. See Table 7.

Table 7
Bivariate correlation matrix (variables centered)

	dpmath	*dpscience*	*c_imath*	*c_iscience*	*g_c_imath*	*g_c_iscience*	*gender*
dpmath	1	.64*	.54*	.53*	.45*	.40*	0
dpscience		1	.61*	.68*	.47*	.51*	.11
c_imath			1	.79*	.73*	.58*	0
c_iscience				1	.58*	.74*	.06
g_c_imath					1	.79*	0
g_ciscience						1	.04
gender							1

Note. * Correlation is statistically significant (p < .01).

Major findings

DP mathematics

Table 8 shows that *b* weights, β weights and structure coefficients for each predictor variable of DP mathematics scores.

Table 8
Unstandardized and standardized regression coefficients for DP mathematics

	B	*Beta*	r_s	*p*
(Constant)	4.99			< .01
c_imath	.45	.45	.98	< .01
g_c_imath	.17	.12	.82	.11
gender	0	0	.02	.99

Note. r_s = structure coefficient.

A multiple regression analysis was conducted to evaluate how well IGCSE mathematics scores predicted the DP mathematics scores. The other predictors in model were the gender and gender*IGCSE math scores (interaction). The multiple regression equation ($p < .01$) is given with unstandardized *b* coefficients in the *Equation 9* after the variables were centered:

$$dpmath = 4.99 + 0.45 * c\_imath + 0.17 * g\_c\_imath + 0 * gender \qquad (9)$$

This equation indicated that if students could increase their IGCSE mathematics scores by one point, their DP mathematics score would increase by 0.45 points. The multiple regression equation ($p < .01$) is given with standardized β coefficients in the *Equation 10* after the variables were centered:

$$Z_{dpmath} = 0.45 * Zc\_imath + 0.12 * Zg\_c\_imath + 0 * Zgender \quad (10)$$

This equation indicated that if students could increase their IGCSE mathematics scores by one standard deviations, their DP mathematics score would increase by 0.45 standard deviations.

After an investigation of the structure coefficients (See Table 7 to estimate r_s), unstandardized *b* coefficients, and standardized β coefficients, the most important statistically significant predictor of DP mathematics scores emerged as the IGCSE mathematics scores ($\beta = 0.45$, $p < .01$). Gender, which was not one of the statistically significant predictors for DP mathematics score ($p > .01$), explained a very small portion of the variance. *Gender* variable with both $\beta = 0$ and $r_s = 0$ was useless. Thus, it was concluded that gender was not a suppressor variable (Thompson, 2008). There was no a statistical significant interaction between IGCSE mathematics scores and gender ($p > .01$). A path diagram was used to visually represent the model. The numbers by the arrows indicate the standardized regression weights (β), presenting an alternative interpretation of the multiple regression equation. See *Figure 3*.

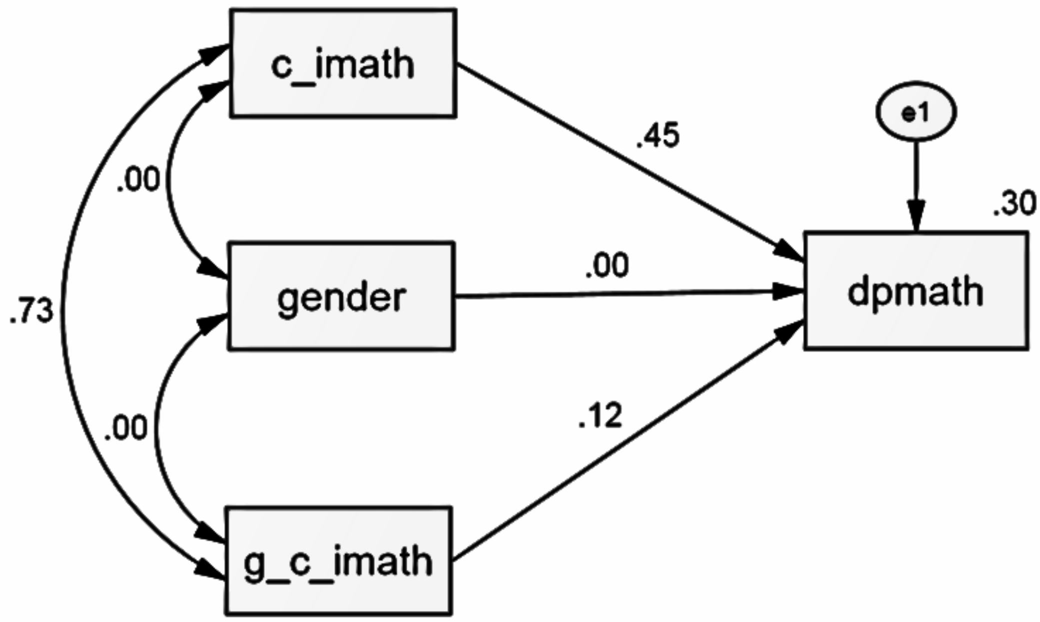

Figure 3. The factors that predict students' DP mathematics scores.

DP science

Table 9 shows that *b* weights, *β* weights and structure coefficients for each predictor variable of DP science score.

Table 9
Unstandardized and standardized regression coefficients for DP science

	B	*Beta*	r_s	*p*
(Constant)	4.36			< .01
c_iscience	.62	.65	1	< .01
g_c_iscience	.04	.03	.75	.64
gender	.17	.07	.16	.15

Note. r_s = structure coefficient.

A multiple regression analysis was conducted to evaluate how well IGCSE science scores and gender predicted the DP science scores. The other predictors in the model for predicting DP science were the gender and gender*IGCSE science scores (interaction). The multiple regression equations ($p < .01$) were given with unstandardized *b* coefficients in the *Equation 11* after the variables were centered:

$$dpscience = 4.36 + 0.62 * c\_iscience + 0.04 * g\_c\_iscience + 0.17 * gender \quad (11)$$

This equation indicated that if students could increase their IGCSE science scores by one point, their DP science score would increase by 0.62 points. The multiple regression equations ($p < .01$) were given with standardized β coefficients in the *Equation 12* after the variables were centered:

$$Z_{dpscience} = 0\ .65 * Zc\_iscience + 0.03 * Zg\_c\_iscience + 0.07 * Zgender \quad (12)$$

This equation indicated that if students could increase their IGCSE science scores by one standard deviations, their DP science score would increase by 0.65 standard deviations.

After an investigation of the structure coefficients (See Table 9 to estimate r_s) unstandardized *b* coefficients, and standardized β coefficients, the most important statistically significant predictor of DP science scores emerged as IGCSE science scores ($\beta = 0.65$). Gender, which was not one of the statistically significant predictors for DP science scores, explained very small portion of the variance. *Gender* variable with both $\beta = 0$ and $r_s = 0$ was useless. Thus, it was concluded that gender was not suppressor variable (Thompson, 2008). There was no statistical significant interaction between IGCSE science scores and gender (*p* >.01). A path diagram was used to visually represent the model. The numbers by the arrows indicated the standardized regression weights (*β*), presenting an alternative interpretation of the multiple regression equation. See *Figure 4.*

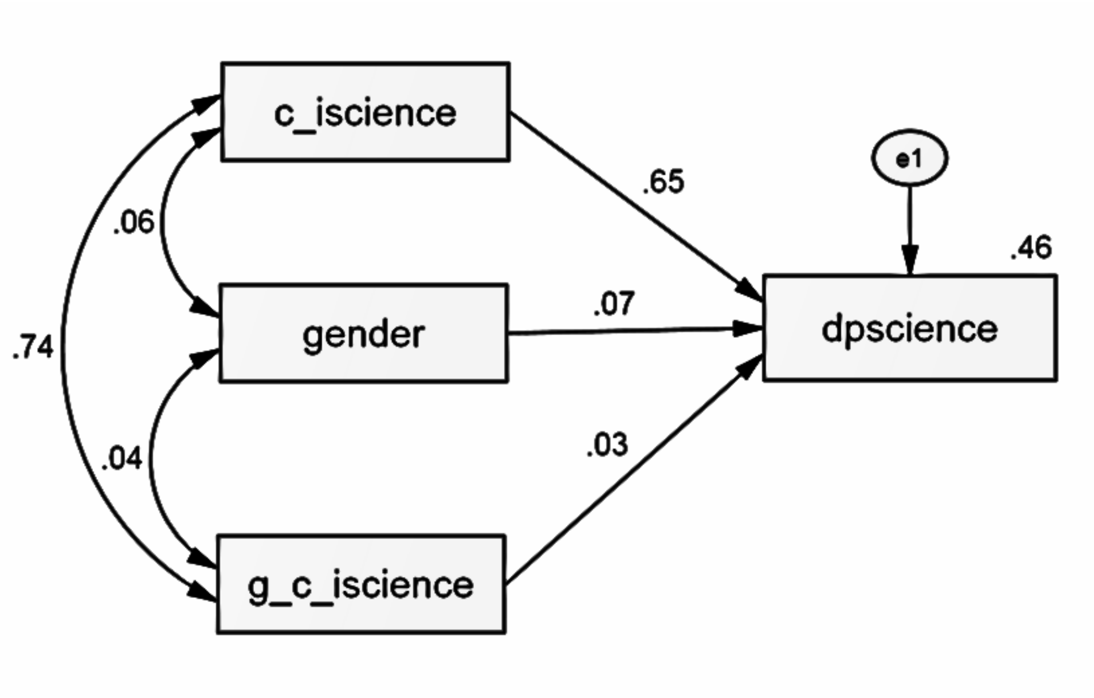

Figure 4. The factors that predict students' DP science scores

Model fit with respect to DP mathematics

The ANOVA table shows that the model was statistically significant:

F (3,246) =34,723, p < .01. See Table 10.

Table 10
ANOVA output for DP mathematics

Source	Sum of Squares	df	MS	F_{cal}	*p*
Regression	116.593	3	38.864	34.723	< .01
Residual	275.343	246	1.119		
Total	391.936	249			

Notes: * Predictors: *gender, c_imath, g_c_imath*.
Dependent variable: *dpmath*

The model summary table shows that the multiple correlation coefficient (*R*) was. 0.55 (R^2 = 0.30; $R^2_{adjusted}$ = 0.29), indicating that 29% of the variance in DP mathematics score was explained. See Table 11.

Table 11
Model summary for DP mathematics

Model	R	R Square	Adjusted R Square
	.55	.30	.29

Predictors: (Constant), *gender, c_imath, g_c_imath*
Dependent variable= *dpmath*

Model fit with respect to DP science

The ANOVA table shows that the model was statistically significant:

$F(3,246) = 70.804$, $p < .01$. See Table 12.

Table 12
ANOVA output for DP science

Source	Sum of Squares	df	MS	F*cal*	*p*
Regression	187.765	3	62.588	70.804	< .01
Residual	217.456	246	.884		
Total	405.221	249			

Notes: * Predictors: *gender,c_iscience,g_c_iscience*
Dependent variable: *dpscience*

The model summary table shows that the multiple correlation coefficient (R) was 0.68 (R^2 = 0.46; $R^2_{adjusted}$ = 0.46), indicating that 46% of the variance in DP science scores was explained. See Table 13.

Table 13
Model summary for DP science

Model	R	R Square	Adjusted R Square
	.68	.46	.46

Predictors: (Constant), *gender, c_iscience, g_c_iscience*
Dependent variable= *dpscience*

CHAPTER 5: DISCUSSION

Introduction

This chapter included a discussion of the major findings, concluding remarks of the current research and recommendations for researchers and practitioners at international schools. The first purpose of this study was to examine the impact of International General Certificate of Secondary Education (IGCSE) mathematics scores on outcome scores in DP mathematics by identifying the quality of the assumed predictor variables. The second purpose was to investigate the impact of IGCSE science scores on outcome scores in DP science.

Summary of major findings

1) IGCSE mathematics scores were the strongest predictor of student scores in DP mathematics. If students could increase their IGCSE mathematics scores by one point, their DP mathematics score would increase by 0.45 points.

2) IGCSE science scores were the strongest predictor of student scores in DP science. If students could increase their IGCSE science scores by one point, their DP science score would increase by 0.62 points.

3) Almost one-third of the variance in student scores in DP mathematics scores was explained with the model developed in the current study.

4) Almost one-half of the variance in DP science scores was explained with the model developed in the current study.

5) Between the two models, the model developed for explaining variance in DP science was more successful than the model developed for mathematics in terms of the amount of variance accounted for.

6) Gender had no effect whatsoever (useless variable – Thompson, 2008) in explaining variance in neither DP mathematics nor science scores.

Discussion of the major findings

Coherence-consistency and alignment

It is evident from the current study that IGCSE provides a good foundational preparation for DP. The strong relationship between IGCSE and DP scores in mathematics and science can be best explained with the strong alignment between IGCSE and DP in terms of their mission, instructional approaches-aims and assessment objectives (Hodgson, 2010; Stobie, 2005). Although the high percentage of the explained variance supports this claim, further analysis of these curricular documents is needed.

Coherence in missions

Both international programs display a similar approach in their intended curricula; developing individuals to be effective learners. For example, DP states its mission as "…to develop inquiring, knowledgeable and caring young people…" (IBO, 2014a, p.3). IGCSE emphasizes similar competencies in its aim: "Our aim is to balance knowledge, understanding and skills in our programs and qualifications to enable candidates to become effective learners …" (CIE, 2014a, p.3).

Consistency in instructional approaches and aims

A consistency between DP and IGCSE is observed at aims specific to mathematics. For example, the role of perseverance, which is formulated as “to develop patience and persistence in problem solving” (IBO, 2014a, p.8) and “to develop patience and persistence in solving problems” (CIE, 2014a, p. 8), appear in almost exact terms in both curricula. Several other similarities exist, including emphasis on communicating mathematically in a variety of ways (Saenz-Ludlow & Presmeg, 2006), mathematical proofs (Hanna & Jahnke, 1993), interdisciplinary connections (Judson, 2013), and appreciation of mathematics as a human endeavor (Corlu, 2013; D'Ambrosio & D'Ambrosio, 1994). Reflecting on the general aim of raising an internationally-minded individuals, while IGCSE states an aim that fosters “international aspect of mathematics, its cultural and historical significance” (CIE, p.8), DP aims to encourage the “multicultural and historical perspectives” (IBO, p.8) of mathematics.

When IGCSE science and DP science (biology, chemistry, and physics) are compared in the intended curricular documents, the application of science in technology seems to be the most apparent commonality. In fact, this is relevant in the latest trends in science education, which advocates the necessity of integrating science and technology in order to prepare the 21st century workforce (Bybee & Fuchs, 2006; Milikan, 2000). Fostering students’ understanding of and skills in using the scientific method is another commonality between the two curricula. Related to this, practical work is heavily highlighted throughout both documents. For example, it is stated in DP science curricula that “develop experimental and investigative scientific skills including the use of current technologies” is one of the main aims. Similarly in IGCSE, the importance of practical work is evident in several aims. The emphasis of both IGCSE and DP on practical work in science education advocates for a strong relationship between IGCSE and DP (Bybee, 1997; Toplis & Allen, 2012).

There is little evidence in the intended curricular documents that instructional approaches can further explain the strong alignment of students' scores in IGCSE and DP mathematics and science. This may mean that teachers are given the liberty to adapt their implementation according to the specific needs of their students. However, this does not mean that teachers are left alone when they need support. In fact, both curricula widely support teachers through materials, planning, resource lists, and training. For example, IGCSE states that it provides mathematics and science teachers with a wide range of support materials that would suit a variety of teaching methods in different international contexts (CIE, 2014; Morrison, 2009). This may show that these support systems narrow the gap between intended and taught curricula at international mathematics and science classrooms. All in all, these evidences may result in organizing extra professional development hours for teachers to improve teaching quality or additional hours of mathematics and science instruction to increase student performance (Bishop, 1995).

All these similarities may explain why students who were successful in IGCSE mathematics were likely to also be successful in DP mathematics. However, it should also be noted that there are a few differences in aims of the two curricula. Due to the IGCSE's main goal of preparing students for the next level at the senior level, it encourages students to a further study in mathematics. This does not seem to be apparent in DP.

Alignment of assessment procedures

An alignment of procedures is evident in both curricula (Resnik, 2012). The alignment can be observed in both the internal and external assessment practices, which are tailored according to students' needs and interests (CIE, 2014; Greatorex, 2007; IBO, 2013d). For example the role of reasoning is assessed in both curricula: "…construct mathematical arguments through use of logical deduction and inference, and by the manipulation of mathematical expressions" (IBO, 2014a, p.8) and "…make a logical deductions from given mathematical data" (CIE, 2014a, p.8). There are other similarities in assessment objectives of IGCSE and DP mathematics, which span knowledge and understanding, problem solving, communication and interpretation, technology and inquiry domains. When IGCSE science and DP science are compared in the science guides, the experimental skills and investigation is the major objective intended to reach. This common objective is formulated as "…interpret and evaluate experimental observations and data" (CIE, 2014b, p.12) and "…interpret data to reach conclusions" (IBO, 2014b, p. 12). The science assessments of IGCSE and IB expect students to demonstrate, apply and use, construct, analyze and evaluate understanding, hypothesis scientific facts as well.

High-stake testing

The strong relationship between IGCSE and DP scores in mathematics and science can be alternatively explained with the need of to "take public examinations before students tackle the demands of the IB Diploma examinations in grade 12" (Nashman-Smith & Taylor, 2004, p. 19). Thus, it may be the case that international school students perceive IGCSE external examinations as a high stakes test (Hayden & Thompson, 1998; Nashman-Smith & Taylor, 2004). This perception may lead students to get used to dealing with high stakes tests during their IGCSE studies in terms of stress management. This may occur during preparation for or during the actual DP external examinations (Hayden & Thompson, 1998). Research suggests that exam-related stress is a common problem faced by students of all age groups, especially in high school years (Kavakli, Li, & Rudra, 2012). It is possible that students not only develop strategic test-taking skills but also learn how to manage their stress during the actual test (Berry & Kingswell, 2012). The ability to cope with such stress can be overcome with regular test-taking practice. In fact, it is a known fact that IGCSE schools organize regular mock exams before the actual test and CIE support schools in their efforts to organize such trial exams (Datson, Sheldon & Sherman, 2010).

Gender

It is evident from the current study that gender is not a noteworthy factor to determine students' success in mathematics or science. The findings in the present study and previous research in the Turkish literature (Usak, Prokop, Ozden, Ozel, Bilen, & Erdogan, 2009) is consistent in their claims that there is no difference between males and females in terms of their mathematics and science achievement. However, there are some other studies which claim that the mathematics proficiency of males is higher than females and females are not as good in science as males (Prokop, Prokop, & Tunnicliffe, 2007). Thus, this finding should be interpreted with some caution because the population of the current study is an unusual group of high school students as they came to their current school from different cultural settings.

Implications for practice

After conducting this study, I believe that there is a strong alignment between IGCSE and DP in mathematics and science. This alignment necessitates teachers to learn the requirements of these syllabi, even if they are teaching only one of them. Teachers should know where students come from or where they are headed to. This is important because senior high school teachers need to understand students' prior knowledge in order to address their needs. Also, junior high school teachers need to know the challenges and requirements of senior high school curricula. I suggest that teachers have a comprehensive knowledge about the philosophies, contents and assessment types of both IGCSE and IB. Teachers can develop their professional expertise by participating in IGCSE and IB teacher-training workshops, following special events, past exam papers, each subject syllabi on the IB's website for teachers the online curriculum centre (OCC) and Cambridge International Examination (CIE) website. The teachers should review relevant support materials published by IB and IGCSE. Teachers can volunteer to become IB and IGCSE examiner for moderating internally assessed student work, externally marking examination papers or marking work submitted by students (e.g., extended essay). I believe if teachers know the differences and similarities between IGCSE and IB in detail, they can be a teacher of both IGCSE and IB.

The examination systems have a pervasive effect on school administrations and parents, as well. I recommend school administrations to arrange regular mock exams. The types of questions on mock exams should be similar to actual tests, so that students can get used to sitting for three or more hours during exams and they will learn how to manage their time. When they practice tests, students can be encouraged to gain habits of planning their schedules, learning different test techniques. School administrations and teachers are also advised schedule extra hours of mathematics and science tutoring and devote some of these hours to help students learn how to be successful in tests.

Both school administrations and teachers can benefit from the regression model developed in the current study or they may want to develop more complex equations specific to their student population. This is important and relevant because IB requires teachers to give predicted grades before the actual exams. This research may help teachers give predicted grade by using more scientific and accurate methods.

Implications for research

Finally, I suggest future researchers to work closely with international schools and help them develop more complex prediction models by including students' nationalities, financial status, home language, their higher education plans or their academic success of other subjects (e.g. Extended Essay, Creativity Service Activity (CAS) or Theory of Knowledge (TOK)). Despite all, there will be a need to analyze curricular documents in terms of coherence, consistency and alignment.

Limitations

The findings of the study can be generalized to students educated in a similar context to that of the current study. The school from which the participants were sampled set no admission criteria for the DP. However, this is not the usual practice for DP schools in Turkey. Thus, a limitation to the current study is that the results may not pertain to schools that channel the ablest students for DP. A second limitation is due to the high rate of student and teacher mobility. For example, in this study, several students were not included in the sample because (a) they left the school and possibly the country after they have taken IGCSE examination, thus they did not have DP scores; and (b) they started school at the DP level without attending IGCSE.

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APPENDICES

APPENDIX 1: Normality assumption

Data were inspected for normality of the residuals by investigating the histogram of the residuals, the normal probability plot and the scatter plot between predicted scores and residuals. Skewness estimates were also examined. If the estimates were less than plus or minus one, the distribution was considered to be a normal (Tabachnick & Fidell, 2007). See the histogram of standardized residuals in *Figure 5* for DP mathematics.

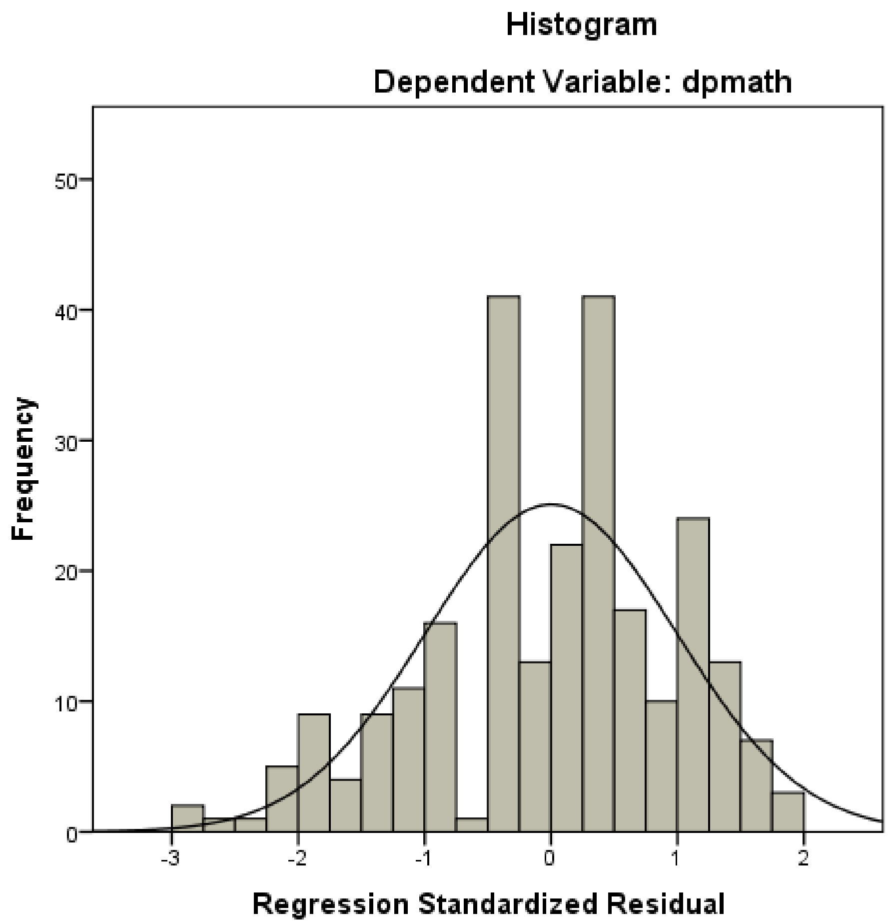

Figure 5. Histogram of standardized residuals for DP mathematics.

Figure 5 shows that standardized residuals for *dpmath* were assumed to be normally distributed because the frequency distribution for *dpmath* resembled a symmetrical bell-shaped or normal curve. Normal P-P plot was also checked. *Figure 6* shows that the plotted points of residuals for *dpmath* match the diagonal line, supporting conclusion that the residuals were normally distributed.

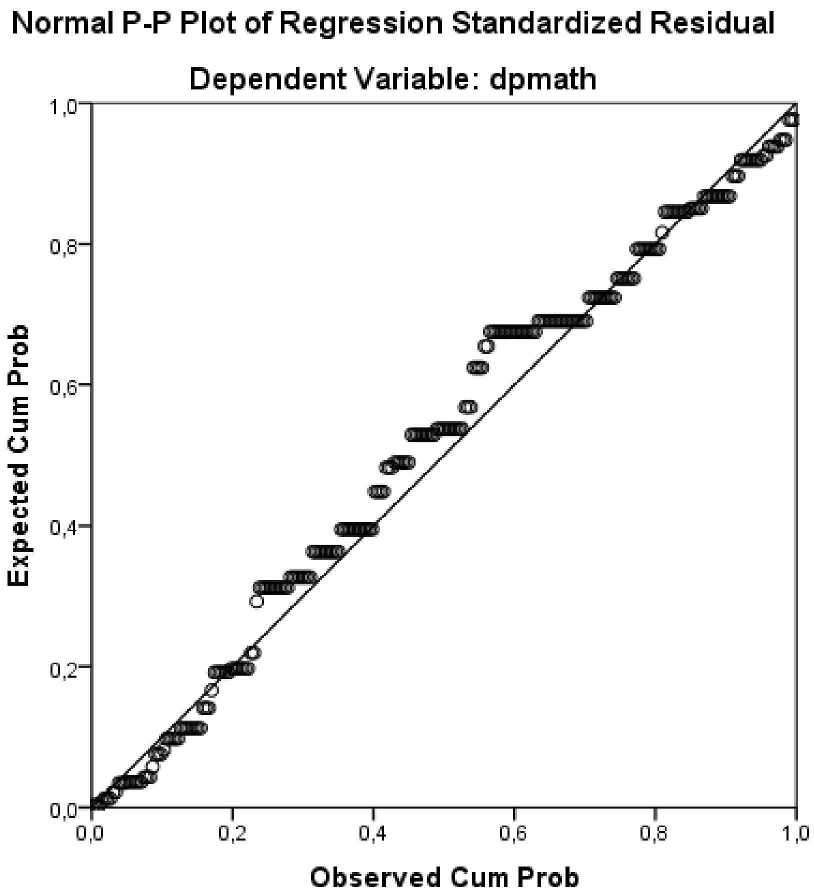

Figure 6. Normal P-P plot of residuals for DP mathematics.

The value of skewness was -0.35; that is *dpmath* skewness value was between -1 and 1. Thus, the *dpmath* variable was concluded to be not influenced by outliers. This claim was supported with the finding that all of the standardized z values between -3 and 3.

Data were inspected for normality of the residuals by investigating the histogram of the residuals, the normal probability plot and the scatter plot between predicted scores and residuals. Skewness estimates were also examined. If the estimates were less than plus or minus one, the distribution was considered to be a normal (Tabachnick & Fidell, 2007). See the histogram of standardized residuals in *Figure 7* for DP science.

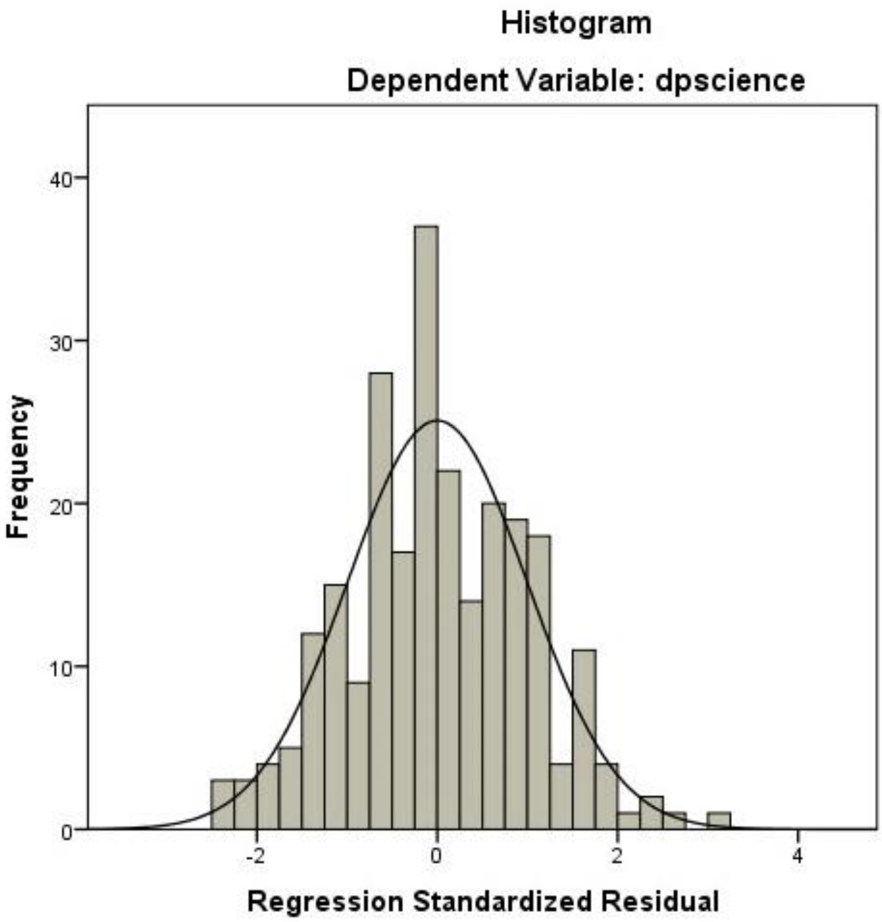

Figure 7. Histogram of standardized residuals for DP science.

Figure 7 shows that standardized residuals for *dpscience* were assumed to be normally distributed because the frequency distribution for *dpscience* resembled a symmetrical bell-shaped or normal curve. Normal P-P plot was also checked. *Figure 8* shows that the plotted points of residuals for *dpscience* match the diagonal line, supporting conclusion that the residuals were normally distributed.

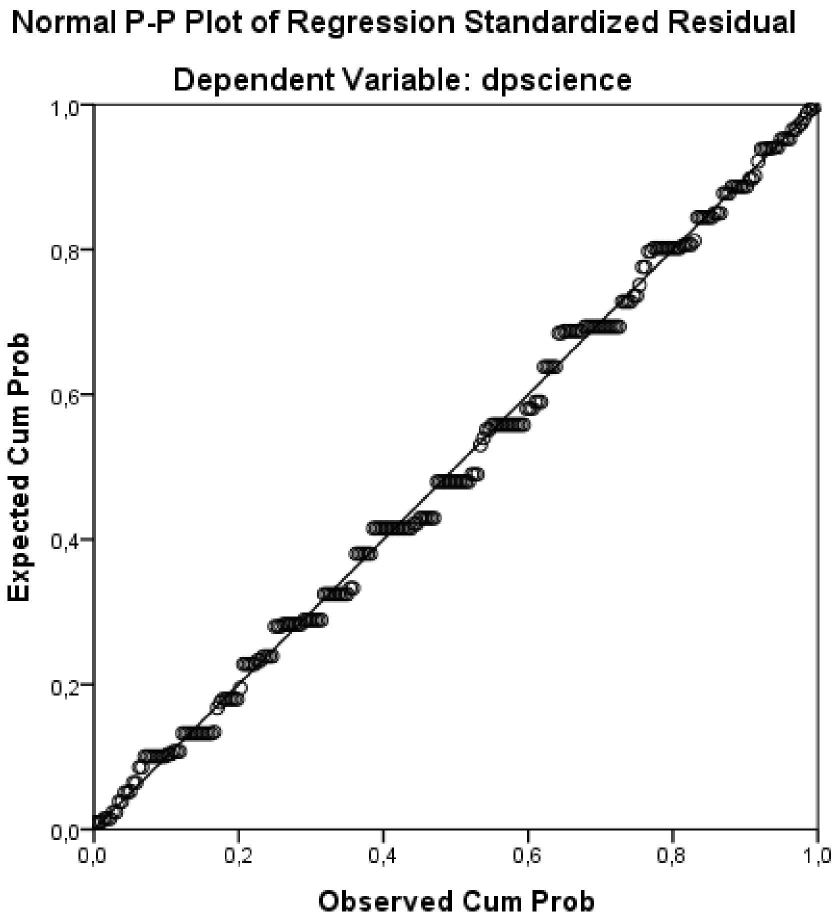

Figure 8. Normal P-P plot of residuals for DP science.

The value of skewness was -0.44; that is *dpscience* skewness value was between -1 and 1. Thus, the *dpscience* variable was concluded to be not influenced by outliers.

This claim was supported with the finding that all of the standardized z values between -3 and 3.

APPENDIX 2: Linearity & homoscedasticity assumptions and multicollinearity

An important assumption of multiple linear regression is that the relationship between the dependent and independent variables is linear. The linearity assumption was checked by examining scatterplots of standardized predicted values against standardized residuals (Huck, 2011). Homoscedasticity means that the variance of errors is the random across all levels of the independent variable, and was also checked by visual examination of a plot of the standardized residuals (the errors) and the regression standardized predicted values plot (Cohen, 1968). See Figure 9 for DP mathematics and See Figure 10 for DP science. The values generally that are close to the horizontal line are predicted well. The figures show that the dependent variables (*dpmath* and *dpscience*) exhibit similar amounts of variance across the range of values for the independent variables (*imath, iscience* and *gender*).

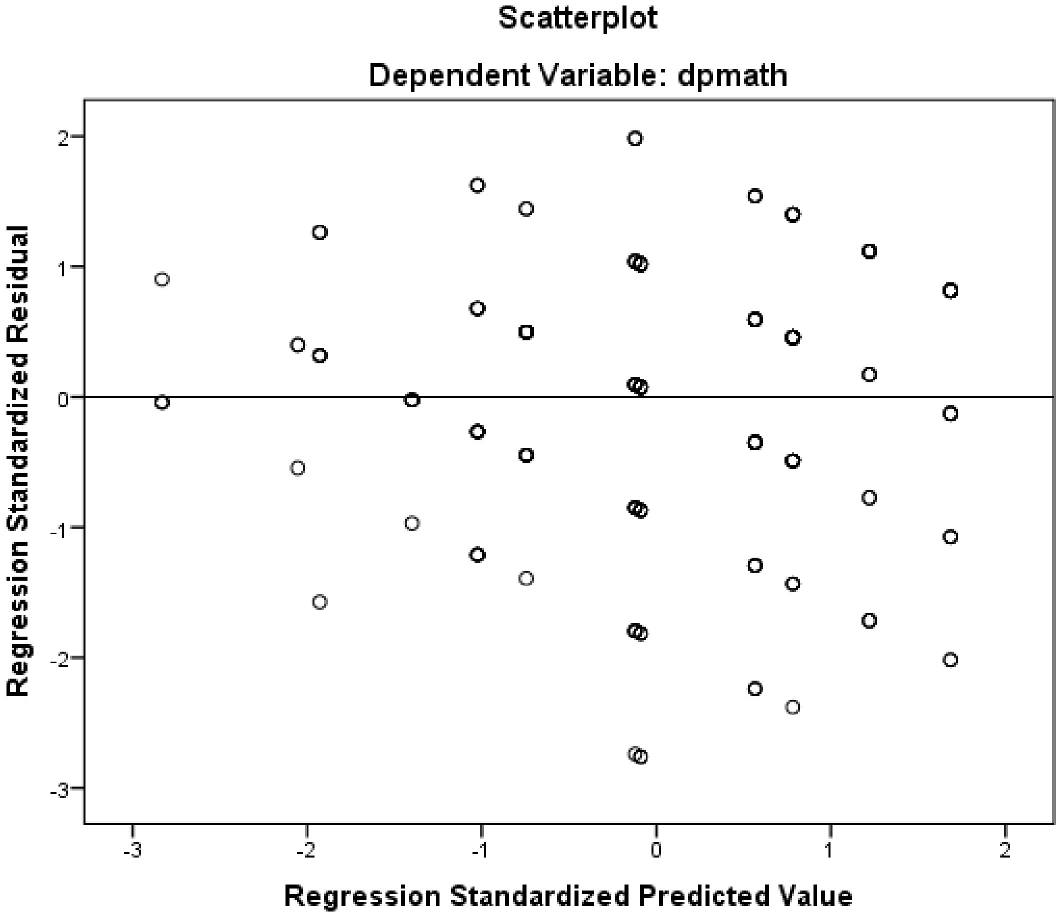

Figure 9. Scatter plots of residuals for DP mathematics.

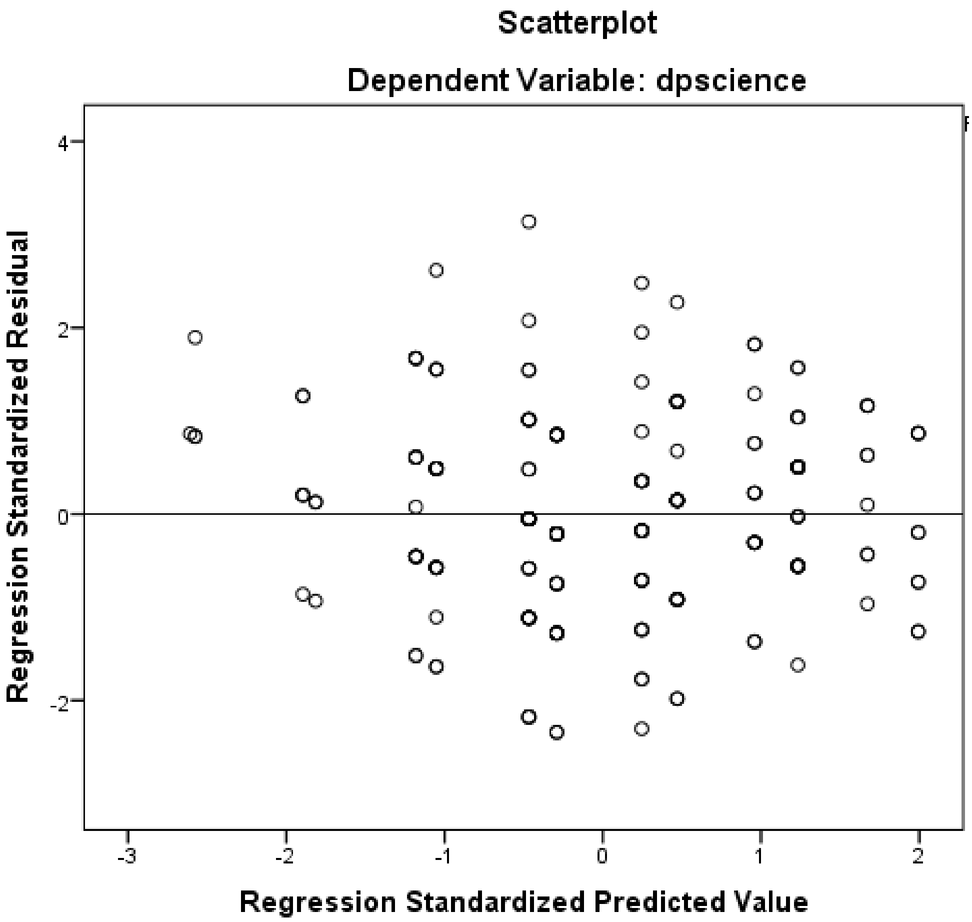

Figure 10.Scatter plots of residuals for DP science.

The final issue includes the checking of assumptions of multicollinearity with In Variance Inflation Factor (VIF) and tolerance statistics. Multicollinearity exists when two or more independent variables are too highly correlated with each other (Tabachnick & Fidell, 2007). It is generally assumed that VIF ≤ 10 so that multicollinearity does not pose a threat (Tabachnick & Fidell, 2001). In the current study, VIF values for *dpmath* and *dpscience* were about 2, both for *dpmath* and *dpscience*.

APPENDIX 3: Unstandardized and standardized weights

A prediction equation involves converting dependent and independent variables into z-score form (i.e., scores transformed to have a mean of 0.0 and an SD of 1.0 via the algorithm.

$$Z_i = (X_i - M_x)/SD_x)$$

The standardized *β* regression weight is a measure of how strongly each independent variable influences the dependent variable. Unlike unstandardized regression coefficient, the *β* is measured in units of standard deviation. That is, a *β* value indicates that a change of one standard deviation in the predictor variable results in change of the *β* value standard deviations in the dependent variable (Pagano, 2010). In this standardized score world, *a* weight is still present but is always zero. That's why equations with standardized weight did not include *a* weight as follows:

$$Z_{dpmath} = \beta_1 * Z_{c\_imath} + \beta_2 * Z_{g\_c\_imath} + \beta_3 * Z_{gender}$$

$$Z_{dpscience} = \beta_4 * Z_{c\_iscience} + \beta_5 * Z_{g\_c\_iscience} + \beta_6 * Z_{gender}$$

Additionally, the *b* and *β* weights can easily be converted back and forth into each other with the following equations.

$$b = \beta \left(\frac{SDy}{SDx}\right) \quad \text{or} \quad \beta = b \left(\frac{SDx}{SDy}\right)$$

APPENDIX 4: Structure coefficients

Structure coefficient (r_s) was used to analyze the correlation between independent variable *y* and latent variable (*Y_hat*) to provide a better understanding the worth of predictors. The structure coefficient is useful in interpreting the β weights—outputs of the regression analysis (Thompson, 2008). According to Thompson (2008), the structure coefficient can be computed using the formula for a given independent variable *X*:

$$r_s = r_{XY} / R$$

,where r_{XY} is the bivariate correlation between the independent variable (*X*) and the dependent variable (*Y*), and R is the multiple correlation coefficient between *Y* and synthetic *Y_hat* scores. Table 14 shows bivariate correlation coefficients (r_{XY}) and structure coefficients r_{sXY} for DP mathematics and Table 15 shows bivariate correlation coefficients (r_{XY}) and structure coefficients r_{sXY} for DP science .

Table 14
Bivariate and structure coefficients for DP mathematics

	r_{XY}	r_{sXY}
c_imath	.54	.98
g_c_imath	.45	.82
gender	0	.02

Note. r_s = structure coefficient.

Table 15
Bivariate and structure coefficients for DP science

	r_{XY}	r_{sXY}
c_iscience	.68	1
g_c_iscience	.51	.75
gender	.11	.16

Note. r_s = structure coefficient.