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Do SEC level Physics, Mathematics and English Language Prepare Students for Advanced-level Physics?

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Abstract
This study investigates the progression from Secondary Education Certificate (SEC) to Advanced (A) level Physics, and inherent problems for students and teachers in Malta. It was based on four research questions concerning: (a) the changes in the 2012 SEC Physics syllabus; (b) SEC Physics as a foundation for A- level Physics; (c) the sufficiency of SEC Mathematics for A level Physics; and (d) the levels of correlation between SEC Physics, Mathematics and English Language results with those in A level Physics. A mixed methods approach was used, including 165 questionnaires and a focus group with second year A-level Physics students, 16 questionnaires from A level Physics teachers and nine teacher interviews with SEC and A level Physics teachers. Teachers felt that the changes rendered the 2012 SEC syllabus insufficient as a good foundation for A level Physics, thus increasing the gap between the two levels. They considered a sound understanding of and a good grade in SEC Mathematics desirable for A level Physics. Students considered SEC Physics as a good foundation for A level and regarded Intermediate Mathematics as the threshold for A-level Physics. Respondents acknowledged the importance of English language skills in understanding A-level Physics questions. The correlation coefficients for SEC Physics, Mathematics and English Language with A-level Physics were all positive at 0.544, 0.452 and 0.411 respectively.

Keywords*:* SEC Physics; SEC Mathematics; SEC English; A level Physics.

Introduction

The syllabus for Secondary Education Certificate (SEC) Physics was changed for the sessions held from 2012 onwards. The changes included: (i) new themes and grouping of topics, (ii) a new section 'Historical and Science, Technology, Society Connections', (iii) new learning outcomes, with the removal of some others (iv) increased weighting (15% to 20%) for 'Design and Planning of Experiments' in the written part of the examination; and (v) the presentation of 15 experiments (two experiments per theme, instead of any fifteen experiments) or 13 experiments and an investigation for the school-based assessment. This study sought, among other things, to investigate the level of preparation for Advanced (A) level Physics provided by this syllabus.

Aim of the research study

The aim of this research study was to investigate the effect of studying Physics, Mathematics and English Language at SEC level on student preparation for Advanced-level Physics in Malta. The investigation was informed by the following research questions:

(i) What were the distinctive changes in the 2012 SEC Physics syllabus?
(ii) Is SEC level Physics a good background for A level Physics?
(iii) Is SEC Mathematics an adequate preparation for A level Physics?
(iv) What are the correlation coefficients between the student grades in SEC Physics, Mathematics and English Language and A level Physics?

SEC Physics as a preparation for A level Physics

One of the aims of the SEC Physics syllabus is to prepare students for A level Physics. One expects that SEC and A level Physics are strongly correlated, being the same subject at different levels. However, students' experience of SEC level Physics may give "the impression that Physics is an easy subject but when they come to Advanced-level studies they find that Physics is much more challenging than expected" while "[t]eachers often described the SEC syllabus as superficial and which does not provide the students with the appropriate tools for the deeper Advanced level syllabus" (Caruana, Farrugia & Muscat, 2009, p.18).

SEC level	A level
On The Move Linear Motion, Newton's Laws of Motion, **Momentum**, Energy, **Power**, **Different forms of Energy**	**Physical Quantities** SI unit, Scalar & Vector Quantities
Balancing Forces Types of Forces, Scalars and Vectors, **Hooke's Law**, Moments, Equilibrium, Centre of Gravity, Pressure	**Mechanics** Linear Motion, Newton's Laws of Motion, Energy, **Circular Motion**, Equilibrium, **Rotational Dynamics**
The Nature of Waves Types of Waves, Reflection/Refraction/ Diffraction of Water Waves, **Light: Reflection/ Refraction/ Total Internal Reflection, Dispersion**, Optics, EM Spectrum	**Vibrations and Waves** **Simple Harmonic Motion**, Superposition of Waves, Optics, The Expanding Universe
The Earth & The Universe The Earth's orbits, Gravity, Solar System, Galaxies, Space Exploration	**Materials** **Solids**
Staying Cool Properties of solids, liquids & gases, **Density**, Heat	**Thermal Physics** Heat, Energy Transfer, Heating Matter, Gases, Transfer of Heat
Electricity in the House Charges, Current, Voltage, Resistance, Circuit Symbols, V-I graph, Plugs, Power, Kilowatt-hour	**Electrical Currents** Charge and Current, Resistance
Magnets and Motors Magnetic Poles, Magnetising and Demagnetising, Magnetic Fields, Solenoid, Fleming's Left Hand Rule, Lenz's Law, Transformer	**Fields** Gravitational Fields, Electrostatic Fields, **Capacitors**, Magnetic Fields, Electromagnetic Induction, Alternating Currents
Radiation and its Uses Atoms, Isotopes, Properties of α/ β/ γ, Uses of Radioactivity, Background Radiation, Half Life, Precautions of Radioactive Materials	**Atomic, Nuclear and Particle Physics** **Quantum Theory**, Evidence for a Nuclear Atom
	Experimental Physics Lab Practice and Data Analysis

Table I: The sections and themes in the SEC Physics and A level syllabi (Source: SEC Physics Syllabus MATSEC Exam Board (2012) and AM Physics Syllabus MATSEC Exam Board (2019))

Additionally, both teachers and students participating in the study carried out by Caruana et al. stated that "there is a considerable gap between SEC level and Advanced level in all the major areas of Physics, including practical work, mathematical skills, and the content itself" (Caruana, Farrugia & Muscat, 2009, p.18) especially in Fields and Nuclear and Particle Physics but less in Mechanics (Caruana, Farrugia & Muscat, 2009).

Table I compares the themes covered at SEC level and the corresponding topics in A level Physics. Some A level topics are introduced at SEC level; for ease of reference, these are highlighted in the same background colour. Some sub-topics in the SEC syllabus do not featrure at A level, and vice versa. The topics that do not appear in one of the syllabi are underlined in the same table.

Several researchers investigated the correlation between grades scored in Physics at SEC and A level. Ventura (2001) found a correlation coefficient of 0.572 between the 1998 SEC Physics cohort and those who sat for A level Physics in 2000. Pace and Bonello (2006) found a correlation coefficient of 0.488 for the 2000 SEC Physics students who attempted A level Physics in 2002. A correlation coefficient of 0.442 was obtained between the 2002 SEC Physics and the 2004 A level Physics examinations carried out by the same authors. Farrugia and Ventura (2007) found a correlation coefficient of 0.62 for the 2004 SEC and 2006 A level Physics comparison. In a study carried out in the UK, Sutch (2013) obtained a correlation of 0.589 for the 2010 GCSE and 2012 A level Physics. Gilchrist and Samuels of Birmingham City University (n.d.) consider these correlation coefficient values as moderate to strong.

Is SEC Mathematics relevant to A level Physics?

Physics is the most quantitative science subject, depending heavily on "many mathematical skills to prove and quantify the different physical laws and principles" (Basson, 2002, p. 682). Hudson and Rottmann (1981) conclude that previous mathematical skills significantly affect student accomplishment in Physics courses. Baylon (2014) reports that "there was a significant positive relationship between Mathematics and Physics Achievement" (p.199). This is corroborated by Sidhu (2006), who states that "Mathematics gives a final shape to the rules of Physics" (p.7).

Gill and Bell (2013) agree with Baylon (2014) when they state that "a good grade in GCSE Mathematics is often required if students wish to take A level Physics" (p.757). This was also confirmed by Caruana and Muscat (2006). Swinback

(1997) considers a higher level of Mathematics learning to be necessary. He states that "those students who do not also study A level Maths are at a particular disadvantage … they often find themselves struggling with mathematical aspects of Physics" (p. 113).

Most mathematical requirements for A level Physics are covered in the secondary school years. However, A level Physics requires other mathematical skills and knowledge that do not feature at SEC level. These include: angles in radians, logarithms and calculus operations such as differentiation.

The correlation coefficient for the 2010 GCSE Mathematics student cohort who sat for their A level Physics examination in 2012 in the UK was found to be 0.557 (Sutch, 2013).

The Role of the English language in Physics examinations

Brookes (2006) shows that students' language is crucial in their learning, particularly when it comes to the concepts of Physics. Similarly, Farrell (2010) believes that students' proficiency in both English and Maltese influences Maltese students' performance in science examinations.

Ojo (2008) maintains that reading ability is of utmost importance in student achievement in Physics. In the Program for International Student Assessment's (PISA) publication, it is reported that there is a high positive correlation coefficient of 0.83 between success in science and reading (Organisation for Economic Co-operation and Development [henceforth OECD], 2009).

Baylon (2014) reports that "[t]here was a significant positive relationship between English and Physics achievement" (p. 199). Aina, Ogundele and Olanipekun (2013) found a correlation coefficient of 0.553 between English language proficiency and students' academic performance in science courses, and conclude that "those who passed English language performed better in science than those who failed English language" (Aina, Ogundele, Olanipekun, 2013, p. 357).

Methodology

Research Design

A mixed research method approach was adopted for this research study. The quantitative data were collected through questionnaires distributed to second year Sixth Form students in all (state, church and private) Sixth Form colleges in Malta and Gozo. A total of 165 duly filled questionnaires were returned. Questionnaires were also distributed among all the 23 teachers teaching Physics to second year Sixth Form students, with 16 being returned.

The grades obtained by students in the 2017 A level Physics and the grades that these students had obtained in the 2015 SEC Physics, Mathematics and English Language examinations were obtained from the MATSEC Support Unit of the University of Malta, the local national examination board.

Regarding the qualitative data, nine face-to-face interviews were carried out: five with second year Sixth Form Physics teachers and four with SEC Physics teachers. Moreover, a focus group involving seven Sixth Form second year students was also held. The interviews and the focus group were aimed at "understanding and interpreting social interactions" (Cohen, et al., 2005, p. 302) in order to understand and decipher better the elements involved in attaining a good performance in A level Physics.

Data Analysis

To interpret the quantitative data generated through the questionnaires, all the responses were first inputted into a Microsoft Excel Office 2010 spreadsheet. Thus, the authors transformed all the data and generated necessary percentages.

IBM SPSS Statistics 23 was also used to calculate descriptive statistics such as frequencies, percentages and correlation coefficients between the different SEC subjects, as well as to run statistical tests on the data.

The A level Matriculation grades are A to F (with grade A as highest, and F denoting a fail) whilst SEC grades range from 1, the highest, to 7 and U – denoting unclassified. For SEC, grades 1 to 5 are accepted as passes for mainstream Sixth Forms. In the quantitative data analysis, grades 6, 7 and U were grouped together as the number of participants in those categories was

extremely small. In order to work out the correlation coefficient, the A level grades were converted to numeric values – grades A to F were converted to numbers 1 to 6 - while the SEC grade U was converted to number 8. Moreover, students recorded as absent in any of the three SEC subjects under consideration were eliminated in the computation of the correlation coefficients. The Spearman rank-order correlation coefficient was used, and was preferred over the Pearson correlation coefficient because the Shapiro-Wilk test showed that all the variables were, not normally distributed (Lund Research, 2018).

The qualitative data generated through the interviews and the focus group were handled as follows: firstly, word for word transcription, followed by reading through the documents and highlighting the important points. During the first phase of the coding process, different codes were generated, which were then grouped and merged using Microsoft Word 2010.

Results, Data Analysis and Discussion

The Participants

A total of 165 Sixth Form second year A level Physics students, recruited from Malta and Gozo answered the questionnaire. Figure 1 reports the students' gender and school type. Seven of these students were also recruited for a focus group in order to collect more in-depth data which could be integrated with the data from the questionnaires.

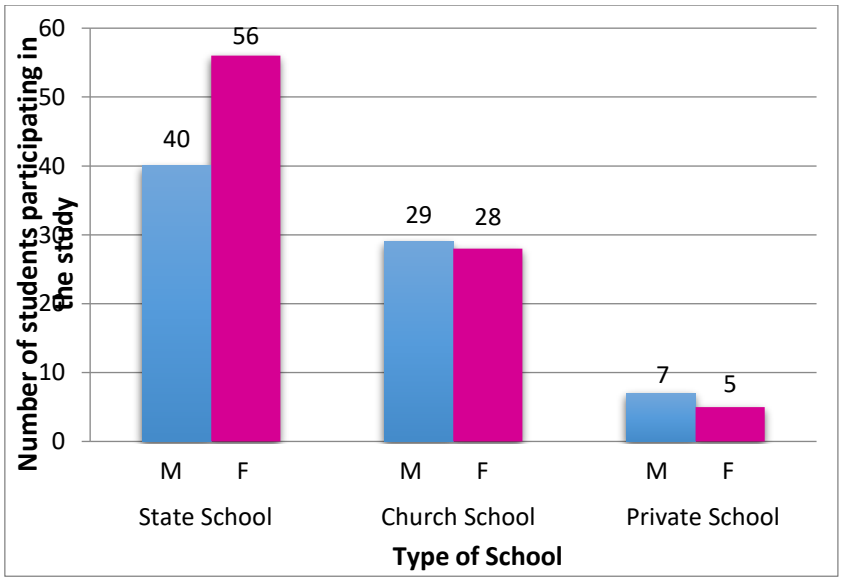

Figure 1: Student participants in the study

A total of sixteen A level Physics teachers also participated in this study. As with the students, they were recruited from both Malta and Gozo. The number of participating teachers according to gender and school type are shown in Figure 2.

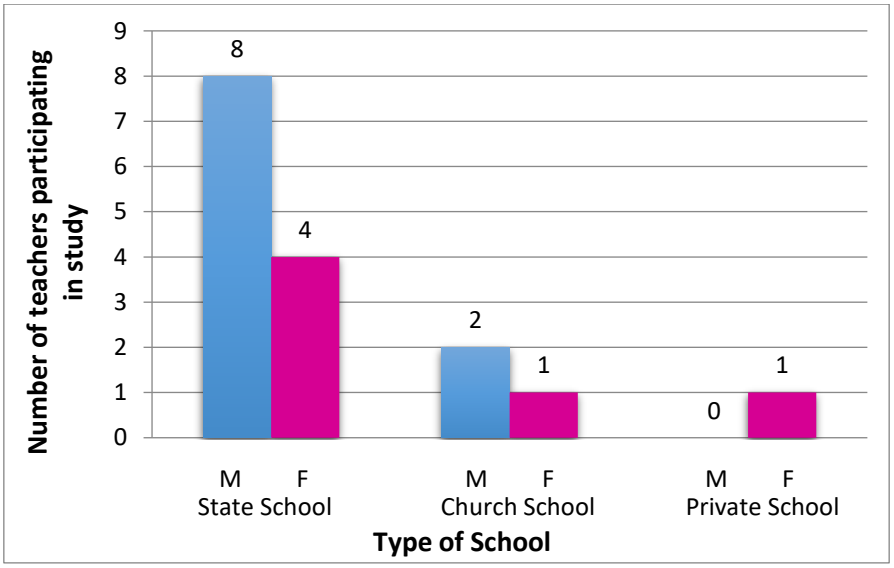

Figure 2: A level Physics teachers participating in the study

Five of these teachers, together with four SEC Physics teachers, were recruited for an individual interview for a more in-depth understanding to be integrated with the data from the questionnaires. The four SEC teachers will henceforth be called Teacher A, Teacher B, Teacher C and Teacher D while the five participating A level teachers will be called Teacher E, Teacher F, Teacher G, Teacher H and Teacher I. For the interviews, the teachers were recruited by reputational case sampling; it is important to note that teachers A and B were Heads of Department for Physics. They were recruited on the grounds that their comments should be more valuable and informed due to their position. Teacher H had carried out research and published several articles on the research topic. Thus, the opinions of these teachers were bound to contribute significantly to this study.

The Changes in the 2012 SEC Physics Syllabus

The study revealed that 68.8% of A level Physics teachers considered the changes in the SEC Physics syllabus as 'not so helpful' to them. A further 62.5% of the teachers considered the changes as 'not so helpful' to students. Regarding changes in the extent and mode of student preparation for A level

Physics before and after the changes in the 2012 syllabus, 56.3% of A level teachers considered students to be prepared at 'the same' level while 43.8% deemed them 'less prepared'. Notwithstanding this slight percentage difference, during their interviews, most teachers, declared that following the 2012 changes, the SEC Physics syllabus lacked the necessary detail to help students in higher order thinking, increasing the gap between the SEC and A level syllabi.

During the interview, Teachers C and D stated that with the reduction in the SEC Physics syllabus, teachers had less time constraints and therefore could cover topics in a deeper way.

Teacher F had mixed opinions about this syllabus change:

> The change in the SEC Physics syllabus could have helped the students as they are now finding it easier. The teacher can now relate the topics more with everyday situations so the students can relate more. However, my concern is that they, for example, associate terminal velocity with a parachute or a fired bullet … and they remain at the association stage … they remain on a superficial level …
>
> SEC students understand the Physics concepts during the lessons. However, when they try to attempt to answer questions, they blank. If we want to teach Physics concepts for everyday life, that's fine, let's keep on teaching it this way ... but, if we want the students to know how to answer a question scientifically, including higher order thinking, we need to start teaching the subject in more detail.

Is SEC Physics a Good Foundation for A level Physics?

Most students (55.8%) believed that SEC Physics is a good foundation for A level since they considered the two levels as only slightly different. Concurring with the findings of Caruana, Farrugia and Muscat (2009), 50% of the teachers, considered SEC Physics 'not so good' a foundation for A level and claimed that some topics could be delivered better.

Moreover, students, at 63.6%, and teachers, at 81.3%, considered A level Physics as a continuation of SEC at a higher and harder level. In fact, one Sixth Form teacher stated that:

> SEC Physics is an introduction to the topics at A level. The students know the SEC topics - however, when, we go in depth at A level, they start to consider it as a totally different subject. Those students who covered the SEC topics well are able to get good grades in A level. However, those students who covered the SEC topics superficially find the A level topics as ambiguous. – Teacher G.

Students and teachers were then asked about students' difficulties in A level Physics. The result was statistically significant. The six options were: (i) discontinuity between what they have learnt in SEC and A level Physics; (ii) understanding Physics concepts, theories and laws; (iii) confusion in the meaning of symbols and symbolic equations; (iv) application of mathematical skills to solve Physics problems; (v) language difficulties in expressing oneself properly and (vi) none of the above. The predominant percentage of students (29.9%) and teachers (27.7%) considered that the students' difficulties in A level Physics concerned 'understanding Physics concepts, theories and laws'. A further 27.7% of the participating teachers argued that student difficulties stemmed from inabilities in 'applying mathematical skills to solve Physics problems'.

Table II shows a chi-square test between SEC and A level Physics. This resulted in a value of 133.235, showing a strong statistically significant relationship between the two levels. In fact, most students with grade 1 (95.7%) and grade 2 (77.4%) in SEC Physics obtained grades A, B and C in A level Physics. Also, most students, (57.4%) with grade 1 in SEC Physics also achieved grades A and B in their A level examination.

One can also infer that a relatively low 42% of the students who achieved a grade 1 in their SEC Physics examination achieved a grade C or lower in their A level Physics examination.

It is important to keep in mind that the SEC cohort includes a wide distribution of students in terms of ability, as Physics is still compulsory in many schools, while the A level distribution of grades concerns students who voluntarily chose Physics at A level and thus, they probably considered themselves to be good at the subject. Moreover, this strong, statistically significant relationship between the students' performance in the two levels is in line with the students' claim that SEC level Physics is a good foundation for A level Physics.

			Physics A level grade						
			A	B	C	D	E	F	Total
Physics SEC level grade	1	Count	13	14	18	1	1	0	47
		Percentage	5.2%	5.6%	7.1%	0.4%	0.4%	0.0%	18.7%
	2	Count	6	25	41	18	2	1	93
		Percentage	2.4%	9.9%	16.3%	7.1%	0.8%	0.4%	36.9%
	3	Count	2	12	25	24	13	6	82
		Percentage	0.8%	4.8%	9.9%	9.5%	5.2%	2.4%	32.5%
	4	Count	0	0	5	10	5	4	24
		Percentage	0.0%	0.0%	2.0%	4.0%	2.0%	1.6%	9.5%
	5	Count	0	0	0	0	2	3	5
		Percentage	0.0%	0.0%	0.0%	0.0%	0.8%	1.2%	2.0%
	6, 7 or U	Count	0	0	0	0	0	1	1
		Percentage	0.0%	0.0%	0.0%	0.0%	0.0%	0.4%	0.4%
Total		Count	21	51	89	53	23	15	252
		Percentage	8.3%	20.2%	35.3%	21.0%	9.1%	6.0%	100.0%

Table II: 2015 SEC Physics grades and 2017 A level Physics grades obtained by the same cohort of students. $X^2(25) = 133.235$, $p < 0.001$

However, there seem to be a large difference between the percentages of students achieving grades 1, 2 and 3 at SEC level (a total of 88.1%) and grades A, B and C at A level (a total of 63.8%). Therefore, the question of whether the 2012 SEC syllabus is preparing the students well for A level Physics arises again. It could be the case that A level Physics students are not so well prepared as they think they are. In fact, during the focus group, student 6 stated that

> Physics topics in the SEC syllabus were covered superficially, that is, not in a lot of detail. Personally, as a student, I was not even 100% sure of certain concepts. So, I think that A level students will greatly benefit if these topics are taught and presented in more detail.

Student 2 believed that "the preparation between SEC Physics and A level Physics is very basic. Thus, if SEC Physics teachers go into some more detail, we would be better prepared for A level Physics." In fact, this statement coincides with what Teacher F stated:

> We might be giving the impression that SEC Physics is easy. In the SEC examinations … higher-order questions are very scarce. Because of this fact, students are achieving a good grade in SEC Physics and believe that they are capable to study it at A level. However, during the lesson, I notice several weaknesses and gaps in their scientific concepts which make it quite difficult for them to keep up with the A level syllabus. At A level, we need a certain level of English, a certain level of Mathematics, a certain level of higher-order thinking which, unfortunately, are not being taught at SEC neither with the old nor with the new syllabus. – Teacher F.

In order to analyse further the transition between SEC and A level Physics, the students were asked to list at least three topics in A level Physics which, in their opinion, do not have a good preparation at SEC Level. One notes that for 22.16% of the students, the most difficult topics at A level were Mechanics and Fields. This corroborates with the findings reported by Caruana, Farrugia and Muscat in 2009. Furthermore, Circular Motion and Rotational Dynamics, Electrical and Gravitational Fields were the sub-topics considered as most difficult.

As shown in Table I, these sub-topics are introduced at A level. This contradicts Farrugia, Caruana and Muscat's (2009) claim, when they state that the gap was especially felt in Fields and Nuclear and Particle Physics and noted less in the topic of Mechanics.

One might presume that the difficulties in these topics occurred because of the reduction of some learning outcomes (LOs) in the 2012 SEC Physics syllabus. However, there were no significant changes in the SEC Physics syllabus with regards to the LOs dealing with the sub-topics of Mechanics in the A level Physics syllabus.

Is SEC Mathematics an Adequate Preparation for A level Physics?

Almost all students (94.5%) and all teachers (100.0%) agreed that mathematical concepts were important for Physics. This validates Hudson and Rottmann's (1981) statement. Out of the four options (i. 25%, ii. 50%, iii. 75% and iv. 100%), 39.4% of the students and 50% of the teachers indicated that as much as 50% of the Physics A level syllabus requires Mathematics.

A total of 58.8% of the students do not feel prepared to work out A level Physics problems with their knowledge of SEC Mathematics. While 71.5% of the students stated that they required Intermediate level Mathematics for A level Physics, 62.5% of the teachers stated that a good grade in SEC level Mathematics would suffice for A level Physics.

While Gill and Bells' (2013) findings that students need to have a good grade in GCSE Mathematics for them to perform successfully in A level Physics involved a different syllabus and a different examination, their study concurred with the teacher's responses in this study. Furthermore, when viewing the SEC Mathematics syllabus, it was concluded that most mathematical requirements of A level Physics are covered during the secondary years.

Additionally, one notes that no teacher chose A level Mathematics as a requirement for A level Physics. The low percentage of students choosing A level Mathematics, at 4.2%, and the fact that none of the teachers chose the option of A level Mathematics to accompany A level Physics greatly contrasts with Swinback's (1997) who stated that UK students who study A level Physics need A level Mathematics.

The authors believe that the reason that some students opt to choose Intermediate level Mathematics alongside A level Physics is to ensure that they have enough mathematical skills and knowledge to be able to cope with A level Physics problems. An Intermediate level course in Mathematics would be an asset for students studying A level Physics. The reason is that although 62.5% of the teachers stated that SEC Mathematics is sufficient for A level Physics, in the interviews these teachers emphasised that students were not well prepared in mathematical skills. They stated that those students who also studied Intermediate Mathematics would surely be in a better position to tackle problems in A level Physics. In fact, even though it is difficult due to time constraints, some A level Physics teachers utilised some of their lesson time to teach mathematical skills which they consider necessary to tackle problems in A level Physics:

> I try to emphasise that my A level Physics students should have at least an Intermediate in Mathematics. In my opinion, SEC Mathematics is not enough for the A level because we need to work with logs to change equations to a straight line graph, exponential decays and growths, radians,

a great amount of trigonometry and algebra. Even the fact that they are still studying Mathematics, they keep up to date with graph plotting, they know what cos and sin waves are, the limit goes to infinity, etc. Those students who stop studying Mathematics at SEC do not know what these are, and I find it extremely stressful as I can't afford to use my lessons to teach the students Mathematics as the A level Physics syllabus is vast. – Teacher F

The students are allowed to study A level Physics having only SEC Mathematics. They are able to do it with a lot of practice, although I do not recommend it. I recommend at least an Intermediate level. This will help them especially in the rate of change and integral which is the area under the graph. – Teacher H

			Physics A level grade						
			A	B	C	D	E	F	Total
Mathematics SEC level grade	**1**	Count	13	22	19	4	1	2	61
		Percentage	5.2%	8.7%	7.5%	1.6%	0.4%	0.8%	24.2%
	2	Count	8	15	35	16	4	3	81
		Percentage	3.2%	6.0%	13.9%	6.3%	1.6%	1.2%	32.1%
	3	Count	0	10	27	24	9	3	73
		Percentage	0.0%	4.0%	10.7%	9.5%	3.6%	1.2%	29.0%
	4	Count	0	2	6	9	4	3	24
		Percentage	0.0%	0.8%	2.4%	3.6%	1.6%	1.2%	9.5%
	5	Count	0	2	2	0	5	3	12
		Percentage	0.0%	0.8%	0.8%	0.0%	2.0%	1.2%	4.8%
	6, 7 or U	Count	0	0	0	0	0	1	1
		Percentage	0.0%	0.0%	0.0%	0.0%	0.0%	0.4%	0.4%
Total		Count	21	51	89	53	23	15	252
		Percentage	8.3%	20.2%	35.3%	21.0%	9.1%	6.0%	100.0%

Table III: 2015 SEC Mathematics grades and 2017 A level Physics grades obtained by the same cohort of students. $X^2(25) = 101.152$, $p < 0.001$

The result of the chi-square test for SEC Mathematics and A level Physics was 101.52 showing a strong statistically significant relationship. This validates Baylon's (2014) finding of a significant positive relationship between Mathematics and Physics achievement. Moreover, from Table III, 88.5% of the students with a grade 1, 71.6% of the students with a grade 2 and 50.6% of the students with a grade 3 in SEC Mathematics obtained grades A, B and C in their A level Physics examination.

For A level Physics students, the most difficult mathematical topics included Graphs (43.1%) and Algebra (33.3%), mostly differentiation, integration and trigonometric functions. One should note that these topics do not feature in the SEC level Mathematics syllabus.

Language Skills and A level Physics

All teachers agreed that English Language skills were important for studying Physics. In fact, out of the four options given (i) understanding the concepts of Physics well; (ii) understanding the question properly; (iii) answering accordingly by applying their knowledge into writing and (iv) none of the above, 39.8% of the students and 36.6% of the teachers agreed that English Language skills greatly helped the students to 'understand the question properly', with the second most popular reply being to 'answer accordingly by applying their knowledge into writing' in an examination. In fact, the participants stated:

> I feel I need to explain something and the way I write it, gives it a completely different meaning to my thoughts. – Student 1

> English is important. Some students have weak language skills and this inhibits them from studying Physics properly. They find it difficult to understand the question properly and find it even harder to express themselves in questions where they are asked to define or explain. – Teacher G

> Due to their weak skills in English, they waste a lot of their examination time to read and fully understand the question properly. This is not the examiner's fault but it is the fault of our educational system which allowed these weak students to progress from year to year. In my opinion, sometimes, some students should not even be accredited with a SEC English certificate! – Teacher E

A chi-square test between SEC English Language and A level Physics resulted in a value of 67.694, showing a high, statistically significant relationship between the performance in the two subjects, in line with Baylon's (2014) statement. Table IV shows that those students who did well in SEC English Language have also done well in their A level Physics examination: 94.7% of students who obtained grade 1, 84.0% of students who got grade 2 and 60.2% of students with grade 3 in SEC English Language obtained grades A, B and C in their A level Physics examination.

			Physics A level grade						
			A	B	C	D	E	F	Total
English SEC level grade	**1**	Count	5	7	6	1	0	0	19
		Percentage	2.0%	2.8%	2.4%	0.4%	0.0%	0.0%	7.5%
	2	Count	9	23	31	5	4	3	75
		Percentage	3.6%	9.1%	12.3%	2.0%	1.6%	1.2%	29.8%
	3	Count	6	11	27	22	4	3	73
		Percentage	2.4%	4.4%	10.7%	8.7%	1.6%	1.2%	29.0%
	4	Count	1	5	15	17	10	5	53
		Percentage	0.4%	2.0%	6.0%	6.7%	4.0%	2.0%	21.0%
	5	Count	0	4	9	4	4	4	25
		Percentage	0.0%	1.6%	3.6%	1.6%	1.6%	1.6%	9.9%
	6, 7 or U	Count	0	0	1	4	1	1	7
		Percentage	0.0%	0.0%	0.4%	1.6%	0.4%	0.4%	2.8%
Total		Count	21	50	89	53	23	16	252
		Percentage	8.3%	19.8%	35.3%	21.0%	9.1%	6.3%	100.0%

Table IV: 2015 SEC English grades and 2017 A level Physics grades obtained by the same cohort of students. $X^2(25) = 67.694$, $p < 0.001$

Correlation Coefficients of the Different Subjects under Test

The correlation coefficients between SEC Physics, SEC Mathematics and SEC English Language and A level Physics were found to be 0.544, 0.452 and 0.411 respectively.

The researchers expected a very strong relationship between A level Physics and SEC Physics, Mathematics and English Language. Even though the correlation coefficients are positive, the actual values of the Spearman correlation coefficient tests did not tally with this prediction as strong to moderate correlations emerged. This could be because examination grades do not depend only on whether students had previously achieved good examination grades, but also on various other factors. Moreover, the correlation between SEC Mathematics and SEC English Language with A level Physics resulted to be lower than that with SEC Physics because being different subjects, they comprise other factors which could have affected the students' achievement. These include, among others (in the case of SEC Mathematics): mental mathematical questions, algebraic and trigonometric representations; and in the case of SEC English Language, spelling and grammar.

It is to be noted that most students with grades 1 and 2 in SEC Physics obtained grades A, B and C in A level Physics while most students with grades 1, 2 and 3 in SEC Mathematics and SEC English Language managed to obtain grades A, B and C in A level Physics. Therefore, one can conclude that students who had managed to obtain SEC Physics grades 1 and 2 had a much better chance of obtaining higher grades in A level Physics than those with grade 3 and under. Thus, in the researchers' opinion, this narrower spectrum between SEC Physics and A level Physics indicates a clearer relationship between the two levels, that is, the better the result at SEC Level Physics, the greater the chances of better grades at A level Physics. This relationship showed a stronger correlation coefficient than with the other subjects.

Conclusion

This study indicates that A level Physics cannot be regarded as a 'stand-alone' subject. Knowledge of the subject in itself does not determine students' performance at A level, as several other factors influence the result.

Both teachers and students considered the changes in the 2012 SEC Physics syllabus as negative. The majority of the teachers affirmed that the SEC Physics

syllabus lacked the necessary detail to help students in higher order thinking, thus, increasing the gap between SEC and A level Physics. Moreover, the authors suggest that the SEC Physics course remains compulsory and, even though it might still be very early, students at year 9, might be given the option to choose one of two separate syllabi: (i) a more in-depth syllabus for those who want a good, deeper understanding of the subject that will help the progression of students' to A level Physics, bridge the gap between SEC and A level Physics and hopefully increase the intake of students choosing a Physics university course; and (ii) a less in depth syllabus that provides students with all the basic knowledge to get a certification of Physics at SEC level.

Approximately half the teachers and half the students believed that SEC level Physics is a good foundation for A level Physics as they considered the two levels to be only slightly different from each other. The other 50% of the teachers claimed that SEC Physics does not provide an adequate background to A level Physics because some topics could be delivered better and in more depth with the inclusion of higher order thinking and skills. This needs better communication and cooperation between SEC and A level Physics teachers for an easier transition for students from secondary to post-secondary school.

Regarding Mathematics, most students would prefer to have at least Intermediate level Mathematics when studying A level Physics. On the contrary, most teachers stated that a very good grade in SEC Mathematics or Intermediate level Mathematics would suffice to study A level Physics.

The correlation coefficient between SEC Physics, Mathematics and English Language and A level Physics were found to be 0.544, 0.452 and 0.411 respectively. Considering these correlations, the authors suggest that extra coaching in Mathematics and/or English Language may be required for particular students to address their lacunae and difficulties and thus improve their performance in Physics.

References

Aina, J. K., & Olanipekun, S. (2013). Effect of English language on academic performance in Physics and Computer Science among College of Education students. *American International Journal of Research in Humanitites, Arts and Social Sciences*, 4(2), 114-117. Retrieved from: http://iasir.net/ AIJRHASSpapers/ AIJRHASS13-352.pdf

Ayres, L. (2008). Thematic coding and analysis. In L. Given (Ed.), *The SAGE encyclopedia of qualitative research method*, 868. Thousand Oaks, CA: SAGE Publications, Inc. http://dx.doi.org/10.4135/9781412963909.n451

Basson, I. (2002). Physics and Mathematics as interrelated fields of thought development using acceleration as an example. *International Journal of Mathematical Education in Science and Technology, 33* (5), 679-690. ww.upd.edu.ph/~ismed/online/articles/relationship/references.htm

Baylon, E. (2014). English and Mathematics: Determinants of Physics achievement among public high school seniors in Naga City. *Asia Pacific Journal of Multidisciplinary Research*, *2*(1), 199-204.

Brookes, D. T. (2006). *The role of language in learning Physics.* Retrieved from: https://www.compadre.org/PER/items/detail.cfm?ID=5703

Caruana, C., & Muscat, M. (2006). *Is SEC Physics an adequate preparation for Advanced level? A Study of Teachers' and Students' Views*. Unpublished B.Ed (Hons) dissertation. Msida: University of Malta.

Caruana, C., Farrugia, J., & Muscat, M. (2009). Is SEC level Physics an adequate preparation for studies at advanced level? *My Physics*, 1(1), 10-19.

Cohen, L., Manion, L., and Morrison, K. (2005). *Research Methods in Education* (5th ed.). New York: Routledge.

Farrell, M. P. (2010). Bilingual competence and students' achievement in Physics and Mathematics. *International Journal of Bilingual Education and Bilingualism*, *14*(3), 335-345.

Farrell, M. P. (1996). *English in Physics*. Unpublished Med dissertation, University of Malta.

Farrugia, J., & Ventura, F. (2007). Predictive Validity of Examinations at the Secondary Education Certificate (SEC) level. *Journal of Maltese Education Research*, 5(2), 21-44.

Gill, T., & Bell, J.F. (2013). What factors determine the uptake of A level Physics? *International Journal of Science Education, 35*(5), 753-772.

Gilchrist, M., & Samuels, P. (n.d.). *Correlation in R*. Birmingham City University Retrieved from: https://www.sheffield.ac.uk/polopoly_fs/1.536458!/file/mash_correlation_r.pdf

Hudson, H. T., & Rottman, R. M. (1981). Correlation between performance in Physics and prior Mathematics knowledge. *Journal of Research in Science Teaching*. 18(4): 291-294.

Lund Research Ltd. (2018). Pearson's Product-Moment Correlation using SPSS Statistics. Retrieved from: https://statistics.laerd.com/spss-tutorials/pearsons-product-moment-correlation-using-spss-statistics.php?fbclid=IwAR039y4TNmjhKMgmZy8-OxaYl678mPSa1GJFOzYYlCXVVSDdwdaZhdtlwXk

Lund Research Ltd. (2018). *Spearman's Rank-Order Correlation using SPSS Statistics*. Retrieved from: https://statistics.laerd.com/spss-tutorials/spearmans-rank-order-correlation-using-spss-statistics.php

MATSEC Examinations Board. (2018). *Matriculation Certificate Examinations statistical report.* University of Malta. Retrieved from: https://www.um.edu.mt/__data/assets/pdf_file/0007/386134/MCStatsReport2018DP,FV.pdf

MATSEC Examinations Board. (2019). *SEC Mathematics Syllabus*. University of Malta. Retrieved from: https://www.um.edu.mt/__data/assets/pdf_file/0019/292312/SEC23.pdf

MATSEC Examinations Board. (2019). *AM Physics syllabus*. University of Malta. Retrieved from: https://www.um.edu.mt/__data/assets/pdf_file/0003/351156/AM26.pdf

Ojo, J.K. (2008). Students' problems in English reading comprehension (ECR): Some observations and research findings. *Nigeria Journal of Educational Studies and Research (NJESR), 5* (1);25- 29.

Organisation for Economic Co-operation and Development (OECD). (2009). *Top of the Class: High performers in science in PISA 2006*. Paris: OECD.

Pace, J., & Bonello, L. (2006). Predictors of overall performance in Physics Matric Advanced level: An insight into entry requirements. *Journal of Maltese Educational Research, 4*(2), 37-53.

Sidhu, K. S. (2006). *The teaching of Mathematics*. New York: Sterling Publishers.

Sutch, T. (2013). Progression from GCSE to AS and A level 2010. *Statistics Report Series No. 69*. Cambridge Assessment. Retrieved from: https://www.cambridgeassessment.org.uk/Images/153531-progression-from-gcse-to-as-and-A level-2010-.pdf

Swinback, E. (1997). Salters' advanced Physics: a new A level course in the early stages of development. *Physics Education*, *32*, 111-114.

Ventura, F. (2001). The predictive validity of the SEC examination for A level sciences: Some preliminary results. *Paper presented at Science Education Seminar, Malta 23rd May 2001*.