Examining the Effectiveness of Technology Use by Educators to Improve Students' Test Scores: A Quasi-Experimental Design in a VET Context

Ayrton Zarb
Ayrton.Zarb@mcast.edu.mt
Learning Support Unit, MCAST

Abstract: The relevance of the use of *educational technology* by educators in the classroom, to improve academic achievement, has been a debatable query in the literature for decades. The purpose of this research is to scientifically quantify and determine the impact of technology use in the classroom (specifically, Computer-Assisted-Instruction and Integrated-Learning-System) on the academic scores attained by level 2 MCAST students. By employing a two-stage quasi-experimental methodology: First, controlling for respondents' characteristics and consequently by delivering the sessions using alternating teaching tools – the study ensured homogeneity between the control and treatment groups. Findings from the Bi-Point serial correlation test prove statistically significant negative returns of the use of educational technology by educators in the classroom on level 2 students' test scores, since on average, the group that was not exposed to educational technology, achieved higher test scores than the treatment group. These results can help teachers of such a student cohort to improve the plan for their lesson; and help institutions such as MCAST, the Ministry for Education and the European Union to design appropriate policies that ensure more effective learning.

Keywords: Computer-Assisted-Learning; Integrated-Learning-System; quasi-experimental methodology; academic achievement

Introduction

Economists and policy makers agree that technology (known as Total Factor Productivity) is one of the main determinants behind long term economic growth in a country, improving labour productivity and leading to structural changes towards a service-based economy (Carrillo et al. 2011). In fact, the fourth United Nations Sustainable Development Goal for 2030, emphasises the delivery of effective education that could be facilitated with the use of technology, intended to ensure economic development.

The challenge is to allocate the limited financial resources making up the annual government budget in the most efficient and effective way to ensure positive returns for the use of technology in education, in terms of higher academic scores. Therefore, given this trade-off in resources and the existing binding constraints being both finances and class time, policy makers strive to make the most rewarding decisions.

Background to the subject

In today's digital era, the amount of financial resources dedicated by the local government to the implementation of technology in state and non-state schools, has exponentially increased by over 700% from 2019 to 2020, mainly due to the government's decision to extend investment in Information Technology (IT) to non-state schools (Ministry for Finance 2020; Figure 1). Furthermore, working groups within the European Union (EU) are developing a 2030 strategy focused on developing the way forward vis-à-vis the installation of technology in Vocational Education and Training (VET) contexts, specifically the: "use of modern learning technologies in VET and higher VET, example Open educational resources" (Europa 2020: 21). Bulman and Fairlie (2016) note that although, globally, the purchase cost of IT devices has decreased over the years, maintenance costs remain high, hence being one of the determinants behind the exponential rise in costs in recent years (Figure 1).

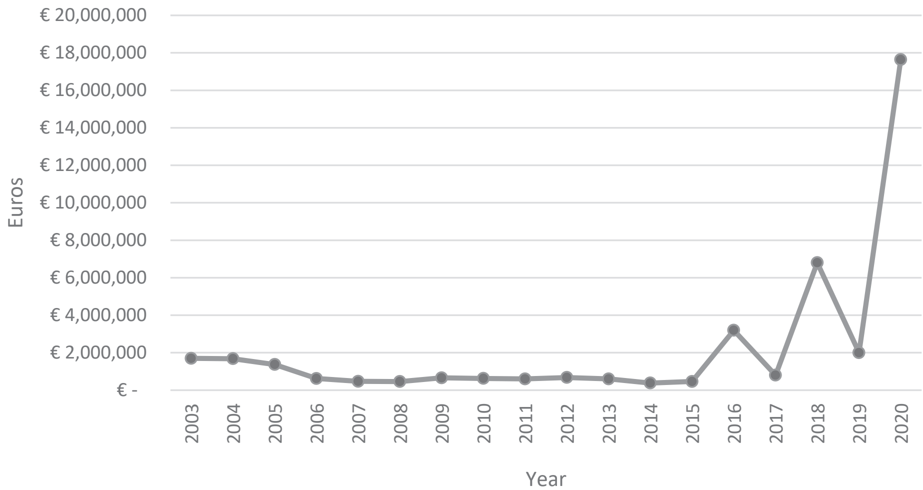

Figure 1: *Expenditure in IT by the Maltese government in state and non-state schools (Sources: Author's own 2020; Budgetary Estimates 2005 – 2020)*

Despite these efforts, latest publications by the Organisation for Economic Co-operation and Development (OECD) compared the performance of Maltese students to that of international learners as part of their Programme for International Student Assessment (PISA) survey. In their report the authors conclude that, "students in Malta scored lower than the OECD average in reading, mathematics and science" (OECD 2020: 1). Moreover, although there has been a drastic decrease in the number of youths aged between 16-18, who are considered as being *Not in Employment, Education and Training* (NEETs), Malta is still classified as one of the least performing countries in terms of early school leavers from formal education. In fact, in 2019, 16.7% of youths aged 18-24 left formal education (see Figure 2). Such revelations contend with Dunlosky et al.'s (2013: 100) statement that, "students are being left behind due to an educational system that is broken and in need of overhaul."

Figure 2: *Early school leavers, 2019 (Source: Eurostat 2020)*

Scope of the study

These revelations have raised the question of whether or not the use of technology by educators in the classroom (specifically *PowerPoint* presentations, videos and interactive whiteboards) is effective to improve academic test scores for students. Specifically, this research seeks to empirically analyse the effectiveness of incorporating educational technology in the lesson plan to improve level 2 students' academic scores (section 3.3.1.1). This study is the first of its kind to undertake a positivist approach through experimental techniques and apply them in a vocational education framework among level 2 students following a course at the Malta College of Arts, Science and Technology (MCAST).

By using a two-stage approach, having a pre-test to uncover participants' behaviour and demographic characteristics, and a Criterion-Referenced-Test (CRT) to quantify the students' performance, this study overcomes the biases present in past studies when inadequate control variables were included in the model. Therefore, this research contributes to the growing literature on the subject as well as, provides insights to legislators, school administrators, and policy makers to allocate financial resources in areas that are most effective in producing proficient learners. Furthermore, as an educator, this study will serve as a manual to lecturers teaching level 2 students while planning lessons, in order to adopt best practices to ensure effective deliveries.

Motivating literature and background

The role of technology as an instrument that enhances students' motivation and academic achievements has been a debatable query since Skinner's teaching machines were enforced in the 1960s (Higgins et al. 2012). Several academics and researchers coming from diverse fields of study have investigated this subject over the years and yet it remains a controversial topic. Ultimately, the underlying principle behind the educational system is to produce proficient learners, and technology might be a tool that facilitates this intention (Flanagan 2008).

The significance of technology in education

The notion of *educational technology* encompasses an array of electronic tools and functions used by educators that facilitate the transfer of knowledge by supporting the learning experience (Al-Bataineh 2016). The pace of technological innovation in education has increased over the years and there are no signs of it slowing down since continuing enthusiasm for new and emerging technologies offers new teaching and learning opportunities (Chan et al. 2006; Steffens 2008). Lowther (2010) adds that educational technology has three main roles:

1. technology as a tutor;
2. technology as a teaching tool;
3. technology as a learning aid.

Specifically, technology as a tutor includes Computer-Assisted-Instruction, Integrated-Learning-Systems and embedded multimedia (Cheung and Slavin 2012). Computer-Assisted-Instruction is defined as: "the instruction or remediation presented on a computer or electronic device" (The Access Center 2020).Conversely, technology as a teaching tool comprises projectors, interactive boards, visuals, digital footprint material, and applications that assist students for development and learning purposes (Raja and Nagasubramani 2018). Wikramanayake (2005) also combines media such as text, graphics, animation, sound and video. Such techniques have enabled the educational system to survive during the COVID-19 period, allowing educators to deliver lessons using digital resources (Rieley 2020). However, technology as a learning aid refers to students' personal use of technology to develop learning (Archer et al. 2014).Despite undisputable direct returns of technology in the labour market, there exist debatable conclusions to the educational returns of technology, expressed using test scores (Fuchs et al. 2004). However, there is consensus that modern technological equipment results in:

- creative learning;
- integrative learning (by linking theory and prawctice);
- student-centred learning (Panitz 1996).

This is especially due to the use of *PowerPoint* presentations and projections, being tools under the umbrella of Integrated-Learning-Systems. Thus, IT changed the role of educators by facilitating a more interactive relationship between students and teachers (Al-Bataineh 2016; Grégoire et al. 1996).

In fact, Johnson claims that Integrated-Learning-Systems and Computer-Assisted Instruction could:

> invoke dreams in the minds of visionary educators who saw endless potential for altering traditional notions of teaching and learning. (Johnson 2003: 2)

However, Baker and Robinson (2018) criticise the use of *PowerPoint* presentations for not engaging students to take personal notes, resulting in negative learning experiences.

The impact of technology on students' academic scores

While the available literature on the notion of Computer-Assisted-Instruction and Integrated-Learning-Systems is extensive (section 2.1), this section will focus on the effects of these tools on students' test scores.

The motive of policy makers and educators is to implement technology in classrooms that results in definitive positive academic effects (Flanagan 2008). Still, there is no consensus in the literature regarding the relationship between technological implementation by educators and test score results, some authors having publishing statistically positive trends (example Cannon-Bowers et al. 2006; Slavin et al. 2011); while others report opposing views (example Chen 2002; Liu 2002). Among the positive attributes of the use of technology for educative purposes, Tinio (2002) and Raja et al. (2018) find that IT improves the absorption of knowledge by teachers and students, especially the use of Computer-Assisted-Instruction, and embedded multimedia (section 2.1). However, the authors acknowledge the negative consequences on writing skills, grammar and thinking abilities.

To investigate this query, Jennifer Flanagan (2008) undertook a two-step approach, starting with a preliminary test intended to assess the academic score attained by students without using technological equipment. After repeating an alternative test to the same cohort while allowing technological facilitators, the author concluded that 44% of the students' test scores improved in the second exam which indicates that technology is a positive determinant towards academic achievement. However, the researcher failed to control for various factors such as students' motivation and stamina between the first and second examinations as well as the fact that students were tested twice.

As a result, meta-analyses studies became popular to identify consistent patterns across the literature on this phenomenon. In several peer-reviewed studies, no consistent positive correlation was identified but a range of values between -0.03 to +1.05 were scored (Andrews et al. 2007; Carter 2009; Kulik 2003; Slavin et al. 2009). On the contrary, Harrison et al. (2004) prove positive statistical relationships between these two variables when evaluating papers examining the 'Impact2Study' programme.

Since meta-analysis failed to produce consistent results (Torgerson and Zhu 2003), time series univariate studies were performed to investigate the correlation between academic performance and technological investment. When Weaver (2000) performed a longitudinal study in the United States, he discovered a slight but positive correlation between technological adoption and pupils' test scores. Similar results were obtained by Machin et al. (2007) when performing time-series analysis while correlating the amount of funds the United Kingdom government invests in IT and students' academic outcome. The concept of time series analysis was also adopted by Banerjee et al. (2007) who concluded that the aftermaths of technology on test scores might require a prolonged period to ensue as they discover statistically significant evidence of the programme in the second year.

Overall, Fairlie (2015: 18) concludes that:

> taken as a whole, the literature examining the effect of ICT investment is characterised by findings of little or no positive effects on most academic outcomes.

According to Fairlie (2015) this may be a result of displacement of other effective instructional methods. In order to address most of the methodological limitations that were repeated in the above studies, a relatively modern technique was developed that investigates the behaviour of participants in a controlled environment, known as experimentation.

Applying experimental evaluation techniques in education

Experimental techniques are scientific approaches involving the modification of one (or additional) determinant/s, while controlling for all other factors, intended to establish any significant cause/correlation with the dependent variable. Therefore, the impact of the programme would be computed through the difference between the experimental and control groups:

$$\text{Impact} = \Delta\text{Treatment group} - \Delta\text{Control group}$$

Hence, this procedure overcomes the selection biases and contaminations present when employing other previously mentioned methodologies (section 2.2). In fact, Carillo et al. (2011: 7) conclude that, "experimental evaluations, while generally more difficult to perform, are widely accepted as the most reliable form of impact evaluation."A common attribute among experimental research is the inclusion of control variables for the treatment; and of control groups to share matching characteristics (Table 1). Hanushek (1979) proposes an education production function to identify the determinants that need to be controlled for by researchers in their experiment:

$$Y_{it} = f(B_{it}, P_{it}, S_{it}, V_{it})$$

Variable	**Description**
	Student (i)
	Test score achieved by student (i) at time (t)
	Vector of family characteristics
	Vector of student's peers
	Vector of school inputs
	Vector of individual academic abilities

Table 1: *Hanushek's algebraic notations*

Hanushek transforms the production function into a linear regression model to assess whether students exposed to educational technology () experience different test scores , while controlling for other determinants (Table 2).

$$Y_i = \beta_0 + \beta_1 T_i + \beta_2 X_i + \varepsilon_i$$

Variable	Description
	Student (i)
	Test score achieved by student (i) at time (t)
	Intercept term
	Measures the impact of the programme on test scores
	A dummy variable taking the value of '1' if the student is part of the treatment group and vice-versa
	Measures the impact of individual control variables on test scores
	Vector of student, household, teacher and school characteristics (control variables identified in Table 1)
	Stochastic error term

Table 2: *Hanushek's algebraic notations*

Unlike most meta-analysis publications (section 2.2), Cristia et al. (2014) controlled for the context that affects test scores during the study and conclude that there are no significant effects of the Huascaran programme on students' academic attainments. Still, unlike Flanagan (2008), the author did not control for students' attributes prior to the study which could create noise in the data.

Carillo et al. (2011), while employing Hanushek's model, utilise a pre-test questionnaire to uncover information about the students and their environment, specifically:

- student's age and gender;
- hours of television watched by each student;
- number of years of teaching experience of the students' teacher;
- number and quality of training courses followed by the students' teacher;
- school characteristics including the amount of investment in it.

After controlling for these variables, students were split equally between treatment and control groups. The experiment's result estimates , means that students in treatment groups experience 38% higher academic scores, vis-à-vis the control group.

In other studies that followed, researchers used alternative auxiliary variables. Archer et al. (2014) also controlled for the person delivering the session, whether being the researcher or a teacher. Kim et al. (2012) concur with such thoughts, finding that when sessions were delivered by researchers, more positive results were accomplished. Furthermore, the type of technology used, pedagogy techniques, teacher's training and effectiveness, and the subject being tutored, were controlled in Tamim et al.'s (2011) study for being significant determinants on the students' test scores. Edwards (2012: 6) agrees to control for the teachers' characteristics by adding that, "success in the classroom depends more than ever on the talent, initiative, and skills of the teacher."

This methodology was replicated by Rabiner et al. (2009) who matched participants based on pre-tests and demographic characteristics. The authors produced similar results, showing that IT helps students improve their academic achievements after producing a correlation coefficient of 0.40. However, Drummond et al. (2011) produced non-significant results when adopting the above methodology among 2,407 sixth form students in two grammatical tests. Similar non-significant experimental evidence was presented by Becker (1994) while applying the above model among a relatively small sample size. The experiment involved the delivery of a 30-minute Computer-Assisted-Instruction session for the treatment group whilst the control group undertook the traditional direct-teaching approach. An end-of-lesson test was included to assess whether teaching tools affect academic scores. Although positive results were produced , the parameter scored low statistical significance. However, when Bass et al. (1986) and Torgesen et al. (2007) performed a similar study involving 73 and 90 participants respectively (considered small sample sizes), the results uncover a positive significant correlation among IT use (Computer-Assisted-Instruction and Integrated-Leaning-System) and test scores.

Under the framework of lab experiments, Vogel et al. (2006) applied the concept of Computer-Assisted-Instruction (section 2.1) through gamification among 44 students in the US. In this intra-school experiment, the control group was taught using traditional techniques while the experimental group used virtual reality. Using a two-tailed test, the control group scored higher than the treatment group. However, when an inter-school quasi-experiment was performed by Leuven et al. (2007), after controlling for demographic and pre-test academic achievements of the participants, the authors concluded that IT improves students' academic success. Opposing views were presented by Barrera-Osorio and Linden (2009) while carrying out an inter-school randomised experiment among 100 public schools. The results obtained were deemed by the researchers as inconclusive with statistically insignificant estimate effects.

Carillo et al. (2011) produced contrasting results to Barrera et al. (2009), although adopting similar methodologies, as well as increasing the sample to 800 pupils. Using a randomised experiment, the authors concluded that treatment groups did not produce higher and robust test scores in comparison to control schools. Opposite to Vogel et al.'s (2006) conclusions, while performing a within-school, within-grade randomised experiment, Rouse and Kreuger (2004: 20) found: "little to no positive effects across a range of standardised tests that should be correlated." Such a statement might adhere to Goolsbee and Guryan's (2006: 23) conclusion when noting that, "IT may build skills that are unmeasured by standard tests." The experimental literature about the effects of educational technology on students' test scores is inconclusive. To this extent, this research, while employing experimental techniques, will shed light on the current situation in Malta (Figure 1), by asking the research question:

Does the use of educational technology by educators positively affect the academic performance by students?

Based on the literature surveyed, this study is critical to add to the library of researches on the subject and help close the gap among the examined studies by building a methodology (Chapter 3) based on the best practices adopted by past researchers. Furthermore, a gap in the literature will be closed since this research will be first to study this phenomenon in Malta among level 2 students following a vocational course at MCAST.

Experimental Design

Overall, there is consensus among scholars and researchers (Barrera et al. 2009; Carillo et al. 2011; Hartley 2007; Leuven 2007; Vogel et al. 2006) to adopt experimental practices in order to identify the potential existence of a causal relationship between the tools used to deliver the lecture and the academic score attained by students (section 2.3). The nature of field experiments permits data investigators to, predict how economic man will behave…what alternatives he sees and what consequences he attaches to them. (Barros 2010: 271)

Research rationale

On the back of the experimental literature surveyed (section 2.3), there is no consensus among researchers about the academic effects of using educational technology in the classroom (such as Computer-Assisted-Instruction, Integrated-Learning-System and multimedia; section 2.1). Under the framework of a quasi-experiment, this study will be performed in a controlled environment in order to minimise the potential existence of confounders in the data and hence help to uncover a possible causal effect between these two variables.

The purpose behind this study is to investigate whether the role of technology as a tutor and teaching tool (section 2.1) has statistically significant positive effects on the test scores achieved by students, a variable used in the literature as a measure of academic performance (Becker 1994; Torgersen et al. 2007). Algebraically, these can be represented using the following hypothesis:

H_0: The inclusion of *educational technology* in the lesson improves test scores

H_A: The inclusion of *educational technology* has no or negative impact on test scores

Research design

The literature on this subject is skewed in favour of using experimental techniques to answer the research question, specifically the use of quasi-experiments to control for potential noises in the data and ensure homogeneity between the treatment and control groups. Such technique builds on former studies that were surveyed in sections 2.2 and 2.3, while overcoming the biases present in Cristia's (2014) and Fairlie's (2015) publications, amongst others.

Primary data will be collected from participants in two separate sessions:

1. Pre-test questionnaire (section 3.3.1).
2. Criterion-Referenced-Test (section 3.3.2).

Following the footsteps of Rouse and Kreuger (2004), Vogel et al. (2006) and Torgersen et al. (2007), the collected data will be correlated relative to each other to uncover possible patterns. Linear regression analyses, while used in past studies (Archer et al. 2014; Kim et al. 2012), will not be performed in this study since they require a relatively large sample size. In fact, it is suggested that there should be, "at least 10 observations per variable" (Statistics Solutions 2020: 1). Consistent with past publications with relatively small sample sizes (Bass et al. 1986; Torgersen et al. 2007), the Bi-point serial correlation test will be employed to uncover a potential relationship between the use of technology and academic scores.This study follows the steps of Rouse and Kreuger (2004) by adopting a within-school, within-grade experiment. Furthermore, it will also be controlling for demographic and behavioural characteristics of the target population prior to holding the experiment (section 3.3.1). To this extent, a pre-test questionnaire was designed to uncover the attributes of potential participants before joining the experiment, intended to ensure homogeneity between the treatment and control groups (section 3.3.1.2).

Hence, this research will be adopting a quasi-experiment setting in the same lines of Rabiner et al. (2009) and Drummond et al. (2011).

Research instrument and format

The notion of quasi-experimentations involves the,

> manipulation of the independent variable whilst participants are not randomly assigned to conditions or order of conditions. (Cook and Campbell 1979)

Hence, a set of control variables (Table 6) founded from the surveyed literature (section 2.3) will be used as a yardstick to assign students between the control and experimental groups. By ensuring comparable groups of students, the inclusion of *educational technology* will be the sole value-added component.

Constructing the preliminary questionnaire

The initial step of the experiment involves the design of a pre-test self-completion questionnaire containing a set of structured questions relevant to uncover demographic and behavioural characteristics of the target population. This was drafted under the direction of Flanagan's (2008) publication whilst also including variables from other peer-reviewed literature. To this extent, the following determinants were used to classify participants among control and experimental classes:

- **Personal data**
  - age
  - gender
  - desired occupation
  - past academic score
- **Behavioural characteristics**
  - technological exposure
  - technological relevance

Survey Design

Using a between-subject technique, the study involves the participation of all first-year students following the Diploma in Foundation Studies for Security, Enforcement and Protection (DSEP) within the Institute of Community Services (ICS) at the Malta College for Arts, Science and Technology (MCAST) during the scholastic year 2019/2020. The college provides students with a Vocational Education and Training (VET) setting, being an alternative route for students over traditional colleges via the course *Extended Diploma in Foundation Studies for Security, Enforcement and Protection* (Extended Diploma in Foundation Studies for Security, Enforcement and Protection: MCAST 2020). For the purposes of this study, all enrolled students (n = 88)[1] making up the population were asked to participate in order to overcome sampling errors as well as generating more reliable results (Tourangeau et al. 2009).Pre-test printed questionnaires were issued between the 5th and 6th of March, 2020 under the supervision of the researcher (being also the class teacher) and the marks were inputted in a *Microsoft Excel* file. The questionnaire was designed and distributed in English, though instructions in Maltese were orally provided to ensure that participants comprehend each question. During this period, a total of 36 responses were received, signifying a call-back rate of 41%.

In order to protect participants from any risk of harm and/or discomfort, the questionnaires were only distributed following ethical clearance from the concerned institute to host such study. Furthermore, students were informed that they are free to skip any questions and that such scores would be used for research purposes only, thereby having no impact on their academic performance. Alongside the preliminary test, a consent form was prepared and distributed to participants to ask for their signed approval for the use of such data.

Survey structure

The self-administered pre-test questionnaire involves eight questions intended to uncover participants' characteristics. The questionnaire was structured on the literature reviewed, as well as Lin et al.'s (2014) publication about the influence of technology on students' behaviour.

Contact Information

Although the designed questionnaire requests participants to input their personal details, being their name and surname as well as their class number, such data will be stored and processed according to ethical guidelines. The purpose of these entries is to corroborate the demographic characteristics and participants' behaviour from the preliminary questionnaire, with the assessment scores obtained in the end-of-lesson test, allowing this research to explore possible patterns in the data.

Demographic Characteristics

There is consensus among researchers to distribute participants equally between treatment and control groups with respect to their age and gender compositions. In accordance to Rabiner et al. (2009), Drummond et al. (2011) and Carillo et al. (2011), participants were asked for these entries in two separate open-ended questions for such purpose.

Desired Occupation

Apart from questions intended to uncover respondents' characteristics, participants were also asked to input their desired occupation to serve as guide when choosing the topic to be covered during the lesson when holding the experimental sessions (section 3.3.2).

Suggestions Form

An open-ended question intended to elicit feedback from students for more effective teaching practices was included in the beginning of the questionnaire (to overcome bias). Such proposals would help identify areas for future research (section 4.3.2).

1 This was the official figure of registered students on 6/3/20, which may also include students who stopped attending lectures without having officially resigned from the course.

Past Academic Score

In Hanushek's 1979 educational function, the author controls for past academic performance of students. Such technique was also replicated in more recent studies by including an auxiliary variable in regression models (Flanagan 2008; Lauren et al. 2007). However, other studies that used statistical correlation tests to identify a link between the use of educational technology and academic scores have controlled for such variable prior to the experiment by assigning participants equally using a pre-experiment test score (Torgersen 2007). To this extent, participants were asked to sign if they give their consent to the researcher to use the mark that they obtained in their first assignment for the unit *Office Administration Skills*; the score of which was confirmed by an internal verifier.

Technological Exposure

In accordance to Carillo et al.'s (2011) study, this research will be controlling for participants' exposure to technological equipment. The first question, drafted following Flanagan's (2008) preliminary test, asks participants to choose the electronic device that they primarily use, intended to reproduce identical treatment and control groups.

Technological Relevance

Respondents were asked about their perceived significance of the use of educational technology by educators was asked, and some examples were given, "videos, PowerPoint presentations, online quiz games, etc." to probe students' memory in this respect, in accordance with Flanagan's (2008) study. Responses from this question will be used to assign students accordingly, as well as to compare empirical findings with students' view on the subject.

Furthermore, under the direction of Sharma et al.'s (2017) questionnaire about technological addiction, a Likert-rubric-scale was designed to uncover the behavioural characteristics of participants towards technology use. The scale provided participants with four options, asking for their degree of approval to a set of statements taken from Lin et al.'s (2014) psychological paper. An even number rating scale was chosen in order to overcome misinterpretations of the mid-point (Moors 2007).Unlike Cristia et al. (2014), given the nature of this study, being a within-school, within-grade examination, school-specific characteristics will not be controlled for since students follow the same course within the same institute. Also, unlike Baker and Robinson (2018), the pre-test questionnaire will not be controlling for teacher specific characteristics, such as years of teaching experience and training courses attended since the sessions will be delivered by the same person, the author of this study (AZ).

Designing the lesson plans and assessment criteria

Based on responses from the preliminary tests, 78% of students intend to work as police officers, followed by 11% who showed interest to work as soldiers with the Armed Forces of Malta. To this extent, the lesson plans and the content to be delivered during the sessions, give an overview of the different roles and units within these two specific local institutions to encourage participation. Meanwhile, for the control group a direct teaching approach was designed for the control group (Becker 1994), the experimental group will discuss the same content however, projected using a *PowerPoint* presentation, multimedia (videos) and an interactive board (Table 3) (section 2.1). Both educators, for the control group and the treatment group were given a briefing which outlined the following:

- items required to deliver the lecture (equipment needed);
- learning outcomes (content material, teaching cues, organisation);
- analysis and application

Direct Approach (Control group)	**Engaging Approach (Treatment group)**
Verbal explanations whilst students listen and copy	Visual and verbal representations whilst the students listen and copy
Use of whiteboard and markers	Use of *PowerPoint* presentations, videos and whiteboard equipment

Table 3: *Comparison between the two teaching methods*

Furthermore, to control for the influence of educational pedagogy on test scores, as identified by Dunlosky et al. (2013) and Miller et al. (2013), the same techniques will be applied between the two groups. Also, to ensure homogeneity, the same classroom will be used (MCAST Student House Room 215).

In total, 4 sessions were planned to be delivered between the 9th and 13th of March 2020, whereby participants were invited, via email, to attend the sessions. For the session, students were equally allocated among classes depending on the answers provided in their pre-test questionnaire (quasi-experiment) (Table 4). For uniformity purposes, each session involved the participation of two classes (classes A-D) to further guarantee consistency between the control and treatment groups.

Session Number	**Session 1**	**Session 2**	**Session 3**	**Session 4**
Date	9/3/20	9/3/20	12/3/20	13/3/20
Time	10:00-11:00	12:00-13:00	14:00-15:00	08:00-09:00
Classes	A + C	A + C	B + D	B + D
Category	Control group	Treatment group	Control group	Treatment group
Venue	Student House Room 215	Student House Room 215	Student House Room 215	Student House Room 215
Planned number of participants	22	21	22	23

Table 4: *Experiment schedule*

The dependent variable for this study will be quantified by using a Criterion-Referenced-Test to be completed by participants attending the experimentation sessions. A 15 minutes test containing 40 multiple choice questions (1 mark each) was produced to examine the impact of lesson delivery techniques on students' test score results. To ensure validity, the questionnaire was reviewed by another lecturer before being issued and each question was orally explained to students prior to answering. Moreover, before responding to the CRT, students were reminded that the mark to be obtained in this study will not have any effect on their course progression.

In total, 36 students participated in this study, equivalent to a turnover rate of 41% (Table 7). A sample of 10% of the CRTs was selected and verified by an external lecturer. No errors were identified, allowing this study to proceed with the test scores.

Empirical plan

Following the collection of the raw data from the experimental sessions (section 3.3), cross-sectional tests will be performed, intended to answer the research hypotheses (section 3.1). For analysis purposes, SPSS will be used primarily to assess whether there is a positive relationship between the use of technology by educators and the test scores by students. The Point-Biserial correlation test will be adopted to examine the strength of association between a continuous variable (SCORE) and a binary variable (TECHNIQUE). The value to be produced in this bi-variate analysis will be between +1 (perfect positive correlation between 'SCORE' and 'TECHNIQUE') and -1 (perfect negative correlation between the two variables). Table 5 summarises Rumsey's (2016) interpretation of correlation coefficients.

= 1	**≥ 0.70**	**≥ 0.50**	**≥ 0.30**	**= 0**
Perfect correlation	Strong correlation	Moderate correlation	Weak correlation	No correlation

Table 5: *Possible correlation coefficients*

For analysis purposes, the variable 'TECHNIQUE' was created, being a dichotomous qualitative dependent variable that captures the technique used during the lesson. According to Gujarati (2010), qualitative variables need to be quantified for statistical functions and hence:

- the treatment group will be assigned a value of '1';
- the control group will be assigned a value of '0'.

Moreover, auxiliary correlation tests will be performed between the dependent and independent variables to identify patterns in the data (Table 6). Such correlation tests will be examined using the Pearson's Product-Moment test when dealing with two continuous variables whilst the Bi-Point serial correlation test will be adopted in case of continuous and dichotomous variables.

Variable name	Acronym	Variable class	Description
Dependent Variable			
Test score	SCORE	Continuous	CRT result
Central Variable			
Lecture technique	TECHNIQUE	Dichotomous	1 – Treatment group; 0 – Control group
Control Variables			
Demographic characteristics			
Age	AGE	Continuous	Age of participant
Gender	GENDER	Dichotomous	1 – Male; 0 - Female
Assignment mark	ASSIGNMENT	Continuous	Mark obtained in the first assignment for the unit *Office Administration skills*
Behavioural characteristics			
Technological exposure	EXPOSURE	Continuous	Weighted score using a Likert scale rubric
Technological relevance	RELEVANCE	Continuous	Scale from -4 (4 is the highest)

Table 6: *Variables analysis for correlation tests*

Methodological Shortcomings

One of the limitations of using an experimental approach is the lack of a link to theory which according to Bhanot (2015: 10) makes them: "more prone to null, mixed, or unclear results". Another shortcoming of this study is the lack of consistency when delivering the sessions where a common slot in the timetables to host such sessions could not be found (Table 4). Since the lessons were delivered on different days and time slots, factors such as fatigue and motivation might vary, potentially affecting test scores. Such limitation was partially minimised by choosing the same venue to host the sessions, intended to reduce bias.

Furthermore, the past academic performance by students was solely based on the results attained in one assignment, creating a level of prejudice. Moreover, even though this study targeted the whole population (n = 88), the call-back rate was of 41% due to national events which had an impact on the performance of this study (section 4.1).

Research findings and discussions

Dataset overview

During the observed period between the 9th and 12th of March 2020, 36 DSEP students participated in this study (Table 7). The final experimental session scheduled for the 13th of March 2020 was cancelled following the announcement by the Ministry for Education to close all schools in light of the COVID-19 virus spread (Table 8). All the data was recorded using *Microsoft Office Excel* and later inputted into the *SPSS Statistics* software for analytical purposes.

Class	Class A	Class B	Class C	Class D	Total
Number of participants	2	17	16	1	36
Number of registered students[1]	22	23	23	20	88

Table 7: *Students' turnover rates by class*

Session	Session 1	Session 2	Session 3	Session 4	Total
Number of participants	11	18	7	cancelled	36
Number of invited students[2]	22	21	22	23	88

Table 8: *Students' turnover rate by session*

Since this experiment was set in a controlled environment whereby the researcher had direct contact with the participants, limited data cleaning procedures were necessary.

Students who had inputted more than one response during the preliminary and CRT questionnaire were asked to correct their entries during the session, allowing the data cleaning process to proceed without any further amendments.

The abovementioned participants were allocated in treatment and control groups depending on their pre-test questionnaire responses. To this extent, the descriptive statistics explore the structure of the control variables, proving similarly in terms of demographic and behavioural qualities between the control and treatment groups (Table 9).

Variable	TECHNIQUE = 0 (Control group) (N = 18)					TECHNIQUE = 1 (Treatment group) (N = 18)				
	Minimum	Maximum	Mean	Standard Deviation	Skewness	Minimum	Maximum	Mean	Standard Deviation	Skewness
AGE	16	18	16.67	0.77	0.69	16	18	16.56	0.62	0.62
EXPOSURE	1	3.75	2.46	0.72	0.01	1.63	3.50	2.60	0.52	-0.27
SCORE	60	92.5	75.97	7.38	0.05	52.5	87.5	68.75	8.71	0.21
GENDER	0	1	0.56	0.51	-0.24	0	1	0.39	0.50	0.50
RELEVANCE	2	4	3.17	0.71	-0.25	3	4	3.3	0.49	0.77
ASSIGNMENT	64	99	82.97	10.58	-0.25	63.16	100	83.41	9.62	-0.08

***Table 9:** Descriptive Statistics Output*

Preliminary data analysis

Exploring the dependent variable

The values of the dependent variable were converted into percentages to facilitate interpretation and examination of results. From the data collected it was noted that all participants passed the Criterion-Referenced-Test multiple choice questionnaire (answering more than 20 correct answers), with the lowest mark recorded being 52.5% and the highest 92.5% (Figure 3). A mean mark of 72% indicates that overall, the data is skewed in favour of higher marks.

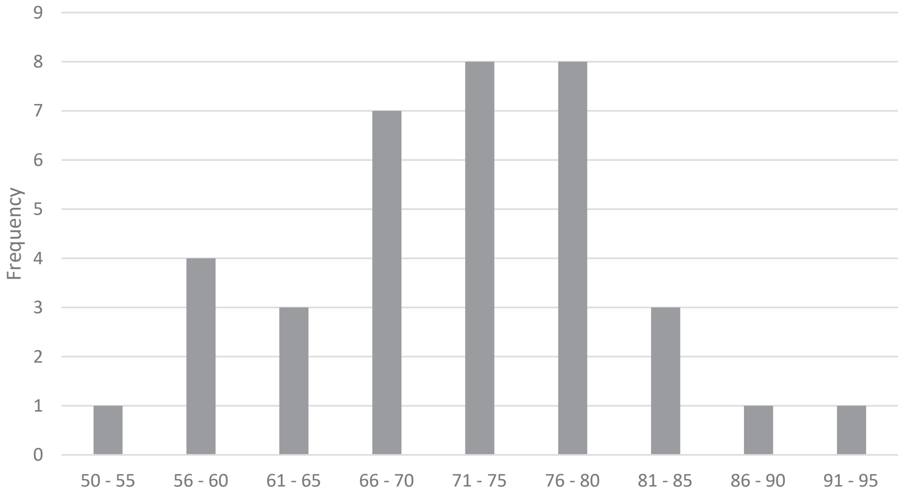

Figure 3: *Distribution of the dependent variable 'SCORE'*

By segregating the above data between treatment and control groups, a preliminary assessment of the impact of educational technology (technology used by educators) on academic performance can be detected (Figure 4). Overall, the chart gives an indication that level 2 DSEP students achieved higher CRT scores when presented with a lesson involving the direct-teaching approach over the one including educational technology. In fact, while 50% of students from the control group obtained a test score greater than 75%, only 22% obtained such result from the treatment group.

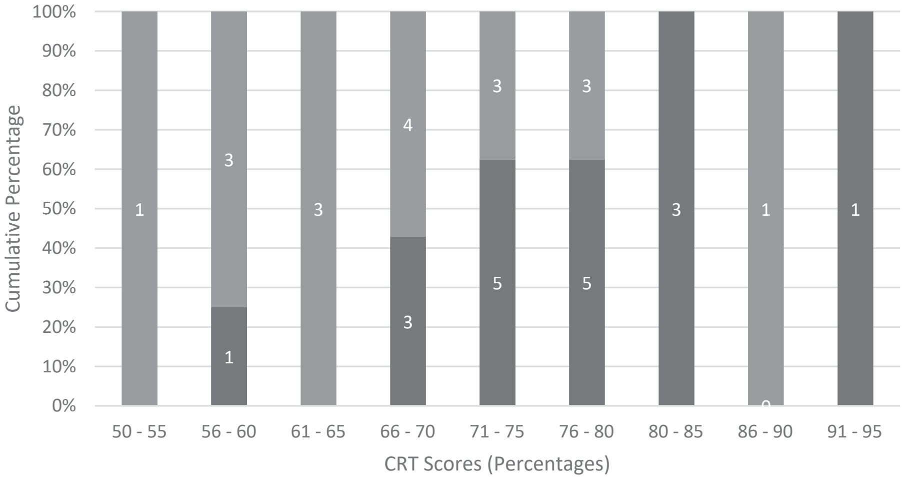

Figure 4: *CRT scores segregated by control and treatment groups*

Moreover, control group participants obtained higher average scores based on the calculations in Table 10. Hence, such preliminary results indicate that educational technology is not an important determinant in the education of vocational lower level students. However, statistical tests need to be performed in order to produce scientific conclusions (section 4.3).

Mathematical calculation	**Mean**	**Mode**	**Median**	**Range**
Control group value	76	78	76	33
Treatment group value	69	73	69	35

Table 10: *Measures of central tendency for the dependent variable (SCORE)*

Exploring the control variables

The population of level 2 first year DSEP students is made up of 58% male (51 learners) and 37% female (37 learners) students. During the distribution period, 17 males (47%) and 19 females (53%) participated in this study, meaning that the data is slightly skewed in favour of females over males, potentially due to the omission of session 4 from this study. A cross variable analysis between 'SCOPE' and 'GENDER' indicates that on average, males attained lower end-of-test scores than females (average score of male participants was 71 while females attained 73; Figure 5). Such finding supports past research on the subject which argues that during teenage years females outperform males due to earlier maturity of the former gender (Pekkarinen 2012). Also, such finding supports Carillo et al.'s (2011) suggestion to control for the demographic characteristics of the participants prior to holding the experiment (section 2.3).

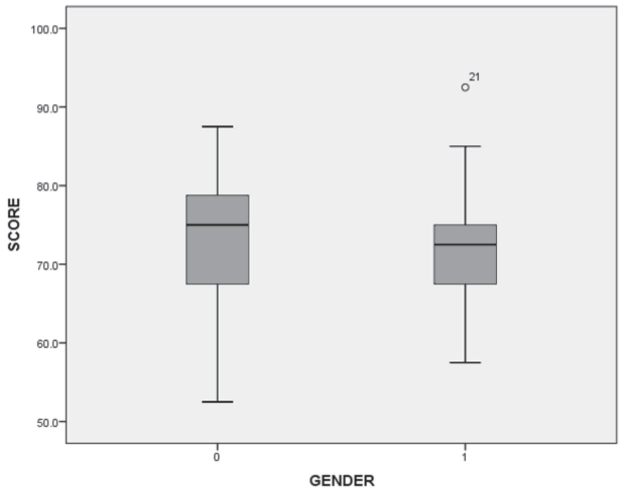

Figure 5: *Test score results segregated by 'GENDER'*

Furthermore, the rapport between the outcome variable (SCORE) and past academic achievements of the students (ASSIGNMENT) was examined using a Pearson Correlation test (Figure 6). Although results signal a positive correlation between the two variables, the relationship is not statistically significant. Such conclusion contrasts Leuren et al. (2007) and Flanagan's (2008) publications when underlining the importance of past educational performance in their production functions (section 2.3).

Correlations

		ASSIGNMENT	SCORE
ASSIGNMENT	Pearson Correlation	1	.194
	Sig. (2-tailed)		.256
	N	36	36
SCORE	Pearson Correlation	.194	1
	Sig. (2-tailed)	.256	
	N	36	36

Figure 6: *Pearson correlation test for 'ASSIGNMENT' vs 'SCORE'*

Following the surveyed literature, the pre-test questionnaire solicits the importance participants place on the use of technology in the classroom (RELEVANCE) alongside the degree of influence IT has on their lives (EXPOSURE). A positive non-significant correlation was exhibited between these two control variables, represented by an upward sloping trend line in the scatter plot (Figure 7). Hence, ongoing technological advancements, for instance the embracing of Industry 4.0, might require educators to place more emphasis on the use of technology for educational purposes which further leads students to identify such techniques as important teaching tools in the classroom.

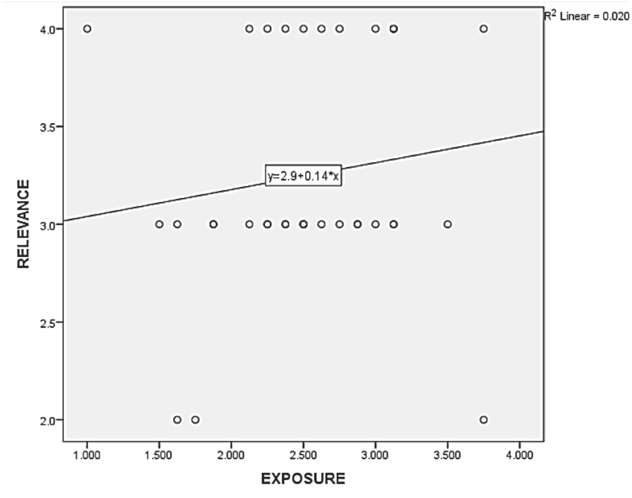

Figure 7: *Scatter plot between 'RELEVANCE' and 'EXPOSURE'*

Main empirical findings and policy recommendations

The work produced in the previous section provides preliminary conclusions to answer the research question which need to be scientifically verified using statistical correlation tests to answer the hypothesis in question.

Results from the Bi-Point serial correlation test confirm that the use of educational technology by educators in the classroom, specifically Computer-Assisted-Instruction, Integrated-Learning-System and PowerPoint presentations, has a negative impact on the academic test scores attained by level 2 DSEP students (Figure 8). Despite being a relatively small sample size, the results are scientifically confirmed under a 95% level of confidence interval. Based on Rumsey's 2016 interpretation of correlation coefficients (Table 5), such correlation is deemed relatively weak.

Correlations			
		ASSIGNMENT	SCORE
ASSIGNMENT	Pearson Correlation	1	-.418*
	Sig. (2-tailed)		.011
	N	36	36
SCORE	Pearson Correlation	-.418*	1
	Sig. (2-tailed)	.011	
	N	36	36

**. Correlation is significant at the 0.05 level (2-tailed)*

Figure 8: *Bi-Point serial correlation test output*

This finding proves that the direct-teaching approach is a more effective tool for level 2 students following a vocational course at ICS to attain higher academic scores.

A narrower analysis could be performed by concentrating on those students who consider the use of IT by educators in the classroom as an important component (by focusing on respondents who gave a 'RELEVANCE' score greater or equal to 3) (n = 33). In this second analysis, under a 99% level of significance, students who were not exposed to IT use by educators during the lesson (control group), on average attained a score 50.3% higher than those students in the treatment group (Figure 9).

Correlations			
		ASSIGNMENT	**SCORE**
ASSIGNMENT	Pearson Correlation	1	-.503**
	Sig. (2-tailed)		.003
	N	33	33
SCORE	Pearson Correlation	-.503**	1
	Sig. (2-tailed)	.003	
	N	33	33

***. Correlation is significant at the 0.01 level (2-tailed).*

Figure 9: *Bi-Point serial correlation test output*

Hence, such results corroborate with the preliminary analysis findings in Figure 4 and Table 10 which declare treatment group students to achieve lower test scores than the control group. Therefore, such result rejects the null hypothesis:

H_0: The inclusion of *educational technology* in the lesson improves test scores

H_A: The inclusion of *educational technology* has no or negative impact on test scores

Comparison with the literature

This result converges with the findings by Vogel et al. (2006) while producing a two tailed statistical test (section 2.3). Similar to this study, while adopting an intra-school methodology with a relatively small sample size (n = 44), the authors conclude that educational technology has a negative impact on students' academic performance.

Furthermore, in both Drummon et al. (2011) and Becker's (1994) publications, the authors concluded that IT use in classrooms does not produce positive effects on students' academic performance, being in line with the findings from this study. Baker and Robinson (2018) (section 2.1) also came to similar conclusions when arguing that the use of Integrated-Learning-System and Computer-Assisted-Instruction, specifically *PowerPoint* presentations, yield negative returns on students' learning experiences. Also, Torgersen (2007) noted how the positive impact of educational technology diminishes as it is implemented at higher levels. Thus, the results of this research could be justified since this study was performed among level 2 college students.
Hence, such conclusions substantiate Underwood and Dillon's (2004: 220) conclusion that,

> when IT is adopted for its own sake, it displaces or replaces other teaching and learning activities which may have been as (or more) effective. (Underwood and Dillon 2004: 220)

Policy Recommendations

Based on the evidence from the educational literature surveyed, together with the interpretations of the results, this research pushes forward a set of policy recommendations addressed to key stakeholders intended to produce more effective teaching practices. The first interpretation is that this experiment and its findings raise several conceptual questions on the direction headed by MCAST for the, "inclusion of technology for distribution and facilitation" (MCAST Strategic Plan 2019-2021), intentioned primarily to engage students, and result in better academic achievements. However, evidence from this study proves that such investment will not be effective when implemented among students with similar academic and behavioural characteristics as the participants of this study (DSEP Level 2 students).

Conversely, such financial resources could be partially dedicated towards organising more practical teaching methodologies such as work placements and internships. Such educational models are renowned in Finland, the country that tops PISA scores (Europa.eu 2020). For such student cohort, by, "conditionalizing the content" (Adomanis et al. 2000) through delivering lessons outside the confines of the traditional classroom, helps students remain engaged by delivering the course in a practical layout. In fact, students' top suggestion based on the pre-test questionnaire answers, was for teachers to design interactive lessons, followed by their request for more visits in workplaces close to their careers (Figure 10). By saving on IT infrastructure and maintenance costs, the state could employ such funds to:

1. Engage more student mentors to monitor learners' individual progress.
2. Schedule regular visits to the Armed Forces of Malta, Malta Police Force and the Civil Protection Department for educational and team-building purposes.
3. Sponsor gym and sport facilities to become a requisite component of the programme.

Such conclusion adheres with Cumbo et al.'s (2019) recommendation to increase physical activity among MCAST students by 54% in a five-year plan. The adoption of this policy recommendation reconfirms MCAST's role as a bridge towards the working industry.

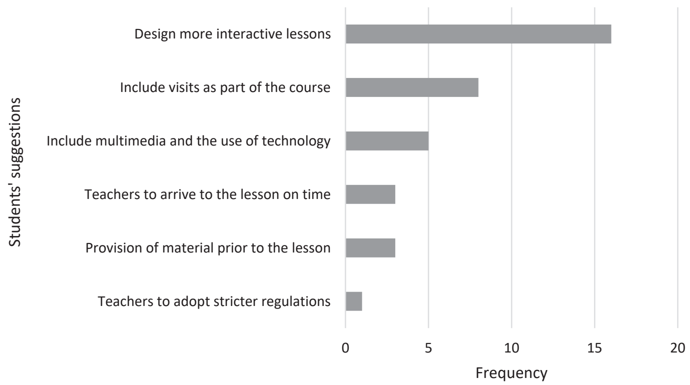

Figure 10: *Students' suggestions for more effective lectures*

A contrasting interpretation of the findings, notes how although IT failed to produce significant positive effects on academic performance, it is still perceived by students as an important determinant to be used for educational purposes (Figure 11). In fact, 92% of the respondents believe that IT use in classrooms is either 'quite' or 'extremely' important. Hence, it could be a tool to keep students engaged during the lesson, although not producing positive academic effects. Also, the use of technology as a learning aid could include the installation of online learning platforms where students and teachers can communicate and share resources while working remotely. Following the closure of schools as a preventive measure against the COVID-19 spread, the relevance of such online learning platforms has inflated.

Besides this proposal, the majority of pre-test questionnaire respondents (81%) chose their *smartphone* as the most common technological device used. Hence, an app could be developed (or an existing app could be purchased) by the institute for teachers to communicate with students on this channel, sharing ideas and good practices.

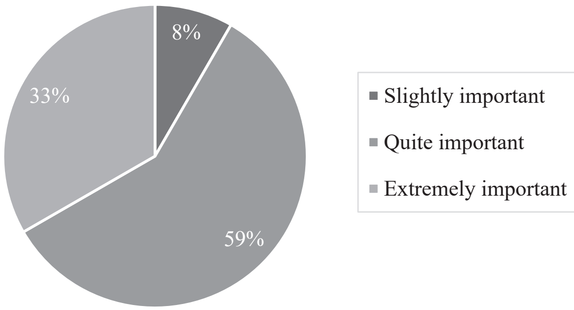

Figure 11: *The importance of technology in education from the students' perspective*

Conclusion

This study undertook a journey to assess whether the use of technology in the classroom by educators, specifically Computer-Assisted-Instruction, Integrated-Learning-Systems and *PowerPoint* presentations, results in a positive impact on the academic score of level 2 DSEP students following a vocational course at MCAST.

This research was the first to examine the academic effects of the use of technology in a vocational education context in Malta. Hence, more research is needed to provide more insight on the subject. Harris et al. (2016: 380) encourage research among learners when suggesting that:

> Teachers must continue to be learners themselves to produce the best teaching methods and introduce technology that works for their classrooms and the specific needs of their students.

This study could be replicated and performed:

- Among the same student cohort to determine long term effects. (Kolb and Kolb 2017).

• Among all level 2 students at MCAST in order to examine whether level 2 students following different fields of study respond differently to the use of technology.

• To investigate whether students in different levels, all following a vocational education course, respond differently to the use of technology for educational purposes (Torgersen 2007).

• To explore other potential returns of educational technology in the classroom, including the role of *assistive technology* to improve functional abilities of students with disabilities vis-à-vis students who do not have identifiable disabilities (Flanagan 2008).

The conclusion from the Bi-Point serial correlation test in chapter 4 identified weak and negative correlations between the use of educational technology and academic score, leading this study to reject the hypothesis tested. Under a 95% and 99% level of confidence interval respectively (allowing 5% and 1% error), these results answered the primary research question set in the introductory chapters. Such conclusions call for key stakeholders to endorse practical teaching techniques for more effective learning; specifically: MCAST, the Ministry for Education and the EU – should direct their resources towards more practical and effective teaching resources.

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