Adapting to Uncertain Times: Implementing Integrated STEM Curriculum during the COVID19 Pandemic and the Impact on Student Attitudes

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***Abstract*—The global pandemic in 2020 thwarted teachers' plans to continue their integrated STEM curriculum implementation as school closures created the urgent need to use distance learning modes to support students. This study highlights the journey of one school that continued to offer STEM project-based curriculum during Covid19 using online learning platforms during one term, for half their cohort of students. The other half of students undertook their STEM project-based curriculum with face-to-face learning once students returned to school after restrictions were lifted. Following an explanatory sequential mixed-methods design (Creswell, 2013), this study explored the impact of blended learning, undertaken during Covid-19 restrictions, on student attitudes in STEM subjects. For students that completed two projects with face-to-face learning, there were no statistically significant differences in STEM attitudes. However, students that undertook STEM with blended learning during Covid19 restrictions indicated a significant increase in their attitude in mathematics. Interviews with three STEM teachers illuminate these findings.**

***Index Terms*—integrated curriculum, STEM education, teacher professional learning, student attitudes and aspirations**

I. Introduction

Now more than ever, students need to be STEM (science, technology, engineering and mathematics) literate and socially responsible citizens (Bybee, 2018 [1]; Erduran, 2020 [2]). Finding ways to develop students' STEM capabilities, and their understandings of worldwide environmental and health issues including the current COVID19 global pandemic, are critical endeavours for teachers. However, the sudden closing of schools has challenged teachers' efforts, creating the need to adapt and be agile during the uncertain times of 2020 and early 2021 (Williamson, *et al*., 2020 [3]). Continuing to teach the way they have always taught has not been an option for secondary teachers of STEM subjects (Tytler *et al*., 2019 [4]). As in other countries, teachers in Australia have had to adapt by delivering curriculum online, often within days of school closures. Some teachers have been more adaptable as they were already using a range of online approaches to support face-to-face teaching and learning (Attard and Holmes, 2020) [5], while others have needed to transition to online learning with limited resources, experience, and capability (Flack *et al*., 2020 [6]). Unsurprisingly, some online learning involved limited use of a range of pedagogical practices suggesting students may not have had access to opportunities to work collaboratively with peers as would be anticipated when implementing an integrated STEM curriculum (Thibaut, *et al*., 2018 [7]).

Integrated STEM curriculum is a relatively new phenomenon in Australian schools, particularly in secondary schools where teachers are usually qualified, and hence teach, just one subject (Tytler, 2020 [8]). Since the Australian Federal Government endorsed a National STEM School Education Strategy (National Council, 2015 [9]), more STEM teachers in secondary schools have begun to work in cross-curriculum teams to embrace the role of curriculum designers exploring new approaches to teaching and learning STEM as an integrated subject (Anderson & Tully, 2020 [10]). The University of Sydney *STEM Teacher Enrichment Academy* (henceforth, the Academy) was developed to provide yearlong professional learning to secondary school STEM teachers as they worked with university mentors to design and deliver integrated STEM curriculum unique to their school contexts (Anderson & Tully, 2020 [10]).

This paper reports on the work of one secondary school that began their integrated STEM curriculum journey in 2019 with grade 7 students before the Covid-19 pandemic. As evidenced through teacher questionnaire data, the integrated STEM program was successful in enhancing teacher self-efficacy and collective efficacy (Anderson & Tully, 2020 [10]). Keen to continue their integrated STEM curriculum work, the school's STEM team developed an integrated STEM program in 2020 for the students who were now in grade 8, but their efforts were impacted by the global pandemic and school closure during the second term of the academic year. While adapting to online learning, the teachers needed to find

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new ways of implementing their integrated STEM program so that students could still achieve the aims of collaboratively working on real-world problems. A new learning model was required with students initially working online and then using a blended learning approach to develop their STEM projects.

We present analyses of questionnaire data from students, and interview data from teachers, to ascertain the impact of the blended learning integrated curriculum model, to compare students' attitudinal outcomes with 2019 outcomes, and to evaluate whether the adaptations enabled or hindered student learning. With consideration of the objectives of the STEM Academy in tandem with relevant research literature and our theoretical framework, this study sought to address the following research questions:

1. Are there differences in students' attitudes in STEM subjects based upon differing modes of STEM instruction (face-to-face vs. blended)?
2. What aspects of differing instructional modes may have influenced changes in students' attitudes to STEM?

II. Literature and Theoretical Rationale

The Academy program is primarily a professional development program (PD) for teachers yet aims to see increased student participation in senior school STEM subjects with a long-term view of promoting pathways for students into STEM careers (Anderson & Tully, 2020 [10]). Based on high-quality, high-impact PD design principles (Darling-Hammond, *et al*., 2017 [11]), the Academy program involved teams of teachers from each participating school, working collaboratively to create tasks, lessons and units of work (Voogt, Pieters, & Handelzalts, 2016 [12]) involving real-world STEM problems that emphasized creativity and critical thinking (Freeman *et al*., 2015 [13]). To inspire teachers, to in turn inspire their students, one of the aims of the Academy was to support teachers' knowledge and understanding of, and abilities to implement, pedagogical strategies promoting student engagement in STEM (Anderson & Tully, 2020 [10]). Across a 12-month period, school-based teams of teachers participated in several face-to-face multi-day sessions with university-based experts to share their work, obtain critical feedback from academic mentors and peers, and develop next steps to further their school's classroom-based STEM initiatives. Between these sessions, academic mentors visited schools to work with their STEM teachers and to provide additional support.

Prior research indicates that future STEM subject selections and the eventual pursuit of a STEM career pathway are often influenced by the attitude students hold towards STEM (Maltese, & Tai, 2011 [14]). As such, attitudes in STEM became an important area for examination in this study. Student attitudes within academic domains are often shaped through the tandem influences of self-efficacy and expectancy-value beliefs (Unfried, *et al*., 2015 [15]; Eccles & Wigfield, 2002 [16]). Self-efficacy is commonly thought of as a person's belief in their ability to successfully complete a task. Research has shown that positive self-efficacy, particularly in mathematics or science, influences student selection of a future post-secondary STEM career path (Watt *et al*., 2017 [17]). Expectancy-value theories suggest that personal ability beliefs, subjective task value and expectations of success impact student related achievement choices (Wigfield & Eccles, 2000 [18]). In merging these theories, the term attitude therefore applied in this study refers to a composite of both self-efficacy and expectancy-value beliefs (Unfried, *et al*., 2015 [15]), beliefs that underpin the theoretical tenets of this research. This definition for "attitude" aligns consistently with that noted by the authors of the survey that was employed in this study (Friday Institute for Educational Innovation, 2012 [19]).

Layered upon the theoretical influences of student attitudes in STEM subjects, are the delivery modes in which STEM instruction for those subjects occur. In secondary school education in Australia, delivery of STEM curriculum is traditionally undertaken in small classrooms, science laboratories or technology spaces with access to a diversity of tools and resources (Tytler *et al*., 2019 [4]). Integrated STEM curriculum has challenged schools to create new learning spaces with bigger classrooms so that students can more easily work together, classes can be combined so that more than one qualified STEM teacher can participate in integrated lessons, and more tools and resources are available (Vivian *et al*., 2020) [20]. Such efforts in Australian schools have enabled greater opportunities for implementing genuine integrated STEM curriculum that has promoted positive STEM attitudes and aspirations (Anderson & Tully, 2020 [10]). However, such efforts began to unravel as the global pandemic in 2020 thwarted teachers' plans to continue their integrated STEM curriculum implementation as school closures created the urgent need to use distance learning modes to support students (Netolicky, 2020 [21]).

Little research has been undertaken that explores how student attitudes within academic domains may be shaped through various modes of instruction, particularly for distance learning in school education (Wallace, 2009 [22]). It is commonly assumed that student outcomes from face-to-face teaching exceed those of distance learning (Johnson, *et al*., 2000 [23]). While distance learning is not a new phenomenon, the merger of distance and face-to-face learning in a "blended" or "hybrid" model is a more current iteration of the distance learning paradigm (Bonk & Graham, 2006 [24]; Welker & Berardino, 2005 [25]). Driscoll 2002 [26] asserts there are basic assumptions when considering the attributes of a blended learning environment.

A combination of instructional approaches that includes collaborative learning, self-directed learning with the use information based technological support ; the use of different pedagogical approaches to optimize learning results; a combination of face to face learning with support of instructional technologies, and; the combination of the application of information and computer technologies with face to face learning to maximize learning and teaching outcomes ([26], p. 1)

Current research highlights the positive aspects of learning undertaken in a blended model (Louwrens & Hartnett, 2015 [27]). More specifically, students cite they can assert increased control and experience autonomy in the distance portion of the learning format, with increased choice and ownership of the learning experience. Deci and Ryan (2008) [28] additionally note that these opportunities of student choice may lead to an improvement in student engagement.

The school under investigation in this paper, the "Charles Casey School" (a pseudonym), joined the STEM Academy program in 2019 along with 11 other secondary schools. They sent a team of six STEM teachers to the PD program (two each of mathematics, science and technology) that worked collaboratively to develop an integrated STEM project for grade 7 students which was implemented during that year. Their final report suggested they had used a face-to-face mode of teaching exclusively, like all other schools participating in the Academy program. It was the pandemic in 2020 that caused a disruption for continuing the face-to-face mode of delivery and required teachers at the school to adapt to new ways of teaching and learning for integrated STEM curriculum. The next section provides further information about the school, the projects they implemented and the data collection for the research.

III. Educational Setting and Research Design

Participants in this study are students and teachers from the "Charles Casey School", a co-educational independent K-12 school serving over 900 students located in suburban Sydney, Australia, close to ocean and waterway access. Approximately 70% of students reside outside a five km radius of the school. The school has adopted a "Culture of Thinking" approach to pedagogy adapted from the Harvard University Project Zero initiative (http://www.pz.harvard.edu/). All staff receive training and participate in professional learning sessions to align with this philosophy of teaching and learning. Teachers also can choose to participate in one of four Professional Learning Groups (PLG), of which one is STEM focused. Of the 92 members of teaching staff, ten have elected to participate in the STEM PLG. Three of those STEM teachers were interviewed for this study.

On the Australian NAPLAN (National Assessment Program in Literacy and Numeracy), students in grades 7 and 9 at the Charles Casey School scored above the state indicators in all measures. As it relates to STEM, students in grade 8 may participate in before-school enrichment opportunities in science. All grade 7 and 8 students participated in an integrated STEM curriculum unit of study timetabled within mathematics, science, and technology subjects. The duration of the STEM projects for grade 7 was six weeks while the grade 8 projects were much longer taking approximately half the school year, or one semester. This study focused on the STEM subject attitudes of students undertaking these projects which were completed by the same cohort of students in successive years. Project one in 2019 with grade 7 and project two with grade 8 in 2020. Project one was delivered in face-to-face mode only while project two was delivered in a blended mode for one of the learning groups.

A. Student STEM Projects

1) Project one (2019): Digital game on waterway pollution

Project one's design brief was to create a digital game that can be used to educate the local community on how they are impacting their local watershed, given the location of the school in an ocean side community. The school partnered with AUSMAP and Tangaroa Blue, nation-wide citizen science initiatives, surveying Australian beaches for micro and macro plastic pollution. The project started with a full STEM day at the end of Term 1 with students building and testing water filters. Additionally, this STEM day focused on developing students' team-building skills and the identification of students' strengths and weaknesses when undertaking group tasks. As the project unfolded, students learned how to collect and present data in a variety of formats during their STEM focused mathematics classes. During STEM science classes, students honed their skills in data collection, water analysis, exploring the sources of plastics in the water ways and dissection of local fish. The content learned in mathematics and science STEM classes provided the platform for students to begin and complete the process of designing and coding a digital game during their STEM Technology classes to heighten awareness of local waterway pollution. The completed games were then played by students in the primary school grades, as well as during a new-student orientation day.

2) Project two (2020): Programmable lamp for a person with disabilities

The brief for this longer project was to design, produce and evaluate a programmable, cantilevered lamp for a person with a physical disability. In the grade 8 timetable, four lessons a week were allocated specifically for STEM. Based on school scheduling, half the cohort (Group A) completed the project in semester one, the other half of the cohort (Group B) completed the project in semester two (see Fig. 1) – the allocation to groups was not based on ability grouping but on other subject selections students had made. Soon after Group A commenced their project at school, public health requirements mandated schools adopt online learning platforms due to the Covid-19 pandemic and imposed quarantined restrictions. The STEM project was moved to online learning. The final weeks of the Semester one project were then completed back on campus once the government allowed schools to return to face-face instruction. Although not originally designed with a hybrid approach to teaching, students in Group A experienced a blended format of learning for their STEM project with a combination of face-to-face and online learning. Students in Group B completed the project completely with face-to-face teaching (see Fig. 1).

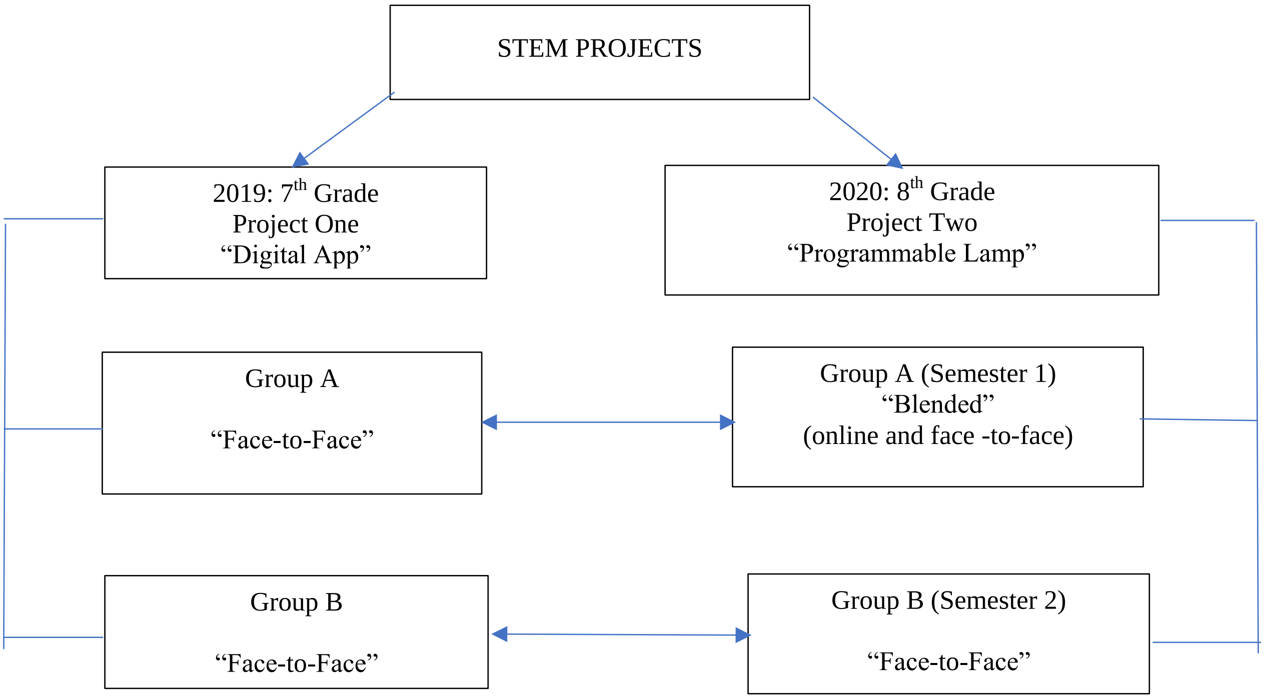

Figure 1. STEM projects and learning groups.

Figure 2. Student Lamp 1.

The mathematics, science, and technology teachers each used a different teaching platform and format in disseminating content during their online STEM classes. The mathematics teacher used the Canvas platform with a combination of recorded lectures and online assignments, with additional tutorials in Mathspace, another online learning platform. To support the STEM project for successful completion, mathematics topics included rates, ratios, surface area and volume. Students could watch the mathematics teaching videos and complete the prescribed written work within their own chosen timeframe during the week. All students for both project timelines accessed their mathematics lessons in this format during their “at home” teaching and learning time during Covid-19 quarantine restrictions. Students that completed their projects in semester two completed revision of those topics in a face-to-face format when they embarked on their project later in the year, as classes were held back in school during Semester two.

For the science component of the project, the teacher continued the delivery of a unit on electricity that included a combination of different online tutorials, predominantly in written format, that led students through the completion of written online activities. The science students engaged with the STILE application platform for their online learning. The science teacher additionally offered a weekly face-to-face check in with students in “real time” through an online Microsoft Teams meeting. This was not a content driven class, but a “check-in” to see how students were managing.

Figure 3. Student Lamp 2.

The technology portion of the project paused during this “learning from home” period due to the impracticality of completing that part of the project at home, which included mixing and pouring concrete for lamp bases from individual student designs; students instead explored topics on the life cycle of design. Once students in the blended learning group (Group A) returned to face-to-face learning for the completion of the project, they could complete a modified version of the concrete base for their lamp (see Fig. 2 and Fig. 3). The programmable portion of the lamp design was also modified during the "at home" portion of learning. The students that completed the project in semester two (Group B) had no modification to the original project curriculum design and all learning was carried out in a face-to-face mode.

B. Research Design

Following an explanatory sequential mixed-methods design (Creswell, 2013) [29], this study explored the impact of blended learning, undertaken during Covid-19 restrictions, on student attitudes in STEM subjects. Both quantitative (student surveys) and qualitative (teacher interviews) data were collected within the context of a single school environment. Explanatory sequential design allows the quantitative results to be further explored through gathering qualitative data to illuminate the quantitative findings (Creswell, 2013) [29].

The student survey used in this study consists of items from the S-STEM survey (Friday Institute for Educational Innovation, 2012) [30] that measures student attitudes in mathematics, science, and technology, and 21st century skills (see Table I). All items from the S-STEM survey utilise a five-point Likert-scale of 1 to 5 (1: strongly disagree to 5: strongly agree). Negatively worded items were reverse coded. Several recent studies have confirmed the validity and reliability of this survey instrument (Noh & Khairani, 2020 [31]; Unfried, *et al.*, 2015 [15]). CFA Goodness of Fit Indices and Cronbach's alphas indicate a high level of validity and reliability. Surveys were administered to students by their teachers after completion of each project.

TABLE I. S-STEM SURVEY SAMPLE ITEMS

STEM Attitude Scale	Number of Items	Sample Item	Response (Likert Scale)
Mathematics Attitude	8	"I am the type of student to do well in math"	1: Strongly Disagree to 5: Strongly Agree (3 items negatively worded and reverse coded)
Science Attitude	9	"I am sure of myself when I do science"	1: Strongly Disagree to 5: Strongly Agree (1 item negatively worded and reverse coded)
Engineering/Technology Attitude	9	"I am interested in what makes machines work"	1: Strongly Disagree to 5: Strongly Agree
21st Century Learning Skills	11	"I am confident I can lead others to accomplish a goal"	1: Strongly Disagree to 5: Strongly Agree

The first survey was administered to students after they completed Project one in 2019, with the second survey administered after completion of Project two in 2020. First and second surveys were identical in content, completed anonymously and matched for analysis based on a prescribed code provided by the students. Surveys that could not be matched were not used in these results. As conditions of normality could not be assumed, non-parametric statistical tests were applied in these analyses. Within Group Differences were measured by comparing the STEM Attitude Indicators for Project One to Project Two for each of the learning groups (Blended Group A and Face-to-Face Group B) using a Wilcoxon-Signed Rank Test. Between group differences (between Group A and Group B) were measured through applying a Kruskal-Wallace test. To avoid a type-I error due to multiple comparisons, a Bonferroni correction (Sedgwick, 2012) [32] was utilized with a 2.5% level of significance applied in this study.

Semi-structured interviews were undertaken with the three STEM teachers that spearheaded both these projects. Interviews occurred after the quantitative data were analysed. The timing of the interviews allowed conversations focused upon illuminating the quantitative results. Interviews were coded using a deductive approach within a framework of thematic analysis (Terry, *et al.*, 2017) [33]. The interviewed teachers were each graduates of the STEM Academy program in 2019.

IV. RESULTS

A. Survey Comparisons

This study sought to discover the potential influence of teaching and learning formats on students' STEM subject attitudes. Students that undertook STEM learning in a face-to-face format for both Project one and Project two (Group B) showed no significant changes in their STEM mathematics attitudes measured at the completion of project one and project two. However, when comparing changes in STEM mathematics attitudes for students that completed their first project in a face-to-face mode, and their second project in blended mode during Covid-19 restrictions (Group A), significant positive differences emerge. A Wilcoxon signed rank test indicated that the median scores for mathematics attitude after completing Project two were significantly higher than the median mathematics attitude scores measured after the completion of Project one ($Z= -2.67$, $p=0.007$) for students that experienced a blended format of learning (Group A). This difference also displayed a large effect size (see Table II). For students in this same group, a statistically significant negative difference emerges when comparing measures of science attitude from Project one to Project two (Z=-2.54, p=0.011).

TABLE II. WITHIN GROUP DIFFERENCES: COMPARISON OF STEM SUBJECT ATTITUDE INDICATORS POST PROJECT COMPLETION (N=24) USING WILCOXON-SIGNED RANK TEST FOR BLENDED AND FACE-TO-FACE GROUPS

	Median Project 1	Std. Dev. 1	Median Project 2	Std. Dev. 2	Z	*p*	ES
Mathematics Attitude[c]							
Group A[a] (n=12)	28.5	4.97	32.0	4.98	-2.67	0.007*	0.55
Group B[b] (n=12)	25.3	4.62	28.5	3.42	-1.57	0.116	0.32
Science Attitude[c]							
Group A[a] (n=12)	29.5	6.38	25.0	5.76	-2.54	0.011*	0.52
Group B[b] (n=12)	27.0	4.12	24.5	6.22	-1.60	0.109	0.33
Engineering/Technology Attitude[c]							
Group A[a] (n=12)	27.5	6.12	25.0	3.29	-1.50	0.134	0.31
Group B[b] (n=12)	26.5	7.06	25.0	5.14	-1.06	0.287	0.22
21st Century Learning Skills[c]							
Group A[a] (n=12)	45.0	6.25	44.0	4.90	-1.06	0.561	0.22
Group B[b] (n=12)	46.0	3.74	45.0	6.05	-0.85	0.397	0.17

Note: a. Group A did project one face-to-face and project two blended online; b. Group B did both projects face-to-face; c. Scale Ranges: Mathematics Attitude (8-40)/Science Attitude (9-45)/Engineering Attitude (9-45)/21st skills (11-55); Effect size (z/sqrt N) small=0.1; medium=0.3; large=0.5 *p<0.025.

Comparisons were also made between the blended learning group (Group A) and the face-to-face learning group (Group B) for both Project one and Project two with respect to STEM attitude indicators. It should be noted that in Project one, both learning groups undertook their projects completely with face-to-face learning (see Fig. 1). There were no statistically significant differences in STEM subject attitudes between these learning groups measured after the completion of project one (Group A vs. Group B). When drawing comparisons between the different learning groups after Project two, there were also no statistically significant differences in STEM subject attitudes between students in the blended learning group when compared to the face-to-face learning group. This is noteworthy, as the blended learning group undertook a substantial part of Project two in a distance learning mode, and there were no significant differences in STEM attitudes when compared to those students that undertook their project with face-to-face learning (see Table III).

TABLE III. BETWEEN GROUP DIFFERENCES: COMPARISON BETWEEN LEARNING GROUPS FOR STEM ATTITUDE INDICATORS AFTER PROJECT ONE AND AFTER PROJECT TWO USING MANN-WHITNEY U TEST (N=24)

	Group A Blended		Group B Face-to-face				
	Median	Std Dev	Median	Std Dev	Z	*p*	ES
Project One 2019							
Maths Attitude	28.5	4.97	25.3	4.62	-0.96	0.334	0.19
Science Attitude	29.5	6.38	27.0	4.12	-1.71	0.087	0.35
Engineering/Tech Attitude	27.5	6.11	26.5	7.06	-0.41	0.685	0.08
21st Century Learning Skills	45.0	6.25	46.0	3.74	-0.55	0.580	0.12
Project Two 2020							
Maths Attitude	32.0	4.98	28.5	3.42	-1.83	0.068	0.37
Science Attitude	25.0	5.76	24.5	6.22	-0.98	0.325	0.20
Engineering/Tech Attitude	25.0	3.29	25.0	5.14	-0.44	0.661	0.09
21st Century Learning Skills	44.0	4.90	45.0	6.05	-0.86	0.954	0.19

Note: a. Learning Group A did project one face-to-face and project two online; b. Learning Group B did both projects face-to-face; c. Scale Ranges: Mathematics Attitude (8-40)/Science Attitude (9-45)/Engineering Attitude (9-45)/21st skills (11-55); Effect size (z/sqrt N) small=0.1; medium=0.3; large=0.5.

B. *STEM Teacher Reflections*

Both the science and mathematics teachers were pleasantly surprised at the level of engagement of the blended group (Group A) of students during the online lessons in semester one during Covid-19 lockdown. They noticed that students were more willing to take a risk in their learning when engaged with their online lessons. The science teacher noted that during group experiments in face-to-face classes, some students can be reticent to participate fully or take a risk fearing they may fail or not offer the "correct response" in front of their peers. However, during the portion of time that students engaged with online learning and completed simulations involving electricity concepts, they appeared more willing to expend effort in making multiple attempts to successfully complete the online simulations. The science teacher also noted that the Group A students, who learned the electricity unit during the online learning block, performed better on their assessment task than students who had learned this unit during face-to-face teaching. The science teacher shares:

"Then when they got back (to face-to-face learning) we ran the actual practical part. They all did really well. In part, I think they actually did better because at home, they all have to individually do that experiment whereas when we do it at school, you get the whole four people do it and one person knows what they're doing. I do feel like we've reached a lot more kids in that way".

The STEM teachers relayed that many students enjoyed the autonomy of the online learning process. While some students needed encouragement to follow through with lessons, most students engaged in the process and enjoyed the flexibility of doing their lessons within their own timeframe, loosely following their school-based timetable. The mathematics teacher shares, "In the juniors (grades 7 & 8), there were a number of juniors who express that sense of, 'Yes, we like being able to learn at our own pace'".

Although students may have enjoyed the autonomy of flexible learning during online lessons, they also informed some of their teachers that the workload seemed greater than that experienced during face-to-face lessons.

The science and mathematics teachers also reflected on their perceptions of whether students are making the connection that STEM actually incorporates the specific disciplines of science, mathematics, engineering and mathematics. In this context, some students may see STEM as a separate subject, apart from those disciplines, especially since STEM is listed as a separate subject in their class schedule. The teachers reflect,

"I do wonder as well whether they actually knew that what we did in science or what we did in the STEM lesson in the science room was related to what they did. I'm not convinced they had got that" (science teacher).

"Because I was teaching across science and maths, I often would make an effort to make those connections…to try and make those connections. But yes, that's definitely been amplified…to just be aware of that and therefore be trying to help them make the connection" (mathematics teacher).

Due to the many constraints placed on the teachers to quickly adapt their lessons to an online platform during the first semester of 2021, communication between the STEM teachers was not as fluid as when the teachers were all on campus.

V. Discussion and Conclusion

When comparing STEM attitudinal indicators for students who completed both projects in face-to-face learning (Group B), there were no statistically significant findings. However, when we compare these factors for students who completed their first STEM project in a face-to-face format and their second STEM project in a blended learning format (Group A), statistically significant differences emerge. Students in Group A indicated a significant increase in their attitude in mathematics after they completed their STEM project through a blended learning format. This could be attributed to several factors including the flexibility in the pace of learning, as well as the use of non-traditional assessment that utilized a project-based format during the online learning block for their STEM project.

Conversely, there was a negative impact on science attitude after completing portions of the project in an online format. This seems surprising considering the increase in engagement and the increase in assessment outcomes for students in science who experienced learning the science component of the second project in an online/blended format. A reason could be the disconnect that student may have relating science to STEM. In the school timetable, there are four periods allocated to STEM. One of these periods is a dedicated science period where they learn a unit on electricity; three of the periods are allocated for design and technology. Although they learn "science" during their designated STEM lessons, the class is not called science. Therefore, as shared by the science teacher, students may not make the cognitive leap that what they are learning in STEM is actually science, therefore impacting how they interpreted the survey which measured science attitude.

When comparing STEM attitudinal indicators between the blended learning group (Group A) and the face-to-face learning group (Group B) after Project two, there were no statistically significant differences. This is a meaningful outcome as it indicates that student attitudes in STEM were not negatively affected by students engaging with STEM projects in online and blended learning formats.

The results from this study suggest little impact on students' attitudes when teachers needed to provide new learning opportunities with the advent of the Covid pandemic in 2020. Indeed, the opportunity to learn mathematics using online delivery may have enabled more positive approaches to the subject. Attard and Holmes' (2021) [5] findings support increased use of online learning in mathematics although further research is needed to examine the impact of STEM project work on the learning of mathematics rather than more traditional learning approaches.

This school decided to deliver their integrated STEM projects through the individual subject teachers of mathematics, science and technology. They planned the integrated projects together but then delivered the necessary knowledge and support in separate subject lessons. Even though lessons and teaching were somewhat segregated, the STEM project work still led to improved attitudes and student engagement demonstrating the potential for integrated STEM curriculum to improve students' attitudes, even with non-traditional learning formats.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Tully designed the data collection, undertook the data analyses, developed the concept for the paper, and wrote original drafts. Anderson wrote the detail about the STEM Academy and edited drafts of the paper.

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