Journal of Advanced Research in Applied Sciences and Engineering Technology 53, Issue 2 (2025) 1-9

SEMARAK ILMU PUBLISHING
202103268166(003316878-P)

Journal of Advanced Research in Applied Sciences and Engineering Technology

Journal homepage:
https://semarakilmu.com.my/journals/index.php/applied_sciences_eng_tech/index
ISSN: 2462-1943

Digital Drone Education in Sarawak: Enhancing STEM Learning through Hands-on Training for School Students

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ABSTRACT

In Sarawak, concerns about low STEM enrolment, digital inclusivity gaps for rural children, and the transition from digital consumption to digital creation led to the introduction of the Drone Education Program. Participants began with foundational drone operation training, advancing to capturing images and videos. Subsequently, they were acquainted with elementary photo and video editing techniques, enabling them to enhance their drone-generated content. The aim of this research is to gauge the impact of the Drone Education Program on refining drone operations, bolstering digital editing competencies, and stimulating STEM engagement in students. In our methodology, we employed tailored pre- and post-surveys for evaluation, and younger students provided feedback via an emoji-based survey. Further analytical methods encompassed non-parametric tests, Exploratory Factor Analysis (EFA), and linear mixed-effect modelling. Results indicated significant post-intervention improvements in the targeted skills. The EFA grouped 21 Likert items into five distinct learning domains. Notable insights include district-wise variances in learning outcomes and the influential role of gender. The initiative showcases promise in confronting Sarawak's educational barriers, championing digital inclusivity, and preparing a digitally proficient generation.

Keywords:
Drone education; digital STEM; digital inclusivity

1. Introduction

In Malaysia, Education standards in STEM (Science, Technology, Engineering, and Mathematics) disciplines have faced significant challenges. The state of Sarawak, for instance, revealed that only 28 per cent of its students are engaged in STEM subjects, falling short of the national goal of 60 per cent [1]. On a broader scale, many students across Malaysia perceive STEM subjects as excessively challenging, a sentiment exacerbated when they observe their peers grappling with these subject [2].

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https://doi.org/10.37934/araset.53.2.19

This sentiment was echoed by the Melaka Action Group for Parents in Education (Magpie), which highlighted the discouragement juniors felt upon seeing their seniors' struggle [2].

To counteract this and boost STEM interest, the government has launched several strategic initiatives. This includes the creation of digital maker hubs, STEM carnivals, and tech-driven Education programs such as the drone Education project. Through hands-on drone training, the program aims to galvanize interest in STEM and equip students with essential digital skills, ensuring that they remain engaged and prepared for the demands of an increasingly digital future. Our core research objective is to ascertain the efficacy of the Drone Education Program in enhancing drone operation skills, advancing digital editing capabilities, and invigorating STEM enthusiasm among participants.

2. Related Work

The pedagogical potential of drones in the Education sphere has garnered attention in recent years. Daponte *et al.,* [3] emphasized the significance of drones in the context of measurement science and education. Duraj *et al.,* [4] explored how drone technology can be used effectively in mathematical education, while Fombuena [5] discussed how drones can foster spatial thinking in geoscience and remote sensing education.

Sattar [6] highlighted the transformative potential of drones, suggesting they can redefine pedagogical methods and learning outcomes. Chou [7] analysed how drone technology can be harnessed to support younger students' learning in sustainable ways. Joyce *et al.,* [8] focused on the fundamentals of geospatial technology, underscoring the role of Mini drones in the teaching process.

Bhaduri *et al.,* [9] delved into the practical applications of UAVs in middle-school engineering education, terming them as tools beyond mere toys. Jemali *et al.,* [10] specifically highlighted the adoption of drone technology in STEM education tailored for rural communities. Alkaabi and Abuelgasim [11] evaluated the role of UAVs for research and education in the UAE, highlighting a global trend towards the inclusion of drone tech in education. Further, Tezza *et al.,* [12] provided a guide on the potential of drones in STEM teaching for children.

Lobo *et al.,* [13] discussed the importance of active learning instruction in preparing students for drone careers, and Khan and Aji [14] examined the impact of programming robots and drones on shaping positive STEM attitudes. Lastly, Chen *et al.,* [15] explored the effectiveness of STEAM education revolving around drone assembly and operation.

These studies collectively affirm the transformative potential of drones in modern pedagogy, a direction that our digital drone education program in Sarawak also aims to pursue.

3. Methodology

We launched a comprehensive training initiative targeting mainly primary school children. The program was designed to provide them with hands-on experience and proficiency in the art of drone flying as well as photo and video editing.

The process began with the participants learning how to operate drones. This foundational knowledge enabled them to capture images and record videos with the flying drones. Following their drone training, we introduced them to basic photo-editing and video-editing skills, equipping them with the necessary tools to enhance and refine their drone-captured media.

Our approach was adaptive, catering to the facilities available in different settings. In urban areas, our training sessions benefitted from robust infrastructure, including a stable internet connection and access to lab computers. Consequently, participants in these areas were introduced to Windows editing software such as Fotor for photo editing and OpenShot Video Editor for video tasks. To gauge the participants' learning and feedback, we employed online survey forms, conducting both pre- and post-training surveys.

Conversely, in rural areas, our training faced infrastructural challenges. Due to the absence of internet connectivity and lab computers, we had to modify our approach. Participants in these regions were taught using Android applications. For photo editing, we utilized Collage Maker, while for video editing, the app of choice was PowerDirector. Given the internet constraints, we reverted to traditional methods for collecting feedback and gauged the effectiveness of our training through manually distributed printed survey forms.

3.1 Feedback Forms and Evaluation

Our study utilized a unique methodology for capturing students' feedback on the Drone Education Program by harnessing the universality of emojis. Given the widespread recognition and innate comfort the younger generation has with emojis, feedback forms were designed with five distinct emoji responses: 😢 (Sad), 😐 (Neutral), 😕 (Confused), 😊 (Satisfied), and (Excited). Students were prompted to select the emoji that aptly represented their feelings or experiences during different segments of the training. This deviation from the conventional Likert-scale response options aimed at capturing genuine, instantaneous feedback from the students. Additionally, the feedback forms included an open-ended segment, inviting pupils to visually articulate their takeaways from the training via drawings.

To comprehensively understand the impact of the Drone Education Program on the participants, feedback was garnered through pre- and post-surveys. These surveys were meticulously organized into specific sections:

Part A: Drone Operation Proficiency (Covering Questions A1-A8)
A1: I am able to take-off a drone.
A2: I am able to land a drone.
A3: I am able to hover a drone.
A4: I am able to change the altitude of a drone.
A5: I am able to let a drone to take right turn.
A6: I am able to let a drone to take left turn.
A7: I am able to capture image by using drone.
A8: I am able to record video by using drone.

Part B: Video Editing Skills (Encompassing Questions B9-B12)
B9: I am able to trim a video.
B10: I am able to add ‘slow motion’ effect onto a video.
B11: I am able to add text to a video.
B12: I am able to add sound to a video.

Part C: Photo Editing Skills (Involving Questions C13-C14)
C13: I am able to insert text to a photo.
C14: I am able to add photo collage effect.

Part D: Perceived Value and Impact of the Program (only post-survey)
D15: Drone Education Program is a valuable learning experience.
D16: It made me more interested in drone.

D17: It made me more interested in technological devices.
D18: It made me more interested in learning technology in schools.
D19: It made me more aware of careers related to technology.
D20: It made me more interested in a career related to technology.
D21: I am confident that I can learn technology in school.

Each section was meticulously crafted to gauge distinct aspects of the training, ensuring a comprehensive understanding of the Program's effectiveness and impact on students.

3.2 Descriptive Data

Our research involved an aggregate of 316 students drawn from 16 different schools located in 6 districts across Sarawak. The age of these students was ranged from as young as 5 years to as old as 16 years. This diverse group provided a holistic overview of the impact of our drone training program across various age groups and geographical settings in Sarawak. Figure 1 elucidates the geographical dispersion of participants, accentuating the expansive reach of our initiative throughout the region.

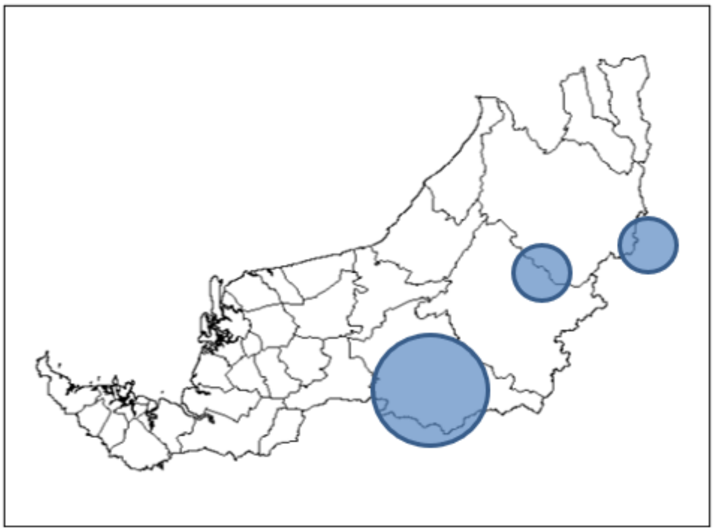

Fig. 1. Spatial distribution of schools across Sarawak

In contrast, Figure 2 delineates the distribution of gender and age among the students, portrayed via a stacked bar chart. Notably, a substantial proportion, exceeding 60% of the participants, belong to the 10-12 age bracket. The gender distribution within the sample revealed a predominance of female students, constituting approximately 60%, while males represented 40%.

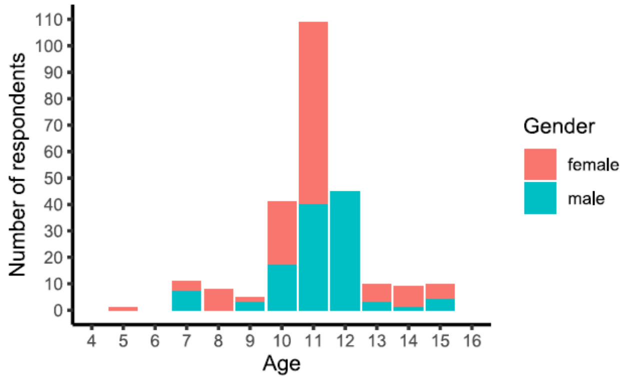

Fig. 2. Stacked bar chat of students' age and gender

4. Analytical Results

For discerning differences in students' experiences pre- and post-Program, we opted for the Wilcoxon sign rank test, a non-parametric approach tailored for Likert scale questions. Every score on the Likert scale manifested significant divergences between the pre- and post-questionnaires. This underscored a discernible evolution in students' perceptions or proficiencies post the Drone Education Program.

As presented in Table 1, items A8 (pertaining to drone video recording), B9 (concerning video trimming), B10 (related to the slow-motion video effect) and C14 (related to photo editing) marked the most pronounced disparities amongst all. Their corresponding V statistics were 481.0, 471.0, and 405.5, indicative of consequential changes.

Table 1
V Statistics for all survey questions

Question	V Statistics	Question	V Statistics
A1	94.0	A8	481.0
A2	198.5	B9	471.0
A3	213.5	B10	405.5
A4	395.5	B11	111.5
A5	254.5	B12	85.0
A6	279.5	C13	56.0
A7	276.0	C14	540.0

In term of survey cohesiveness, the measure of internal consistency, Cronbach's alpha, for the ordinal data was estimated at α=0.95±0.03. This elevated value infers robust inter-item correlation. However, it's worth noting that correlations are comparatively lower for items in Section D, specifically from D17 to D21, when juxtaposed against items in Sections A and B, as shown in Figure 3 below. On the other hand, The Kaiser-Mayer-Okin (KMO) measure sampling adequacy stood at 0.88, corroborating that factor analysis was aptly suited for our dataset.

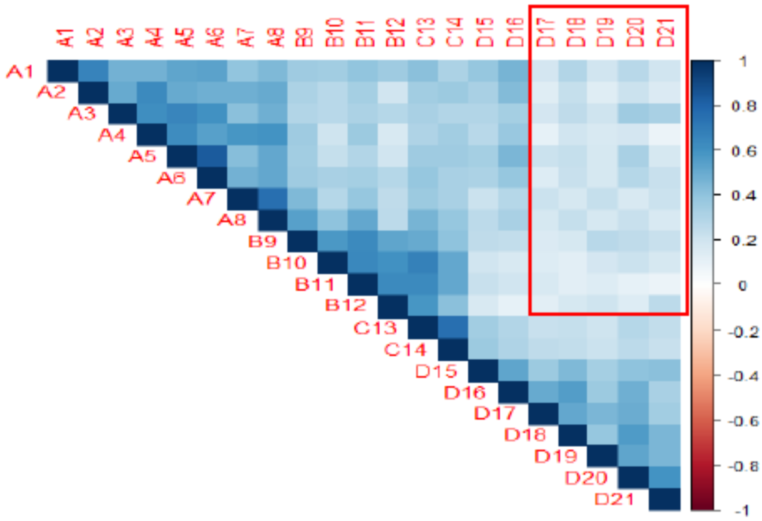

Fig. 3. Correlation plot for all Likert items

To further on the analysis, both the Scree plot (as Figure 4) and parallel analysis championed the extraction of a quintet of principal factors. Followed by the Exploratory Factor Analysis (EFA) efficiently distilled the 21 Likert items into these factor clusters:

i. *Group 1:* Video and Photo Editing
ii. *Group 2:* STEM Education and Career Interest
iii. *Group 3:* Basic Drone Operation
iv. *Group 4:* Advanced Drone Operation
v. *Group 5:* Drone Launch & Land

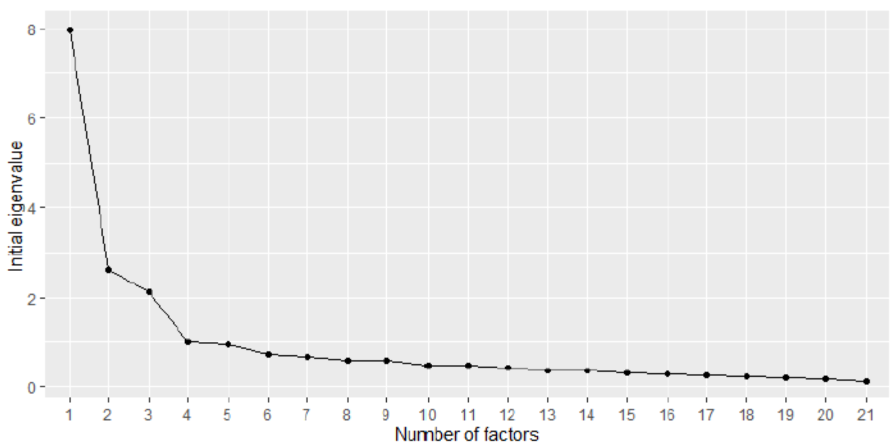

Fig. 4. Scree plot based in correlation matrix

Analysis of Variance (ANOVA) also being conducted to facilitate an evaluation of score fluctuations contingent on parameters like school nature, locational urban-rural dichotomy, gender, and district affiliation. Table 2 presented that the district emerged as a pivotal determinant, corroborated by its significant values. This accentuated the role of district origin in shaping students' cumulative scores. Gender, too, emerged as consequential, underlining its capacity to mould students' post-Program perceptions and competencies.

Table 2
ANOVA analysis on school, urban-rural, gender & district

Grouping	Sum_ABC	Sum_A1A2	Sum_A3A6	Sum_A7A8	Sum_BC	Sum_D
School_type	0.134778	0.03165*	0.119549	0.5428	0.09051	0.892862
Type (Urban vs Rural)	0.556095	0.30580	0.30580	0.8832	0.22695	0.071091
Gender	0.017141*	0.03069*	0.03069*	0.2451	0.02364*	0.242863
District	0.002528**	0.02107*	0.02107*	0.0411*	0.04102*	0.003685**

To comprehend the multilayered impacts of diverse parameters on student scores, linear mixed-effect modelling was instituted. District-centric Variations, the level-2 variance attributable to the district stood at 8.971, suggesting its pronounced influence over student scores. On the other hand, gender-centric level-2 variance of 2.098, also emerged more impactful, albeit to a lesser extent than the district, in modulating student scores.

5. Discussion

The essence of our investigation into the Drone Education Program in Sarawak has been to understand its impact on students' technological competencies and their interest towards STEM fields. The results obtained unveil a rich tapestry of outcomes, some expected and others more surprising, shedding light on the effectiveness of technological interventions in Education paradigms.

i. *Enhanced drone operational skills and technological competencies*: Our evidence suggests that hands-on drone training significantly bolsters operational skills, which parallels the broader educational understanding that emphasizes hands-on experiences in skill development [16]. However, our observation of students gaining proficiency in specific drone video techniques, like trimming and applying slow-motion effects, stands out. While experiential learning is a widely acknowledged pedagogical tool, our focus on drones as an instrument for this kind of engagement presents a novel contribution to tech-STEM education.
ii. *The nexus of multimedia editing and STEM Interest*: Broadly, tech-STEM research recognizes the value of technology-enhanced learning in spiking STEM interest [17,18]. Our study, however, goes further by pinpointing the direct relationship between multimedia editing skills and heightened STEM enthusiasm. This precise correlation, while embedded within a broader theme, is a unique insight our research offers.
iii. *Implications of socio-demographic factors*: The mosaic nature of educational outcomes based on districts and gender resonates with wider educational studies that consider local contexts crucial [19]. Yet, our specific observations on the variance in outcomes from the Drone Education Program—especially the pronounced differences tied to district and gender—bring fresh nuances to this discussion, emphasizing the uniqueness of each educational landscape even within tech-STEM.
iv. *The broader landscape, multilevel influences and their implications*: Studies on multilevel educational influences have traditionally emphasized a myriad of factors, from socio-economic to pedagogical [20]. Our findings underscore the pronounced influence of districts—perhaps more than gender. This shift in focus to district-specific determinants as primary influencers is a deviation from some traditional views and beckons deeper explorations in this direction.

6. Conclusions

The research into Sarawak's Drone Education Program encompassed 316 students from 16 diverse schools across six sub-districts, unveiling its profound educational potential and transformative impact. Spanning a broad age range from 5 to 16 years, the findings emphasize the program's effectiveness in instilling technical skills and altering perceptions regarding drone operations and multimedia editing. The consistent benefits noted across diverse age groups and regions validate the program's strength and reliability, in line with the research goal of determining its extensive impact. An innovative facet of the methodology was the emoji-centric feedback mechanism, tailored to resonate with younger participants and ensure genuine, engaged responses. Detailed statistical analyses further delineated significant variations attributed to district-based determinants and gender. Such insights indicate that while the program boasts marked success, forthcoming educational strategies might gain from a more localized approach, tailoring interventions to align with specific community needs and contexts. Overall, the combination of descriptive data and nuanced analysis stands as a testament to the program's efficacy, suggesting a promising blueprint for subsequent educational initiatives in the area.

Acknowledgement
This research was funded by Universiti Malaysia Sarawak and Malaysia Digital Economy Corporation.

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