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Using Drones to Attract K-12 Students Towards Construction: A Pilot Study of Middle School Students' attitudes, Perceptions, and Interests

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Drones continue to support the growth of the construction industry; however, activities that use drones for K-12 education are still minimal and exploratory. Particularly, no studies have explored the use of drone technologies to attract students towards construction disciplines. The contribution of this study centers on better understanding how drones can be relied upon to create interest and motivation in K-12 students by showcasing the construction domain to the next generation of the workforce. This study investigated the attitudes and interests towards construction of eleven middle school students enrolled in a Summer Youth Camp at the Michigan Technological University. During this study, a construction-centric drone education activity was designed and implemented during a 3-hour long session within a large lab space. Students completed an adapted version of the S-STEM Survey before and after participating in the activity. Although differences in the survey scores for attitudes towards STEM subjects and interests in construction careers were noticed, no significant changes were observed by the educational activity. Ultimately, this study recommends the use of drones in K-12 activities and purposes exploring how students can be attracted to the construction disciplines as future research.

Key Words: Construction Drones, K-12 Education, Attitudes, Interests, Career Pathways

Introduction

Construction is one of the largest adopters of drones for commercial tasks (DroneDeploy, 2018). This increased drone usage in construction has been linked to the aerial robots' capability to access unreachable or unsafe areas and perform tasks safely and time-efficiently (Albeaino & Gheisari, 2021). Even though technological advances such as drones are helping construction grow as an industry, reports continuously show problems with workforce labor shortages (Olsen et al., 2012). These workforce shortages are the result of older professionals leaving the industry once they reach

retirement age and a low influx of new professionals (Suryadi, 2018). Researchers indicate that there are large difficulties to engage and retain new students in the construction disciplines (Bigelow et al., 2018). Some studies report that there are negative perceptions (e.g., physically demanding, limited career progression, unsafe) of the construction industry, with over 70% of parents indicating that they would not advise their children to pursue construction careers (NCCER, 2020). Other researchers point to the lack of representation of women, minorities, and persons with disabilities in a largely white, male-dominated industry sector (Manesh et al., 2020) and that students simply do not get sufficient exposure to the industry in terms of career exploration, work experiences, or field trips (Bigelow et al., 2018).

Drones and robotics in the education domain have been used effectively to engage students and foster interest in STEM careers. Middle school students are often the focus of these investigations within the context of drone and robotics activities, as research has shown that students at this age-range start to develop interests in STEM and begin to consider career aspirations (Almeda & Baker, 2020). To engage middle school students, drone and robotics education leverages extracurricular events such as competitions, workshops, and after-school programs (Ribeiro & Lopes, 2020). These events have been successfully implemented in a limited number of STEM disciplines (e.g., computer science, mathematics) to increase motivation and engagement (Chou, 2018; Bartholomew & Mayo, 2018) as well as self-efficacy and interest (Tezza et al., 2020).

To address the growing need to engage a new generation of construction professionals, the goal of this study is to explore the utilization of drones to attract middle school students towards considering construction as a career path. A pilot intervention was designed and implemented using construction-centric contents and drones to achieve this goal. Middle school students' attitudes, perceptions, and interests towards construction were captured before and after a pilot educational intervention. The contribution of this study centers on better understanding how drones can be used to create interest and motivation in K-12 students by showcasing the construction domain to the next generation of the workforce.

Background

Drones – also known as unmanned aerial vehicles (UAVs) or unmanned aerial systems (UASs) – are defined as remotely piloted aerial robotic platforms equipped with several onboard sensors (Albeaino & Gheisari, 2021). In the construction domain, drones are being used in different phases, from pre-construction (e.g., site planning, site mapping and surveying), construction (building inspection, safety management), to post-construction (building maintenance, post-disaster reconnaissance) (Albeaino & Gheisari, 2021). These type of drone applications in construction have been recognized to save time, improve accessibility to compromised spaces, and reduce the cost of construction tasks (Gheisari & Esmaeili, 2019).

In the educational domain, drones have been found to promote engagement, motivation, and interests through the use of active, hands-on experiences (Sattar et al., 2017). Literature has identified that drones can help students to transform abstract concepts into concrete learning (Tezza et al., 2020), develop technical knowledge and skills (Chou, 2018), and acquire positive attitudes towards STEM disciplines (Yousuf et al., 2019). Existing drone-based curricula designs provide opportunities to understand the concepts of drones, use drones to accomplish some tasks (e.g., drone building, flying, collecting data, programming), and conclude by reflecting on the acquired knowledge (Chou, 2018; Bartholomew & Mayo, 2018; Tezza et al., 2020). To implement these curricula, researchers and educators have utilized tangible drone hardware in combination with software tools for student experimentation in laboratory or classroom environments (Khan, 2018; Chun, 2021).

Activities that use drones in the construction education domain are still minimal and exploratory. Most existing activities in construction drones are mainly focused on higher education settings, teaching college and university students drone regulations, flight operations, data collection, and data processing (Eiris et al., 2018; Williamson III & Gage, 2019; Albeaino et al., 2022). Drone activities in disciplines such as computer sciences, Mathematics, and aviation are situated within the context. For example, computer sciences can do drone programming, Mathematics can do problem solving, and Aviation can do drone flying. However, we have many constraints in construction due to legal and safety concerns. Drone flights introduce liability and legal concerns, ranging from personal injury and property damage caused by drone operation errors, to issues such as invasion of privacy, trespassing, property rights, or insurance issues (Gheisari and Esmaeili 2019). Moreover, taking students to construction sites is inherently difficult, as construction remains one of the most dangerous industries.

Research Motivation and Scope

The construction industry is in great need for a new generation of construction professionals to join the workforce. Although, drones have been shown to have the capability to produce interest and engagement in K-12 students (Burack et al., 2019), there are no studies that investigate how to expose students to construction drones prior to their enrollment in higher education programs. This study discusses the design and implementation of a construction-centric drone K-12 educational activity to engage students at an early age. Particularly, middle school students were targeted, as students in this age range start to develop career interests (Almeda & Baker, 2020). A pilot pre-, post- experimental design was used to measure attitudes, perceptions, and interest metrics through a validated survey.

Research Methodology

Educational Context for Construction-Centric K-12 Drone Intervention

For this study, an educational activity for drones in construction was planned as part of a Summer Youth Program at the Michigan Technological University (MTU). The Summer Youth Program at MTU offers K-12 students' hands-on explorations of STEM disciplines within campus. Students enroll in a week-long program based on their preferences and the departmental offerings at MTU. Multiple activities occur each morning and afternoon of the program, guided by faculty, staff, and graduate students. The drone activity in this study was hosted within the "Building a Better World" program in partnership with the Civil, Environmental, and Geospatial Engineering Department at MTU. From the K-12 educational range, only students from 6^{th} to 9^{th} grade participated. This study took place in a three-hour, three-part module on the morning of the second day within the week-long program. The educational intervention was constrained and driven by this context and time module requirements. Following is a description of design and implementation of the activity for this pilot study.

Construction Educational Activity Design and Implementation

The education activity to expose K-12 students to construction disciplines was designed based on the existing STEM literature that recommends three major components: (1) providing an understanding of the drone concepts, (2) using drones to accomplish some tasks (e.g., drone building, flying, collecting data), and (3) offering a reflection activity from the acquired knowledge (Chou, 2018; Bartholomew & Mayo, 2018; Tezza et al., 2020). To achieve these components of previously successful K-12 drone STEM activities, three modules were designed as shown in Figure 1.

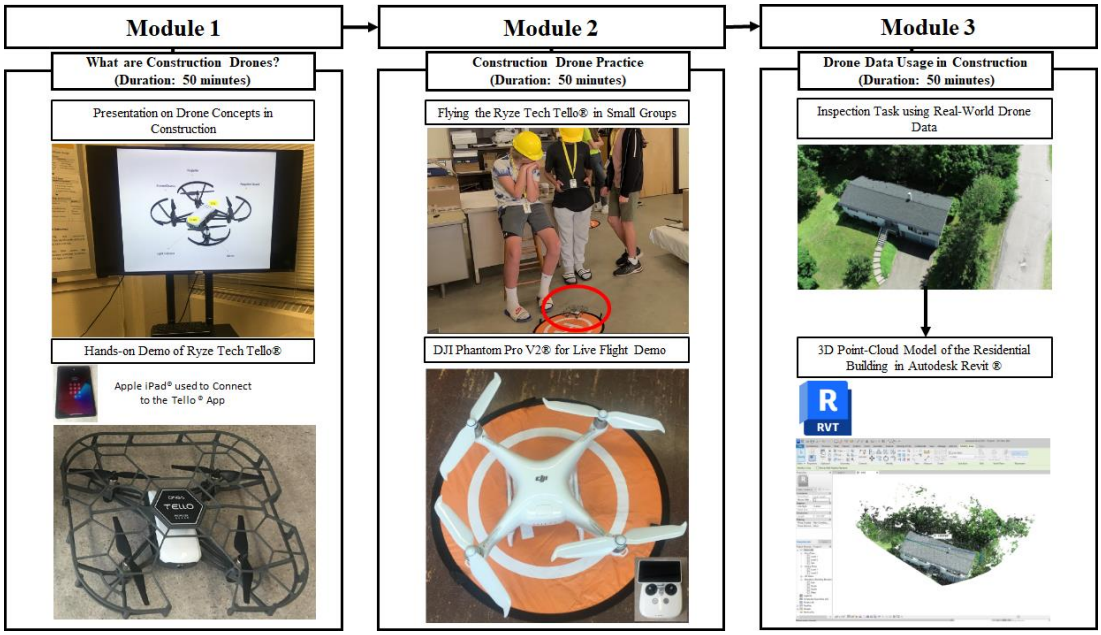

Figure 1. Construction Drones Educational Activity Design

Module 1 – What are Construction Drones? – This module focused on introducing construction drones to students. A discussion was provided regarding the different parts of drones (e.g., propellers, batteries, data capturing sensors), construction drone applications using multiple sensors (e.g., building inspection task, quantity takeoffs, energy monitoring), and drone flight safety requirements on construction sites. Additionally, an introductory description of the basic flight operations was delivered for students prior to practicing their drone flight skills.

Module 2 – Construction Drone Practice – This module enabled students to perform hands-on flight employing a Category 1 drone (less than 0.55 pounds; Ryze Tech Tello®) in an indoor lab environment. The flight task was inspired by construction building inspection tasks, requiring pilots to observe objects using an onboard camera sensor during a drone flight. Moreover, in this module, students learned about construction drone flight operations and applications through a live flight.

Module 3 – Drone Data Usage in Construction – This module offered students the opportunity to reflect on prior modules by using drone collected data. Through the use of Autodesk Revit®, students performed a building inspection task using a point-cloud model of a residential building. A discussion was held regarding the use of drones in construction through the data visualization task, elaborating on the dimensions necessary to add a garage to the house project.

The implementation of this construction drone educational activity was done after approval from the MTU Internal Review Board (IRB-1912793-2). Prior to the activity, parents and students provided informed consent through an established protocol. The duration of the activity and the data collection totaled 3 hours. Each module lasted for approximately 50 minutes and the data collection took 15 minutes before and after the drone activities. Before starting the construction drone educational activity, a demographic questionnaire, and an attitudes, perceptions, and interest survey were completed by the students. After completing the drone activity, the same attitudes, perceptions, and

interests survey was completed again. To make sure all operations were safe for the students, all flights were conducted with a drone less than 0.55 pounds (Category 1), with a safety cage blocking any exposed rotating parts that could lacerate human skin. Additionally, hardhats and safety glasses were required at all times. All activities were overseen by a Federal Aviation Administration (FAA) – Part 107 remote pilot certificate holder. The activity modules were held in an indoor, controlled laboratory space. Five Ryze Tello® drones and Tello® Propeller Guards were used for Module 2. Students were split into small teams of three, each using one drone battery that delivers 10 to 15 minutes of flight time. All students used the Tello® companion app in an Apple iPad® device to operate the drones.

Activity Evaluation and Metrics

To measure students' attitudes, perceptions, and interest towards construction, this study utilized a pre-, post-test experimental design. Students completed an adapted version of the Middle/High School (6^{th} – 12^{th}) Student Attitudes towards Science, Technology, Engineering, and Math (S-STEM) Survey (Unfried et al., 2015). This survey measures changes in student attitudes and perceptions in STEM subjects, and interests in STEM careers. Adapted version of the S-STEM survey was used in this study, consisting of 25 items divided into two sections. The first section of the survey had 18 items with a 5-point Likert scale measuring students' self-perception and attitudes towards STEM subjects across three dimensions – Math, Science, and Engineering. The Math dimension contained five questions that were rated between 1 = Strongly Disagree, and 5 = Strongly Agree. The Science dimension contained five questions that were rated between 1 = Strongly Disagree, and 5 = Strongly Agree. The Engineering dimension contained eight questions that were also rated between 1 = Strongly Disagree, and 5 = Strongly Agree. The survey questions used statements that revealed how the students perceive themselves in relation to Math, Science, and Engineering (e.g., I am good at math; I know I can do well in science; I am curious about how to construct things). The second section of the survey used a 4-point Likert scale used to measure participants' interests in STEM and construction careers. The survey question in this second section described potential careers (e.g., Energy, Computer Science, Construction) and students rated their interests using a scale between 1= Not at all interested, and 4 = Very interested. Each career name included its definition and short description of their work environment.

Results and Discussion

Demographics

A total of 14 middle school students participated in the construction drone activity during the Summer of 2022. From the 14 student participants, the data from 3 had to be discarded due to incomplete responses. The remaining 11 participants (2 females and 9 males) were considered for analysis in this study. In terms of participant demographics (Table 1), students ranged in age from 12 to 14 years, with a mean age of 13 years. The sample collected included students in grades 7^{th} through 9^{th}, with the majority (55%) being in 8^{th} grade. The majority of participants were male (82%), and a small portion female (18%). Most participants identified as White (73%), with a small percentage identifying as other races (27%) (Asian, Indian, and 1 Unspecified). A large percentage of the students reported to have used a drone more than once before (82%).

Table 1. Demographic information on Construction-Centric K-12 Drone Intervention participants

Participants	Categories	Number	Percentage
Sex	Male	9	82%

	Female	2	18%
Age	Years	12-14	13
	White	8	73%
Race	Other (e.g., Asian, Indian, and 1 Unspecified)	3	27%
	7th	2	18%
Grade	8th	6	55%
	9th	3	27%
	No, Never	1	9%
Have you ever used a drone before?	Only Once	1	9%
	A few times	9	82%

Attitudes and Interests

The data from pre- and post-test survey for the construction drone activity was analyzed with both descriptive and inferential statistics. Table 2 shows the results from this analysis. A lower mean score was obtained in the post-test attitudes and perception towards STEM subjects compared with the pre-test results for Math (pre = 4.61; post = 4.39; delta = 0.22), Science (pre = 4.11; post = 3.99; delta = 0.12), and Engineering (pre = 4.19; post = 4.11; delta = 0.08). The largest score differential observed was for Math (delta = 0.22) and the lowest overall score means were obtained for Science (pre = 4.11; post = 3.99). These attitudes and perception results for the Math and Science dimensions of the survey can be potentially attributed to the lack of student exposure in the construction drone activity to Math or Science topics as typically done in a middle classroom setting (e.g., algebra problems, reading assignments). Overall, both Math and Engineering scores were observed positive, with a mean score above 4 (Agree) on the Likert scale of pre- and post-test survey. For the test results on interests in STEM careers, it was found that the mean scores where high for all careers. It is important to highlight that the pre- and post-test results for interest in Engineering (pre = 2.73; post = 3.27; delta = 0.54) and Construction (pre = 2.91; post = 3.27; delta = 0.36) careers show the largest mean scores among all the survey careers (both pre and post-test). These career interest results could be explained by the fact that the designed construction drone activity offered direct exposure to the construction domain, while no exposure to the other careers in the survey was offered to the students.

The inferential statistical analysis was performed using a paired-samples t-test. This statistical analysis revealed that there were no significant differences in the attitudes and perceptions students regarding STEM subjects, or in the interest in STEM and Construction careers due to the construction drone activity. The lack of significant differences between pre-test and post-test could be explained by a small sample size. Although the construction drone activity data set only contained 11 students, the results of this study suggest that there might be positive relation between interest in STEM and Construction careers and the experiences offered by the construction drone activity.

Table 2. Adapted S-STEM Survey for Attitudes and Interests

Categories	**Pre-test**	**Post-test**	**P-value**
	Mean (SD)	**Mean (SD)**	
Attitudes towards STEM Subjects			
Math	4.61 (0.19)	4.39 (0.17)	0.23
Science	4.14 (0.16)	3.94 (0.09)	0.15
Engineering	4.19 (0.26)	4.11 (0.18)	0.48
Interests in STEM Careers			

Biology and Zoology	2.41 (0.10)	2.64 (0.11)	0.69
Mathematics	2.45 (0.11)	3.00 (0.11)	0.31
Computer Science	2.55 (0.10)	3.00 (0.08)	0.30
Chemistry	2.45 (0.08)	2.73 (0.09)	0.49
Energy	2.45 (0.10)	3.18 (0.07)	0.12
Engineering	2.73 (0.12)	3.27 (0.08)	0.14
Construction	2.91 (0.09)	3.27 (0.08)	0.37

Lessons Learned: Opportunities and Challenges

Opportunities: Throughout the construction drone activity, students displayed engagement and excitement. Module 2 – Construction Drone Practice, was observed to be the most engaging of the activities to the students. Additionally, students displayed excitement about construction drones through asking questions such as the drone costs, and taking pictures and videos while flying the drones in the lab space. These observations regarding the hands-on nature of drone activities match what prior studies have found in terms of drone effectiveness to attract students towards STEM disciplines (Chou, 2018; Bartholomew & Mayo, 2018). It was also found that the simplicity and accessibility of the Ryze Tello® drones enable the completion of the activities without major issues for the duration of the activity. These drones were easy to fly and students quickly learned how to employ the camera sensor to capture data within the lab space. Moreover, there was institutional and parental buy-in to perform this activity. MTU provided the funds needed to perform this study and all parents authorized their children to participate in the activity. It is particularly important to get parents' interest, as research shows that parental approval significantly influences student engagement and motivation in STEM (Bempechat & Shernoff, 2012).

Challenges: Despite the educational opportunities learned from this study, there were several challenges observed. Although the drones selected were suitable for this type of study, there were limitations in terms of flight time and network interference from multiple Ryze Tello® drones. During the “Module 2 – Construction Drone Practice”, several flight interruptions were experienced during the practice event. These interruptions occurred due to network issues with connection between the ground control station and the drones, producing sudden disconnections and loss of control of the drone. Another challenge faced by the researchers was the limited amount of time for the activity. The overall activities lasted for three hours in a single exposure. This limited amount of time reduced the ability of students to internalize the learned contents and constrained the design of the module to very simple topics in construction and drones. A more comprehensive curriculum with a longer exposure time (e.g., few days) is recommended to increase the effectiveness of such activities to engage, motivate, and attract students towards construction.

Research Limitations

In disciplines such as computer science, mathematics, and aviation, drone activities are situated within the context of their corresponding domains. For example, computer science students can get direct exposure to programming using drones, mathematics students can do problem solving, and aviation perform drone flights. However, construction disciplines students do not get direct exposure to jobsites due to legal and safety issues. These constraints can potentially contribute to lower impact on student engagement for construction in comparison to other disciplines. This study had several limitations related to the sample size, the limited exposure time, and the lack of exposure to real-world drone operations. First, the sample size was small and lacked diversity. The sample composition consisted of only 7th through 9th grade middle school students with most of the

participants (73%) being from one race (White). Additionally, the sample ratio of male-to-female was disbalanced, with a very small proportion of females (18%). Second, this study took place in a three-hour module on the second day of the week-long program. The educational activity was constrained and driven by this context and time each module required. Third, the drone activity design and implementation of this study was not situated in a real-world construction site. The lack of exposure to construction sites was due to safety concerns for flying drones by a large group of middle school students. This is a common limitation of educational studies in higher education (Eiris et al., 2018; Williamson III & Gage, 2019; Albeaino et al., 2022) that extends into this exploratory study.

Conclusion and Future Study

Although drones continue to support the growth of the construction industry, no studies have explored how to employ drone technologies to attract K-12 students towards construction disciplines. An experimental K-12 activity was designed to enhance students' attitudes and perceptions towards construction, as well as to provide a method to foster interest in construction domain careers. The created K-12 educational activity was piloted with eleven middle school students, introducing them to construction drones, allowing them to perform hands-on flight operations, and offering them opportunities to reflect on drone-collected data through the use of point-clouds. Data was collected from the middle school students before and after exposing them to the construction drone activity through the use of an adapted version of the S-STEM Survey (Unfried et al., 2015). The S-STEM survey measured changes in attitudes, perceptions, and interest regarding STEM and construction. The results obtained from the pilot study showed mean score differences in attitudes and perceptions towards STEM, and interests in construction careers. However, these results did not show statistically significant differences, mainly due to the small study sample size.

We concur with previous researchers that drones can be effective in attracting students towards construction as it has worked in other disciplines (Bartholomew & Mayo, 2018; Khan, 2018; Yousuf et al, 2019; Tezza et al, 2020). Our results provide hints that drones might enable to engage students in construction. However, further research is necessary to definitively answer this question. Future studies exploring the attraction of K-12 students to construction disciplines should adapt the design provided in this study for a larger cohort of participants. By collecting a larger sample with more robust gender and racial/ethnic diversity, researchers would be able to understand what aspects of drones and construction attract different types of students to construction. Furthermore, there is a need to understand how exposure to real-world drones, actual construction sites, and practicing construction professionals might enhance the design of the presented activity. Finally, other variables such as knowledge, engagement and motivation, and self-efficacy should be explored to better understand the mechanism that changes in students' attitudes, perceptions, and interests towards construction.

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