www.ijres.net

iDrone Online Camp: Enhancing Middle and High School Students' STEM Affinity and their STEM Career Aspiration

Jiyoon Yoon
University of Texas Arlington, U.S.A.

Jae Hyeon Ryu
University of Idaho Boise, U.S.A.

To cite this article:

Yoon, J. & Ryu, J.H. (2025). iDrone online camp: Enhancing middle and high school students' STEM affinity and their STEM career aspiration. *International Journal of Research in Education and Science (IJRES), 11*(1), 150-165. https://doi.org/10.46328/ijres.3548

IJRES International Journal of Research in Education and Science
2025, Vol. 11, No. 1, 150-165 https://doi.org/10.46328/ijres.3548

iDrone Online Camp: Enhancing Middle and High School Students' STEM Affinity and their STEM Career Aspiration

Jiyoon Yoon, Jae Hyeon Ryu

Article Info

Article History

Received:
15 July 2024
Accepted:
22 December 2024

Keywords

iDrone online camp
STEM education
STEM affinities

Abstract

The iDrone Online Camp aims to enhance middle and high school students' engagement in STEM fields through hands-on experiences with drone technology. By immersing participants in project-based learning activities, competitions, and discussions on FAA part 107 regulations, the camp seeks to cultivate critical thinking, problem-solving skills, and teamwork abilities. Through a mixed-methods evaluation approach, the study assesses the impact of the camp on students' attitudes, interests, and self-efficacy in STEM. Findings reveal that the camp positively influences participants' STEM affinities and career aspirations, highlighting the importance of experiential learning in fostering a passion for STEM disciplines. Recommendations for future improvements and research directions are discussed to sustain students' interest and engagement in STEM education.

Introduction

As technology continues to advance, the importance of STEM (Science, Technology, Engineering, and Mathematics) education becomes increasingly evident (Becker & Park, 2011). In this digital age, drones have emerged as a versatile tool with applications ranging from aerial photography to disaster response (Custer, 2016). The integration of drones into K-12 educational settings presents a unique opportunity to engage students with practical, hands-on learning experiences that can enhance their interest and skills in STEM fields (Janke et al., 2022).

Recognizing the potential of drones to captivate and educate students, drone camps have been established to provide immersive learning environments where middle and high school students can explore STEM concepts through the construction, programming, and operation of drones (Yepes et al., 2022; Ryu et al., 2021; Ryu et al., 2020). These camps aim to not only teach technical skills but also foster critical thinking, problem-solving, and teamwork (Amanda et al., 2023).

Despite the growing popularity of such camps, there is a need for empirical research to understand their long-term impact on students' STEM affinities and career aspirations (Yoon & Ryu, 2024). This study aims to fill this gap by investigating the effects of participating in a drone camp known as the interstate drone league (iDrone) targeting to middle and high school students. Specifically, the research will examine changes in students' interest, self-

efficacy, and engagement in STEM activities, as well as their perceptions of and aspirations towards careers in STEM fields (Chen et al., 2024).

By providing insights into how hands-on drone activities can influence students' attitudes towards STEM, this research aims to contribute to the development of more effective educational programs that can sustain and enhance students' interest in these critical fields. The findings will be valuable for educators, policymakers, and program developers who seek to leverage innovative tools and methods to inspire the next generation of STEM professionals (National Research Council, 2012).

Literature Review

This research on iDrone camp aligns with and build upon existing literature that emphasizes the benefits of hands-on, experimental learning in STEM education, especially enhancing students' STEM affinities and their careers in STEM areas.

STEM Affinities

STEM apprenticeship programs enhance students' understanding of the nature of science and scientific inquiry, which can lead to increased interest in STEM careers (Chen, et al., 2024). These programs provide students with practical experiences that deepen their comprehension of scientific principles and methods, thereby fostering a stronger connection to STEM fields (Yoon & Ryu, 2024). Similarly, the hands-on experiences provided by iDrone camps help cultivate a new generation of STEM-literate individuals. By engaging students in the construction, programming, and operation of drones, these camps equip them with the skills and confidence needed to pursue careers in emerging fields (Yepes et al., 2022). Through such immersive learning environments, students develop both technical expertise and a genuine interest in STEM disciplines, setting the stage for future career opportunities (Tai, et al., 2006).

Hands-On Learning and Engagement

Chou and Chan (2015) discuss the positive impact of interactive learning environments on student performance in STEM education, highlighting how such environments can significantly boost student engagement and achievement. Recent research further supports these findings by demonstrating that interactive and hands-on learning experiences, like those offered by iDrone camps, contribute to enhanced student outcomes in STEM fields (Janke, et al., 2022). These camps focus on building and coding drones, working as a team collaboratively, and receiving mentorship, all of which align with the principles of interactive learning environments that Chou and Chan emphasize.

Such activities not only make learning more engaging but also improve students' self-efficacy and interest in STEM subjects (Maltese, et al., 2011; Yoon & Ryu, 2024). By immersing students in practical applications of STEM concepts and fostering a supportive learning community, iDrone camps help to cultivate a deeper

commitment to STEM careers and skills development by meeting modern industries requirements.

Problem-Solving and Critical Thinking

The study by Bell et al. (2003) underscores the development of critical thinking and perseverance through addressing technical challenges in STEM education. This research highlights how engaging with complex problems can enhance students' ability to think critically and persist in the face of difficulties. Similarly, iDrone camps provide a platform where students confront technical challenges related to building and programming drones from scratch. These camps engage students in problem-solving, resourcefulness, and teamwork, thereby teaching them specific STEM concepts and fostering broader skills such as critical thinking and perseverance (Custers, 2016; Chou & Chan, 2015). By immersing students in hands-on activities that require creative problem-solving and collaboration among peers, iDrone camps help develop these essential skills, aligning with the findings of Bell et al. and contributing to a more robust STEM education experience (Yoon & Ryu, 2024).

Collaboration and Teamwork

Recent studies, such as Faif Pasani and Amelia (2023), emphasize the importance of collaboration in STEM education, highlighting how working together on projects enhances learning and problem-solving skills. The social aspect of iDrone camps, which facilitates peer connections and teamwork, aligns with these findings. By creating opportunities for students to collaborate on building and programming drones, iDrone camps not only make the learning experience more enjoyable but also underscore the significance of teamwork in STEM projects (e.g., functional drones for people with disabilities, AI-enabled drones for cleaning ocean pollutants, and Cloud seeding drones to combat severe drought). These collaborative interactions help students develop essential skills for working effectively in team environments, preparing them for future STEM-related endeavors (Yoon & Ryu, 2024).

Research Questions

Research studies on STEM education have highlighted the significance of hands-on, experiential learning in fostering students' interest and proficiency in STEM careers. iDrone camps offer a unique platform for engaging students in interdisciplinary learning, combining principles of physics, mathematics, engineering, and technology. Furthermore, studies have shown that exposure to STEM activities such as iDrone camps at a young age can positively influence students' critical thinking and attitudes towards STEM careers (Ryu et al., 2021; Ryu et al., 2020). Overall, the literature suggests that iDrone camps provide a valuable educational experience by combining interactive learning, critical thinking, and collaboration. These elements contribute to a deeper engagement with STEM concepts and help prepare students for future challenges in STEM careers. This study proceeded with the following research questions:

Research Question 1. How do iDrone camps influence middle and high school students' affinities for STEM fields and their aspirations for STEM careers?

Research Question 2. In what ways do the technical challenges and problem-solving activities in

iDrone camps contribute to the development of students' critical thinking and perseverance?
Research Question 3. What role does the social aspect of iDrone camps, including peer connections and teamwork, play in enhancing students' enjoyment and effectiveness in STEM learning?

Methods

Participants

The study involved 88 middle and high school students, aged 12 to 18, who attended an online iDrone camp during the spring of 2024. The camp lasted for 4 days, with sessions held for 4 hours each day. The participants were drawn from a diverse range of locations across the United States, including major cities and states such as Washington D.C., Texas, California, Illinois, Minnesota, New York, Washington, Ohio, Florida, and Oregon. This national representation provided a broad perspective on the impact of the iDrone camp and ensured a varied sample in terms of geographic and educational backgrounds. By including students from different regions, the study aimed to capture a wide range of experiences and insights regarding the camp's effectiveness in fostering STEM interest and career aspirations.

Procedure

Pre- and post-camp surveys were administered to assess students' affinities in STEM, their knowledge & skills in drone technology, and career aspirations in STEM fields. Additionally, qualitative interviews were conducted with a subset of participants to gather in-depth insights into their experiences at the iDrone camp.

The iDrone curriculum module (ICM) consists of nine sub-modules. In Module 1, participants were introduced to their groups and took pre-surveys to gauge their initial knowledge and expectations. Module 2, Drone Building, involved learning how to control motors and calibrate drones, with participants building their group drones from scratch using provided parts and tools. In Module 3, Drone Coding with Arduino Sketch IDE, they set up their group drones for coding exercises and were introduced to coding drones using the Arduino Sketch IDE. The participants were introduced to the Arduino Sketch IDE, a user-friendly platform for writing and uploading code to Arduino-compatible microcontrollers. The IDE provides a straightforward environment for beginners to start coding while offering advanced features for more experienced users. With the IDE installed, students engaged in a series of coding exercises. These exercises began with basic programming concepts such as writing simple commands to control drone movements (e.g., take-off, landing, hovering). As students progressed, they tackled more complex tasks, including programming the drones to follow specific flight patterns, respond to sensor inputs, and execute autonomous missions. Figure 1 shows the coding session with the participants.

Module 4, Drone Coding with MIT Scratch, allowed participants to practice drone coding using MIT Scratch, a more visual and beginner-friendly coding environment. In Module 5, Mission Plan, each group developed projects using their built and coded drones, planning mission objectives and tasks. Module 6, Poster Session, provided an opportunity for groups to share their projects through posters, presenting their mission plans, coding, and drone builds to peers and instructors (see Figure 2).

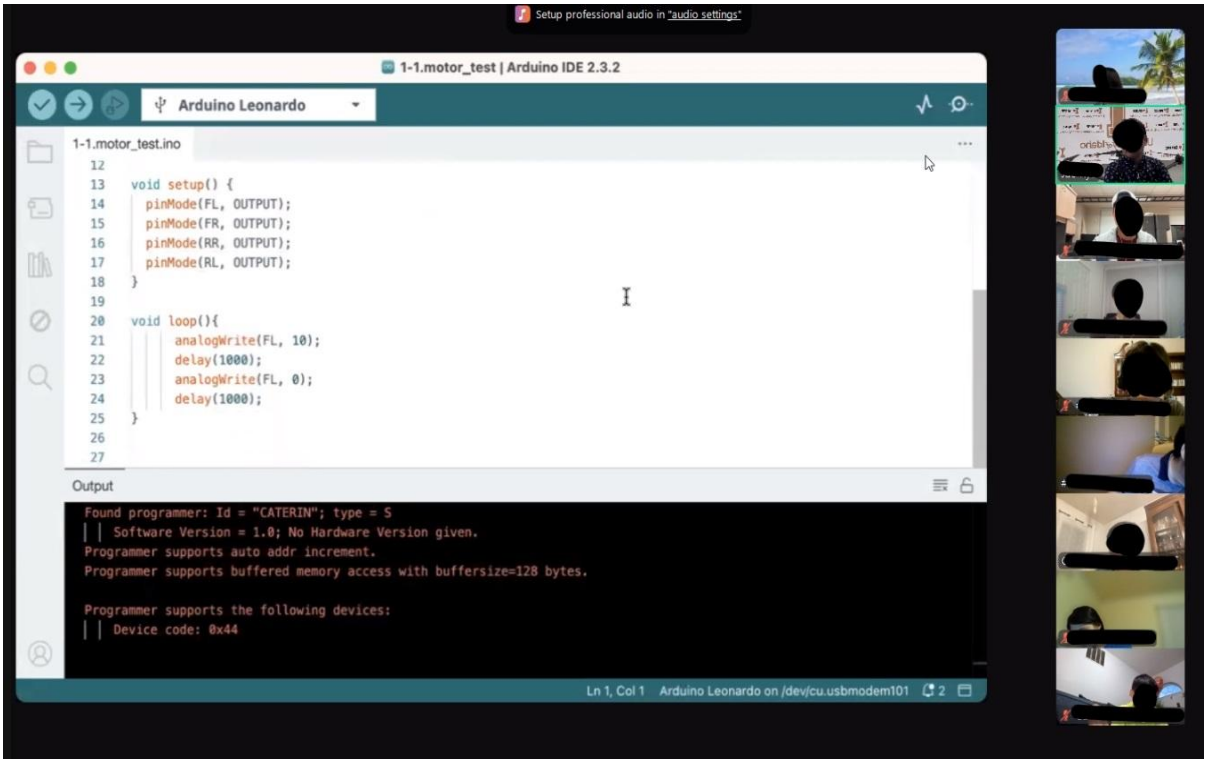

Figure 1. Session for Coding with Arduino Sketch IDE

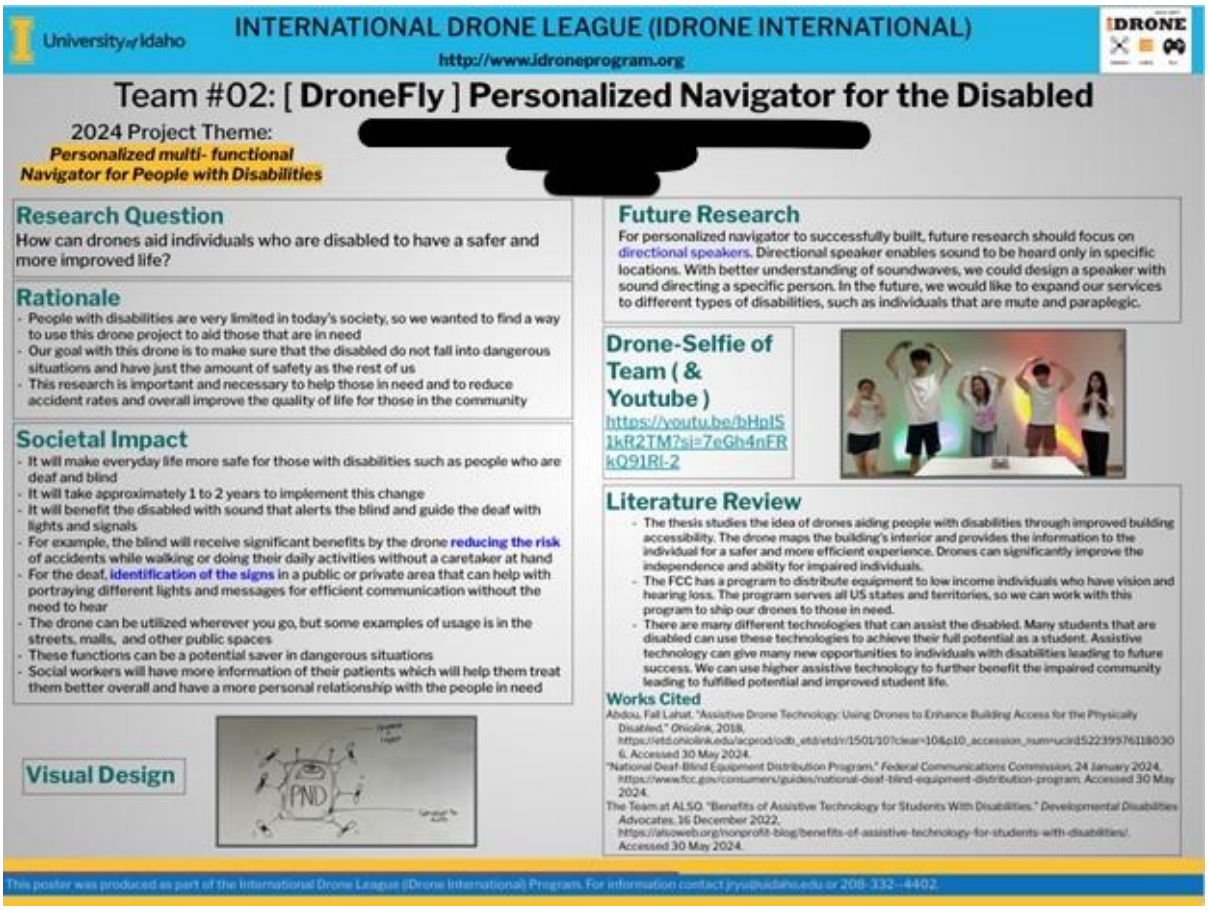

Figure 2. A group poster for the Poster session

Each group created posters outlining their drone mission plans. These plans detailed the objectives of their drone projects, such as specific tasks their drones were designed to perform or particular flight patterns they aimed to achieve. By presenting these plans, students demonstrated their understanding of project planning and the practical applications of drone technology. During the poster session, groups presented their posters to their peers and instructors. This interaction facilitated valuable feedback, with peers asking questions and offering suggestions, while instructors provided professional insights and guidance. This feedback loop was essential for enhancing the students' understanding and improving their projects.

Module 7, Competition, saw groups participate in a competition where they demonstrated their drone projects and mission plans. In Module 8, FAA Part 107, participants learned about FAA Part 107 regulations and their application to drone operations. Finally, in Module 9, Discussion and Post-CAMP Survey, participants engaged in a discussion reflecting on what was learned and experienced throughout the camp and took post-camp surveys to assess the knowledge gained and overall camp experience. Table 1 shows the iDrone camp schedule.

Table 1. iDrone Camp Schedule

Module	**Topic**	**Details**
1	Preliminaries	Introduce groups & Take pre-survey
2	Drone Building	Learn how to control motors and calibrate drone by building group drones from scratch using parts and tools.
3	Drone Coding with Arduino Sketch IDE	Set up group drones for coding exercise.
4	Drone Coding with MIT Scratch	Learn Drone coding using MIT scratch.
5	Mission Plan	Develop group projects with their drones.
6	Poster Session	Share their projects through posters.
7	Competition	Demonstrate their drone projects and mission plans
8	FAA Part 107	Learn about FAA Part 107 regulations and their application to drone operations.
9	Discussion and Post-CAMP Survey	Discuss reflecting on what was learned and experienced throughout the camp and take post-camp surveys

Data Analysis

To evaluate the impact of the iDrone camp, the study team used a mixed-methods approach, including quantitative surveys and qualitative coding of narrative reflections and their instructional artifacts. These evaluations measured changes in participants' attitudes and self-concept for STEM, providing valuable data for refining the program and enhancing its effectiveness.Quantitative data were collected through pre- and post-camp surveys (see Appendix) designed to assess participants' attitudes, interests, and self-efficacy in STEM. These surveys included 28 questions using a 5-point Likert scale, ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). The survey tools measured various dimensions of STEM engagement, including STEM Identity, Self-concept, Value,

Personal Interest, and Attitudes, to evaluate the effectiveness of the educational initiative (Fouad & Santana, 2017). Descriptive statistics and paired-sample t-tests were used to analyze the survey data, examining changes in STEM affinities before and after the camp. The STEM Affinity Test demonstrated high reliability, with Cronbach's alpha coefficients typically above 0.80, indicating consistent and dependable measurement of participants' STEM-related attitudes and self-concept.

Qualitative data from interviews were thematically analyzed to identify recurring patterns and themes related to students' perceptions of the iDrone camp's impact on their STEM interests and career aspirations. The participants shared their insights about their experiences from the iDrone camp through the interview. During the interviews, students answered five reflection questions designed to explore various aspects of their experiences:

Question 1. *Your STEM Affinities (Interest, Self-Efficacy, Attitudes, & Identity):* Can you describe your overall experience participating in the iDrone Camp initiative?

Question 2. *Challenging Problem Encountered:* Can you describe a challenging problem you faced during the iDrone Camp and how you solved it using STEM concepts?

Question 3**.** *Future Careers in STEM Fields:* How has the iDrone Camp initiative influenced your perception of potential careers in STEM?

Question 4. *Understanding the Connection Between STEM Education and Career Options:* How did the iDrone Camp help you better understand the connection between STEM education and potential career options?

By integrating both quantitative and qualitative data, this evaluation provided a comprehensive assessment of the iDrone camp's impact on participants, guiding future improvements and supporting the ongoing development of the program.

Results

STEM Affinity

The STEM affinity is primarily composed of five subcomponents: STEM identity, personal interest in STEM, self-concept of ability in STEM, STEM values, and attitudes toward STEM. The impact of the iDrone program on students' STEM affinity is presented in Table 2. The findings indicate there was no significant increase in students' STEM affinities after participating in the iDrone camp. It can be observed that the mean scores in most subcomponents of STEM affinity did not have statistically significantly improved.

Table 2. Results of Students' STEM affinity

Categories			Mean	SD	t	p
STEM Affinity	STEM identity	pre	3.91	0.49	2.11	.13
		post	3.65	0.60		
	Self-concept	pre	3.96	0.13	0.74	.53
		post	3.89	0.11		
	Value	pre	4.54	0.17	2.98	.09
		post	4.11	0.22		

Categories			Mean	SD	t	p
	Personal interest	pre	4.11	0.15	2.30	.07
		post	3.89	0.29		
	Attitudes	pre	3.86	0.50	5.88	.000
		post	3.58	0.53		

For *STEM identity*, the mean scores slightly decreased from before the camp to after the camp, indicating a small reduction in how strongly students identified with STEM. However, this change was not statistically significant, as reflected by the p-value.In the category of *self-concept*, which measures students' perception of their abilities in STEM, there was a minor decrease in the mean scores post-camp. This decrease was also not statistically significant, suggesting that students' self-perception of their STEM abilities remained relatively stable.

When examining ***value***, which assesses how much students value STEM education and its importance, there was a notable decrease in the mean scores from pre-camp to post-camp. Although this decline approached statistical significance, it did not reach the conventional threshold, indicating a trend that may warrant further investigation. *Personal interest* in STEM also showed a decrease in mean scores after the camp, suggesting a decline in students' enthusiasm and interest in STEM subjects. This change was close to being statistically significant, hinting at a potential shift in students' personal engagement with STEM.

Lastly, in the category of *attitudes***,** which measures overall positive or negative feelings towards STEM, there was a significant decrease in mean scores post-camp. This change was statistically significant, indicating that students' attitudes towards STEM became less positive after attending the camp. This decrease was revealed through the interviews, which highlighted the challenges students faced during the camp. The interview results provided insights into the reasons behind this decrease in attitudes. Overall, the results suggest a trend of declining scores across all categories of STEM affinity post-camp, with a particularly notable and statistically significant decrease in students' attitudes towards STEM.

Interview

However, qualitative analysis revealed themes such as increased confidence in problem-solving, heightened interest in STEM fields, and a greater awareness of career opportunities in technology-related industries after they participated in the iDrone camp. Students enjoyed building and coding the drones, appreciating the hands-on experience and the guidance provided by mentors. They found the coding aspect particularly interesting and engaging. Many students expressed a desire for more time to work on their projects and pitches, suggesting that an extended duration could enhance their learning and overall experience. The camp facilitated positive social interactions, with students noting that they enjoyed connecting with their peers and working as a team. Students also reported an increased understanding and comfort with STEM concepts, particularly in relation to drones and coding. They felt that the camp provided a valuable opportunity to engage with STEM in a practical and interactive manner:

It was fun building the drone, and I appreciated the time to work in it with the guidance from the mentors. It was also very interpreting to code the drone and to play with different commands.

I had a good time but I wish we had more time to work on our pitch and also on our drones. I feel like we should've had more time overall. I had a nice time connecting with my peers and had a fun time overall.

It was fun and interesting. I learned more about drones and coding.

The iDrone Camp overall was good, with a great instructor and great people to work with.

I had a valuable opportunity to learn about STEM and drones. Before I took the camp, I didn't really get a chance to get active in STEM and learn about the programs. However, after taking this camp, I feel comfortable interacting in STEM and talk about drones. I had a fun time learning coding and teamwork! Overall, I enjoyed the camp alot and I think it would help me later in life.

I think it thought be a lot about how Arduino works and the design of a drone. It taught me how to problem solve and how to use what you have to make things work. I think the instructors were very clear and helpful.

pretty fun, some slow parts but generally informative and good

it was fun and l learned a lot

Very fun and interesting. I learned a lot.

During the iDrone camp, students faced several challenging problems that likely contributed to a decrease in their overall attitudes by the end of the program. These challenges included technical issues with Arduino, broken motors, and connectivity problems with the coding app. Students had to employ various problem-solving skills to address these issues. For instance, they changed variables one at a time to isolate problems, switched cords to check for faulty connections, and used observation and trial-and-error methods to resolve technical difficulties. Despite these efforts, some problems remained unresolved, which could have led to frustration and a sense of inadequacy among students.

Moreover, developing ideas for the poster presentations was another significant challenge. Some students found it difficult to conceptualize and organize their project information effectively. To overcome this, they had to work together, engaging in collective problem-solving and emphasizing the importance of teamwork. This collaborative effort, while beneficial, also highlighted the complexity of the tasks at hand and the limitations of their current skills, possibly leading to a feeling of being overwhelmed. The persistence required to tackle these ongoing challenges, coupled with the pressure to perform and present their work, may have contributed to a temporary decline in their attitudes towards STEM activities. According to Schunk and Pajares (2005), self-efficacy can be adversely affected when students encounter repeated difficulties, particularly if they perceive these challenges as insurmountable. Additionally, Bandura (1997) suggests that the perception of failure, even in a supportive environment, can negatively impact students' motivation and attitudes.

However, it's important to note that despite these difficulties, many students maintained a positive attitude and continued to engage with the camp activities. Their ability to persist and seek solutions, even when facing unresolved issues, demonstrates resilience and a strong foundation for future learning in STEM fields. This

resilience aligns with the findings of Duckworth and Quinn (2009), who emphasize the role of grit and perseverance in overcoming obstacles and achieving long-term goals:

Arduino would not work, so i changed the variables one or a time.

The main challenge for me was that one of my motors broke for the drone and I couldn't really fix it but that's ok.

I had an issue with my drone not turning on, and through observation and trial and error, I was able to fix the issue and fly my drone.

I could not get the drone to show a port when I connect it in the coding app so I switched the cord and it worked. Thinking of good ideas for poster, solved by working together and problem solving how to set up the coding, I searched it up.

The iDrone camp helped expand students' perceptions of potential careers in STEM. Exposure to different roles and opportunities broadened their understanding of the diversity and importance of careers in this field. Several students found inspiration from interacting with professionals who have careers in STEM. Seeing successful people in the field made a significant impact, increasing their interest and motivation to pursue STEM careers. Through the camp, students realized that there are more career options in STEM than they initially thought, and they acknowledged the significance of these careers. This increased awareness can influence their future career decisions positively:

I think having people who have careers in STEM was very inspiring.

It has expanded my perception of potential careers.

Just by showing successful people in the field, I am more interested in STEM now.

I want to work on drones in the future.

There are more careers instead than I thought and they are rather important.

As conclusions, the iDrone camp was successful in expanding students' awareness of potential careers in STEM and demonstrating the practical applications of STEM skills. The inspiration from STEM professionals and the emphasis on self-driven activities were particularly impactful, although there may be a need for more accessible explanations to ensure comprehensive understanding for all participants:

It sorts of did, but it was hard to understand.

By hearing people who have careers in STEM.

Yes, by showing multiple careers and the importance of self-driven activities.

I saw real world applications of STEM in jobs and lives, two are really connected.
Showed me some possible stem career paths.

Discussions and Conclusions

The findings of this research study suggest that iDrone camps have a positive impact on middle and high school students' STEM affinities and their future career aspirations in STEM areas. By providing hands-on experiences with drone technology, these camps contribute to fostering a new generation of STEM-literate individuals who are equipped with the skills and confidence to pursue careers in emerging fields. The camp effectively engaged students in hands-on STEM activities, enhancing their interest and self-efficacy in STEM. Students enjoyed building and coding drones, working as a team collaboratively, and receiving guidance from mentors, which contributed to a fun and educational experience.

Students encountered various technical challenges during the camp, which they addressed through problem-solving, resourcefulness, and teamwork. These experiences not only taught them specific STEM concepts but also helped develop critical thinking and perseverance. The camp successfully broadened students' perceptions of potential STEM careers. Interaction with STEM professionals and exposure to real-world applications of STEM demonstrated the diverse opportunities available and inspired many students to consider STEM careers more seriously (Bell et al., 2003).

Some students expressed a desire for more time to work on their projects and pitches, indicating that extending the duration of the camp could enhance the learning experience. Additionally, while the camp increased awareness of STEM careers, some students found certain aspects difficult to understand, suggesting a need for clearer communication and additional support in these areas (Chou et al., 2015). Hearing from successful individuals in STEM and seeing practical applications of STEM in various careers motivated students and reinforced the connection between STEM education and career opportunities. This inspiration is crucial for maintaining their interest and drive to pursue STEM fields in the future (Maltese et al., 2011).

The camp provided a valuable opportunity for students to connect with their peers and work collaboratively. This social aspect, combined with teamwork, not only made the camp enjoyable but also emphasized the importance of collaboration in STEM projects (Faif Pasani & Amelia, 2023).In conclusion, the iDrone camp was successful in engaging students in STEM activities, enhancing their problem-solving skills, broadening their awareness of STEM careers, and providing inspiration and motivation for future pursuits in STEM fields. Addressing the need for more time and clearer communication could further improve the effectiveness of the camp. Overall, the positive experiences and skills gained by the students suggest that the iDrone camp is a valuable initiative for promoting STEM education and career awareness.

Future Implications

To gain a comprehensive understanding of the impact of iDrone camps on students, it is essential to conduct in-depth research focusing on their long-term effects. This research should begin by tracking students' continued involvement in STEM activities over an extended period following their participation in iDrone camps. It is important to assess whether students remain engaged with STEM fields and sustain an interest in technology-related subjects.Tracking students' ongoing engagement can involve monitoring their participation in extracurricular STEM activities, courses taken in school, and involvement in STEM-related clubs or competitions. Additionally, surveys and interviews can provide qualitative insights into their sustained interest and motivation in STEM subjects.

Furthermore, evaluating how participation in iDrone camps influences students' career choices within STEM fields is crucial. This includes determining if students pursue higher education or career paths related to technology and engineering. Longitudinal studies can follow students' educational trajectories, noting enrollment in STEM degree programs and subsequent career choices.It's also important to investigate factors that may influence these outcomes, such as mentorship during and after the camp, the role of family support, and access to ongoing STEM resources. Understanding these factors can help enhance the design of iDrone camps and ensure they have a lasting impact on students' engagement and career aspirations in STEM fields.

Recent literature supports the idea that immersive STEM experiences, like iDrone camps, can have a significant impact on students' interest and persistence in STEM careers. For example, studies have shown that hands-on, project-based learning environments can increase students' engagement and interest in STEM subjects, leading to higher enrollment in STEM courses and degrees (Maltese & Tai, 2011; Tai, Liu, Maltese, & Fan, 2006). Additionally, exposure to STEM professionals and real-world applications can help students see the relevance of STEM education to their future careers, which can be a powerful motivator (Chou & Chan, 2015). By conducting comprehensive research in these areas, educators and program developers can gain valuable insights into the long-term effects of iDrone camps and develop strategies to sustain students' interest and engagement in STEM education.

Acknowledgement

We gratefully acknowledge the generous support of the Korean American Scientists and Engineers Association (KSEA) for providing funding for this project. Their contribution has been instrumental in its success, and we deeply appreciate their commitment to successfully completing this project and advancing STEM education.

Ethics Statement

This study was conducted in accordance with the ethical standards and guidelines of the Institutional Review Board (IRB) at University of Texas Arlington. The protocol for this research project was reviewed and approved under the protocol number 2023-0207. Informed consent was obtained from all participants and, where applicable,

their guardians prior to participation. All data collected was anonymized to protect the privacy and confidentiality of the participants. The research was performed in adherence to the principles of the Declaration of Helsinki and the ethical standards of our institution.

References

Amanda, F., Sumitro, S., Lestari, S., & Ibrohim, I. (2023). Enhancing critical thinking and problem-solving skills by complexity science-problem-based learning model. *Multidisciplinary Journal of Educational Research, 13*(1), 1–19. https://doi.org/10.17583/remie.9409

Bandura, A. (1997). *Self-efficacy: The exercise of control.* Freeman.

Becker, K., & Park, K. (2011). Effects of integrative approaches among science, technology, engineering, and mathematics (STEM) subjects on students' learning: A preliminary meta-analysis. *Journal of STEM Education: Innovations and Research, 12*(5–6), 23–37.

Bell, R. L., Blair, L. M., Crawford, B. A., & Lederman, N. G. (2003). Just do it? Impact of a science apprenticeship program on high school students' understandings of the nature of science and scientific inquiry. *Journal of Research in Science Teaching, 40*(5), 487–509. https://doi.org/10.1002/tea.10086

Chen, Y., So, W. W. M., & Zhu, J. (2024). STEM learning opportunities and career aspirations: The interactive effect of students' self-concept and perceptions of STEM professionals. *International Journal of STEM Education, 11*(1). https://doi.org/10.1186/s40594-024-00466-7

Chou, P.-N., & Chan, K.-C. (2015). An interactive learning environment for enhancing student learning performance in a STEM educational program. *Journal of Educational Technology & Society, 18*(2), 167–179. https://www.jstor.org/stable/jeductechsoci.18.2.167

Custers, B. (2016). *The future of drone use: Opportunities and threats from ethical and legal perspectives.* https://doi.org/10.1007/978-94-6265-132-6

Duckworth, A. L., & Quinn, P. D. (2009). Development and validation of the Short Grit Scale (Grit-S). *Journal of Personality Assessment, 91*(2), 166–174.

Faif Pasani, C., & Amelia, R. (2024). Developing collaborative skills through STEM approach. IntechOpen. https://doi.org/10.5772/intechopen.113880

Fouad, N. A., & Santana, M. C. (2017). SCCT and underrepresented populations in STEM fields: Moving the needle. *Journal of Career Assessment, 25*(1), 24–39. https://doi.org/10.1177/1069072716658324

Janke, C., Luthi, K., Kleinke, S., & Lin, Y. (2022). Using small UAS for STEM education: Introducing robotics and mechatronics with drones. *Florida Conference for Recent Advances in Robotics 2022.* https://commons.erau.edu/publication/1852

Maltese, A. V., & Tai, R. H. (2011). Pipeline persistence: Examining the association of educational experiences with earned degrees in STEM among U.S. students. *Science Education, 95*(5), 877–907. https://doi.org/10.1002/sce.20441

National Research Council. (2012). *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas.* The National Academies Press.

Ryu, J., LaPaglia, S., & Walters, R. (2020). Idaho Drone League (iDrone) to Stimulate STEM workforce, Journal of STEM Education: *Innovation and Research, 21*(2),

https://www.jstem.org/jstem/index.php/JSTEM/article/view/2384

Ryu, J., Walters, R., & Ziegler, H. (2021). Interstate Drone League (iDrone National) to promote hands-on remote STEM learning using cloud-based virtual meeting platforms in the global pandemic (COVID-19), Journal of STEM Education: Innovation & Research, 22(4), https://www.jstem.org/jstem/index.php/JSTEM/article/view/2534

Schunk, D. H., & Pajares, F. (2005). Competence perceptions and academic functioning. In A. J. Elliot & C. S. Dweck (Eds.), *Handbook of competence and motivation* (pp. 85–104). Guilford Press.

Tai, R. H., Liu, C. Q., Maltese, A. V., & Fan, X. (2006). Planning early for careers in science. *Science, 312*(5777), 1143–1144. https://doi.org/10.1126/science.1128690

Yepes, I., Barone, D. A., & Porciuncula, C. M. D. (2022). Use of drones as pedagogical technology in STEM disciplines. *Informatics in Education, 21*(1), 201–233. https://doi.org/10.15388/infedu.2022.08

Yoon, J., & Ryu, J. (2024). STEM Talk: Cultivating Students' STEM Affinity and Careers, *Contemporary Mathematics and Science Education,* 5(1), ep24006, https://doi.org/10.30935/conmaths/14473

Author Information

Jiyoon Yoon

https://orcid.org/0000-0002-1268-5604

University of Texas Arlington

502 Yates Street, BOX19777

Arlington, TX 76019

U.S.A

Contact e-mail: *jiyoon@uta.edu*

Jae Hyeon Ryu

https://orcid.org/0000-0002-4686-4723

University of Idaho Boise

322 E. Front Street

Boise, ID 83702

U.S.A

Appendix. STEM Affinity Test

Items					
STEM identity	SD	D	N	A	SA
1. My teachers encourage me to do STEM.					
2. My family and friends encourage me to do STEM.					
3. I am good at STEM.					
4. I think of myself as a professional in STEM area.					
Personal interest in STEM	SD	D	N	A	SA
5. I think about the STEM I experience in everyday life.					
6. I am not satisfied until I understand why something works the way it does.					
7. I study STEM to learn knowledge that will be useful in my life outside of school.					
8. I enjoy solving STEM problems.					
9. Learning STEM changes my ideas about how the world works.					
10. Reasoning skills used to understand STEM can be useful in my everyday life.					
Self-concept of ability on STEM	NVG	NG	N	G	VG
11. How good at STEM are you?					
12. If you were to rank all the students in your STEM class from the worst to the best in STEM, where would you put yourself?					
13. Compared to most of your other school subjects, how good are you at STEM?					
STEM values	NVG	NG	N	G	VG
14. How important is it that you learn STEM?					
15. How interesting is STEM to you?					
16. How important do you think STEM will be to you in the future?					
Attitudes toward STEM	SD	D	N	A	SA
17. STEM is fun.					
18. I do not like STEM, and it bothers me to have to study it.					
19. During STEM class, I usually am interested in learning STEM more.					
20. If I knew I would never get to STEM class again, I would feel sad.					
21. STEM is interesting to me, and I enjoy it.					
22. STEM makes me feel uncomfortable, restless, irritable, and					

Items
impatient.
23. STEM is fascinating and fun
24. The feeling that I have towards STEM is a good feeling.
25. When I hear the word STEM, I have a feeling of dislike.
26. STEM is a topic which I enjoy studying.
27. I feel at ease with STEM, and I like it very much.
28. STEM is boring.

Note1. SD: Strongly Disagree (1), D: Disagree (2), N: Neutral (3), A: Agree (4), SA: Strongly Agree (5)

Note 2. NVG: Not Very Good (1), NG: Not Good (2), N: Neutral (3), G: Good (4), VG: Very Good (5)