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The Benefits of Hand-Launched Gliders in Undergraduate Aerospace Engineering Education

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Abstract

This paper examines a low-cost, hand-launched glider activity that integrates construction, flight testing, and quantitative analysis in undergraduate Aerospace Engineering education. Twenty-six students built balsa-wood gliders, conducted iterative flight trials, and worked in teams to analyze performance by comparing theoretical predictions with observed flight behavior. Post-activity surveys administered several weeks later indicated learning across multiple domains, including aerodynamic concepts, craftsmanship and precision, theory-to-practice connections, design thinking, and student motivation. Students described developing understanding of stability, center-of-gravity effects, and airfoil geometry through immediate observable feedback and troubleshooting performance differences arising from small construction variations. The activity's effectiveness appears to stem from three design features: rapid feedback loops, inherent performance variance that creates authentic engineering challenges, and structured analytical closure linking classroom theory to physical systems. Using materials costing approximately $5 per student and requiring only basic hand tools, this work demonstrates that accessible, construction-analysis activities can meaningfully bridge the theory–practice gap while fostering engagement across experience levels.

Introduction

Despite decades of emphasis on experiential learning in engineering education, a challenge remains: creating hands-on experiences that effectively connect classroom theory to physical engineering practice while they remain accessible to students with diverse backgrounds. Experiences that compress the full predict-build-test-verify cycle into short feedback loops can help students develop intuition for how theory manifests itself in physical systems. Rather than evaluating a single activity in isolation, this paper identifies pedagogical design features such as rapid feedback, performance variance, and structured analytical closure that may inform other accessible, theory-integrated hands-on experiences in aerospace engineering education.

This paper describes student learning from an activity in which aerospace engineering students built hand-launched, balsa-wood gliders, tested them through iterative flight trials, and worked in teams to quantitatively analyze performance. This activity combined hands-on construction with quantitative analysis. Students measured wing areas, estimated flight velocities, calculated theoretical performance, and compared predictions with observed flight behavior. By documenting student reflections on this integrated experience, we provide information and design insights for educators seeking accessible hands-on learning opportunities that connect theory to physical practice. This activity has been done numerous times by the instructor over the past 35 years of the course, but this study provides the first formal documentation of student learning outcomes.

We examined what students learned from this integrated experience to answer the following research question: *How do students experience and describe their learning from a low-cost, hand-launched glider activity that integrates construction, testing, and quantitative analysis within a compressed timeframe?* This question was addressed through post-activity surveys with open-ended questions about knowledge contributions, design thinking, takeaways, and enthusiasm impacts. Twenty-six students completed surveys several weeks after the activity. The activity was deliberately accessible: supplies had a cost of around $5 per student, and only basic hand tools were required. This simplicity allowed focus on pedagogical structure rather than specialized fabrication techniques.

Background

A persistent challenge in engineering education is helping students transfer theoretical knowledge to practical problem solving. Students may solve textbook problems involving lift coefficients and moment equations, yet struggle to apply these principles when diagnosing why a physical aircraft behaves unexpectedly. This disconnect between knowing and doing has been documented across Science, Technology, Engineering, and Mathematics (STEM) disciplines [1], [2], [3]. Kolb's experiential learning theory [4] argues that deep learning requires cycling through concrete experience, reflective observation, abstract conceptualization, and active experimentation. Traditional coursework emphasizes abstract conceptualization, but provides limited opportunities for concrete experiences that connect theory to observable phenomena. When connections occur in capstone projects or professional practice, the temporal gap may span months or years, diluting the connections between theory and application. Students who cannot see relevance of theoretical coursework experience decreased motivation and engagement [5]. Effective hands-on activities must provide clear physical feedback while remaining connected to theoretical principles.

While hands-on activities are common in engineering education, few deliberately integrate physical construction with rigorous quantitative analysis [6], [7]. Students might build artifacts in one course and learn theory and perform calculations in another, but activities intentionally combining these are less common. When construction and analysis are integrated, students close the loop between theoretical prediction and experimental observation. They experience engineering methodology: using theory to predict performance, constructing physical systems, measuring actual behavior, and comparing predictions with results. Physical construction informs analytical understanding. Sanding a wing to achieve proper airfoil shape develops a tactile sense of aerodynamic geometry. Conversely, analytical work informs construction. When calculations reveal that the center of gravity critically affects stability, students attend carefully to weight distributions.

The immediacy of feedback matters significantly [4], [8]. When students launch a glider and observe within seconds whether construction decisions produced desired flight characteristics, they can iterate rapidly by adjusting, re-testing, and refining based on observations. This maintains cognitive connection between physical adjustments and consequences. Contrast this with semester-long projects where months elapse between design decisions and testing. In these experiences, students form weaker connections between their design decisions and their physical consequences.

Variance in hand-built systems creates authentic engineering challenges. When students follow identical plans but produce artifacts with different performance, they confront real problems requiring diagnosis. Why does one glider spiral while another flies straight? Answering requires applying theoretical knowledge to troubleshoot actual systems. This variance isn't a problem to eliminate; it's a pedagogical feature creating learning opportunities.

Study Context

This study was conducted in AERSP 204H/404H, the Flight Vehicle Design and Fabrication Course at The Pennsylvania State University. This is a vertically and horizontally integrated course as previously described [9], [10], [11], [12] enrolling lower-level (204H) and upper-level (404H) undergraduate students working collaboratively on full-scale flight vehicles such as sailplanes and human-powered aircraft. The vertically integrated structure allowed both beginning and advanced students to engage with the same physical system at different levels of analysis, mirroring authentic engineering teams and supporting peer-mediated learning.

Methodology

Flip Glider Activity Overview

The Flip glider activity provided students a complete engineering experience integrating fabrication, testing, measurement, analysis, and verification within a compressed timeline. Students worked with balsa wood, which is inexpensive, readily available, and easily shaped with basic tools. The activity used a plan from the Midwest Products Co., Inc. (Fig. 1) rather than requiring design from scratch, focusing the attention of the activity on relationships between fabrication precision, theory, and observed performance.

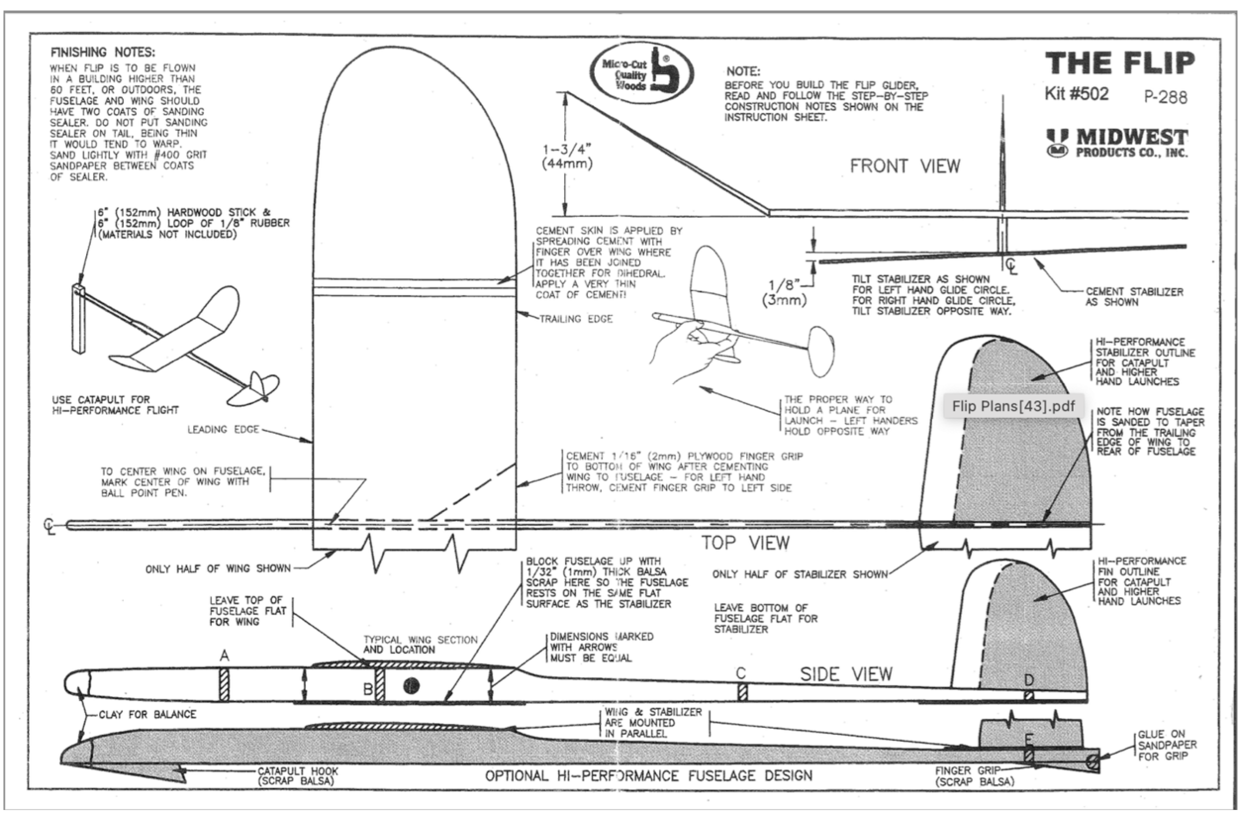

Fig. 1. Flip plans (source: Midwest Products Co., Inc.)

Construction Phase

Students received plans for a Flip, which is a simple hand-launched glider consisting of wing, fuselage, horizontal stabilizer, and vertical stabilizer, all constructed from balsa wood. Construction required approximately 1-2 hours. Key challenges included airfoil shaping, which required sanding the wing leading edge to a rounded profile and tapering the trailing edge while maintaining proper camber. Even following the same plans, every glider emerged slightly different due to variations in sanding, glue application, assembly alignment, and material properties. This variance proved pedagogically valuable, creating authentic differences in flight behavior requiring explanation and troubleshooting.

Fig. 2. (Left) Students shaping the wings for their Flips. (Center) A completed Flip ready for testing. (Right) Small variations in sanding, alignment, and assembly can be seen in the Flips despite following the same plans.

Testing and Iteration Phase

Students flight tested Flips through hand launches, observing pitch behavior, lateral stability, and glider performance. Immediate feedback of launching and watching flight created rapid iteration opportunities. Students made adjustments to their Flips and tested again within minutes, adding or removing clay, reinforcing broken components, and re-sanding rough surfaces. The iterative process required forming hypotheses about the glider behavior, making changes to both their Flips and to their launch techniques, based on their theoretical understanding and immediately observing whether predictions were correct.

Fig. 3. Hand-launch testing enabled immediate observation of pitch, stability, and glide performance, allowing rapid iteration within minutes.

Fig. 4. Students repair and make adjustments to gliders during testing.

Team Analysis Phase

Following individual construction and testing, students were organized into teams of 3-4 with each team led by a fourth-year mentor. Teams collaboratively analyzed glider performance through measurement, calculation, and comparison to their flight results. Teams measured physical parameters such as weight, wing and tail area, and flight velocity.

Using measured data, teams calculated lift-to-drag ratio from glide measurements, sink rate from timing and altitude loss, and verified that their calculated lift-to-drag ratios matched observed glider performance. For upper-level students, this calculation process required recalling theoretical relationships from coursework and applying them to the physical systems they had built and flown. For lower-level students, it allowed them to begin to build an understanding of these concepts before they've learned the theory in their coursework. The depth of analysis can be tailored to the level of material that students have been exposed to. Since the fourth-year students have taken courses covering aircraft aerodynamics, performance, and flight dynamics, the breadth of questions that can be considered is quite large. These topics are addressed in standard texts such as Anderson [13], McCormick [14], and Bertin and Cummings [15].

A critical component of this phase was closing the loop between prediction and observation. Students compared theoretical lift-to-drag ratio predictions to observed lift-to-drag, determined predicted sink rate versus measured sink rate, and expected flight characteristics based on center of gravity location, including determining the predicted load on the horizontal tail for trimming at the best lift-to-drag ratio flight velocity. Each team presented findings to the class, explaining observed flight characteristics, measured performance, and analytical results. Presentations created peer learning opportunities as teams shared insight about construction techniques, measurement methods, and aerodynamic observations. Fourth-year mentors guided teams through the analysis, helped interpret results, and modeled engineering problem solving.

Educational Data Collection and Analysis

Several weeks after completing the activity, students completed a post-activity survey including open-ended questions assessing knowledge gains, design thinking, project takeaways, enthusiasm and motivation. The delayed survey allowed students to reflect on sustained impacts rather than immediate reactions. A copy of the open-ended survey questions can be found in Appendix A.

Open-ended responses were analyzed using thematic coding organized into five categories: (1) Technical Knowledge and Aerospace Concepts, (2) Theory-to-Practice Connections, (3) Practical Skills and Craftsmanship, (4) Design Process and Problem Solving, and (5) Motivation and Belonging. Multiple codes could be assigned to a single response. Two researchers independently coded 20% of responses, and discrepancies were resolved through discussion until consensus was reached.

Participants

The sample included 26 students (17 male, 9 female) enrolled in AERSP 204H/404H during Fall 2025. Participants represented second-year (n=6), third-year (n=13), and fourth-year (n=7) students. Prior experience with model airplane building varied: none (n=13, 50%), some experience (n=7, 27%), and extensive experience (n=6, 23%).

This study was determined to be exempt by the Institutional Review Board at The Pennsylvania State University (IRB STUDY #00027852). Participation in the post-activity survey was voluntary, and responses were anonymized prior to analysis. Photo and video release consent was obtained for all students pictured or recorded.

Results and Discussion

Analysis of survey responses revealed learning outcomes across five categories: Technical Knowledge and Aerospace Concepts (100% of students), Practical Skills and Craftsmanship (92%), Theory-to-Practice Connections (62%), Design Process and Problem-Solving (46%), and Motivation and Belonging (92% of students reported increased enthusiasm). We present findings for each category followed by a discussion of what students' responses reveal about the activity's effectiveness.

Technical Knowledge and Aerospace Concepts

Students frequently described gaining understanding of aerodynamic principles through hands-on experience and observation. The most commonly mentioned concepts were trim and stability, center of gravity effects, and airfoil design. Technical knowledge appeared in 100% of student surveys, making it the most frequently stated learning outcome. One student explained, "We learned a lot about different factors that contribute to flight such as the center of gravity, aerodynamic center, neutral point, and pitching moment. These are things that have not yet been covered in my other classes." Another described learning "…airfoil shapes, where the CG of the plane had to be to achieve stable flight, using the tail to trim out the plane, and using concepts from thin-airfoil theory like the 'quarter chord.'"

Students particularly valued learning through component failure or unexpected behavior. One noted: "When my vertical tail broke off, my Flip could not glide, it just spiraled and fell. This showed me that the vertical tail is for stability." This kind of observational learning provided insights that diagrams and equations cannot convey. The student didn't just know intellectually that vertical tails provide directional stability; they observed the consequences of losing that stability and could explain why the glider spiraled.

The team analysis phase deepened technical understanding. Students mentioned specific insights from calculating performance metrics: "CG location and trim have massive effects on glider performance" and "understanding of aerodynamic center, finding trim speed, and aviation dynamics." The process of measuring their gliders, calculating expected performance, and comparing predictions with observed flight behavior connected theoretical relationships to physical systems they had built and flown.

Why This Worked: The immediate observable feedback proved critical. Students could launch their glider and within seconds see whether their understanding of trim, stability, or weight distribution was correct. When a glider pitched up sharply, students immediately connected that behavior to CG location or tail loading, concepts that might remain abstract in purely analytical coursework. The variance in how different gliders flew created puzzles requiring application of theoretical knowledge to solve. When one student's glider spiraled while another's flew straight despite following the same plans, students had to diagnose what differences in construction, such as wing alignment, weight distribution, or even launch technique might explain the performance differences. This troubleshooting process required returning to fundamental principles and applying them to diagnose real systems, precisely the kind of engineering thinking that we want students to develop.

Theory-to-Practice Connections

Students emphasized how the activity bridged classroom theory with physical reality. This theme appeared for 62% of students but was particularly prominent among students with no prior model building experience (85% vs. 29% of students with prior experience) and among female students (89% compared to 47% of male students). Given the relatively small sample size, these differences should be interpreted cautiously, but they suggest potentially important patterns worthy of further study.

Students described the connection in various ways. Some framed it as making abstract concepts concrete: "It helped me apply the things we were learning in class, see flight characteristics on a small scale." Others described it as a validation of classroom learning: "I could see that the information taught in class was, in fact, real and applicable." One student captured the fundamental shift simply: "For me, it was moving from none (number of planes built) to one, so it was very important."

One student reflected: "It made me more enthusiastic, it put the math into something physical." Another explained how the activity made the field more accessible: "This certainly made my major more reachable (the concept of aerospace engineering is so distant, so it started to put it into perspective)." For students who might find aerospace engineering intimidating or abstract, building something that actually flies provided evidence that they could do engineering, not just study it.

Several students explicitly mentioned seeing classroom concepts come to life: "It was nice to see concepts we learned in class be used in a practical application" and "I learned that supplementing knowledge learned in class with hands-on work greatly aids the understanding of that knowledge."

Why This Worked: The short timeline and rapid feedback seemed particularly important for theory-to-practice connections. Students experienced the complete cycle (predict based on theory, build, test, observe, analyze) within days rather than weeks or months. This kept the cognitive connections fresh. The equations they had learned in class were still recent when they observed those principles manifesting in flight. The immediacy of feedback maintained the link between theoretical understanding and physical observation. The simplicity of the system also mattered. Students could see direct cause-and-effect relationships without the complexity of larger systems obscuring fundamental principles. When they adjusted tail angle and immediately observed changed pitch behavior, the connection between control surface deflection and moment generation became real, not just intellectual.

The demographic pattern of a higher emphasis on theory-to-practice responses among novices and female students suggests that the activity was particularly effective at providing accessible entry points for students who might not have had informal opportunities to connect theory with practice through childhood hobbies or tinkering. This has important equity implications: when hands-on learning builds primarily on prior experience, it may inadvertently advantage students who had previous access to opportunities. Activities that successfully bridge theory to practice for all students, regardless of background, can help level the playing field.

Practical Skills and Craftsmanship

Nearly all students (92%) recognized that construction quality directly affects performance. The majority of design improvement suggestions focused on better craftsmanship: sanding more carefully, assembling more precisely, using less glue, and centering components accurately were all mentioned.

Students articulated this understanding clearly: "little changes can drastically change how it flies," "some people aren't workshop people, building planes takes attention to detail," and "precision is important, each part of the plane serves an important purpose." The recognition that "trimming the plane is VERY small adjustments" captured an important insight about engineering practice: achieving desired performance often involves fine-tuning rather than dramatic changes and small adjustments can have significant effects.

Although all students followed a standardized plan, their gliders flew differently due to variations in construction quality. Students' responses showed specific diagnoses linking construction decisions to flight behavior. "Wing wasn't centered, some of my sanding jobs weren't perfect," "I made the wing tips too angled upward," "I created the wing in such a way that the airfoil shape was reversed and the wing was installed backwards." These responses demonstrate engineering thinking. Students aren't making generic complaints about poor craftsmanship, but statements about how construction errors affected aerodynamic performance. The student who installed the wing backwards had to figure out why the glider didn't fly as expected, understand how airfoil orientation affects lift generation, and identify the root cause.

Why This Worked: Variance was a critical pedagogical feature in the activity design rather than a flaw. When all students achieve identical results, there are no anomalies to explain, no failures to diagnose, and no unexpected behaviors to troubleshoot. The variance in hand-built gliders created real engineering problems requiring theoretical knowledge to solve. Students couldn't simply follow a procedure; they had to understand why their specific glider behaved as it did and how construction differences might explain performance variations.

In this activity, students weren't viewing sanding or gluing as craft activities separate from engineering. They recognized these as technical decisions affecting aerodynamic performance. This represents deeper understanding of engineering practices: that the discipline requires both analytical thinking and careful execution, that precision matters, and that manufacturing decisions have functional consequences. The accessible materials allowed students to focus on aerodynamic principles and the relationship between construction quality and performance rather than wrestling with specialized fabrication techniques like composites or CNC machining. Yet the simplicity didn't trivialize the engineering. Achieving good performance with basic materials required genuine skill and understanding.

Design Process and Problem Solving

While this category appeared less frequently (46%), students who articulated insights about design process demonstrated sophisticated engineering thinking. One student explained: "The airplane stability problem can be broken up into different parts allowing you to influence different flight characteristics by altering individual variables. It also taught building techniques and how to work with balsa wood." This response shows understanding that came from experiencing both physical construction and analytical decomposition.

Some students reflected on the paradox of simple systems embodying complex principles. One observed: "You can design an airplane with very minimal parts but each part of the design is crucial for successful flight." Another noted: "It doesn't take much or cost much to get valuable engineering experience. While the Flips are pretty small, they are still actual planes and everything we learn in class can be applied to achieve the best flight."

A few students expressed interest in experimentation and design exploration: "I would differentiate my design from the set instructions to possibly gain more aircraft design knowledge through hands-on testing" and pursuing "the high-performance version of the Flip which involves a smaller tail and a notch to launch via rubber band."

Why This Worked: The integration of construction with analytical verification transformed the activity from a building project into an engineering investigation. Students measured their own gliders, the specific artifacts that they had built and tested, rather than generic examples from the textbook. This created ownership and investment in getting the analysis right. The comparison of predictions with observations closed the loop in ways that pure calculation exercises cannot. Students could see whether their theoretical understanding actually predicted real flight behavior. When calculations suggested higher lift-to-drag ratios than observed performance, students had to think critically about what their analysis might be missing or what sources of error could be. This kind of critical thinking about the gap between theory and reality represents engineering reasoning.

The team-based analysis, led by fourth-year student mentors, created collaborative problem solving opportunities. The vertical integration was particularly effective here. Upper-level students reinforced their own understanding by teaching while beginning students gained guidance from more experienced peers.

This activity successfully communicated that engineering isn't just about large, complex systems. Fundamental principles matter regardless of scale or complexity. The Flips aren't model airplanes; they're airplanes on a small scale. The accessible entry point didn't limit learning. Instead, it enabled focus on aerodynamic relationships without the cognitive load of complex systems integration. Students developed respect for careful execution and attention to detail, recognizing that achieving good performance with simple materials requires genuine engineering skills, not just following instructions.

Motivation and Belonging

An increase in enthusiasm for aerospace engineering was reported by 24 of 26 students (92%). Students used strong language about passion, excitement, and renewed interest. Of the two students who did not report an increase in enthusiasm, one reported that they were "already pretty into it" and the other stated that "endless sanding was annoying."

Some students described the satisfaction of building something that works: “I am a big airplane person, so anytime something I build actually flies I get super enthusiastic and can feel the passion.” Others emphasized how the activity changed their perception of the field: “I’d say it made me much more enthusiastic about the aeronautics side. I always preferred astronautics and space flight, but I like them equally now.”

Several students reported concrete behavioral changes indicating genuine engagement shifts: “I have ordered another wooden kit, joined the RC airplane club, and I am hoping to build more models in the next few years.” These actions represent significant investment beyond course requirements.

For some, enthusiasm came from seeing theory validated: “I was very enthused after this project, because I could see that the information taught in class was, in fact, real and applicable.” For others, from making aerospace feel achievable: “It reminded me why I love aerospace and what I want to do.”

The enthusiasm increases were remarkably consistent across demographic groups. Students with no prior experience showed 85% increased enthusiasm, those with some experience 100%, and those with extensive experience 100%. This consistency suggests the activity successfully engaged students regardless of background.

Why This Matters: Affective outcomes such as motivation, enthusiasm, and sense of belonging are critical for retention in engineering, particularly for students from underrepresented backgrounds who may question whether they belong in the field. When theoretical coursework feels abstract and disconnected from tangible outcomes, students can lose sight of why they entered engineering. This activity successfully reignited that motivation by providing concrete evidence that students could do aerospace engineering, not just study it. The satisfaction of building something that actually flies and watching their Flip glide smoothly across a field after hours of careful construction provided tangible confirmation of capability. As one student noted, the activity helped make “my major more reachable,” transforming aerospace engineering from an abstract concept into something real.

The high rate of enthusiasm increase across all demographic groups is worth noting. This activity worked for students who love aeronautics but also engaged students who were uncertain, who preferred other areas such as space, and who had never built anything before. The fact that novices showed similar enthusiasm gains as experienced builders suggests the activity provided accessible entry points while offering sufficient depth to interest everyone. The behavioral changes some students reported such as joining clubs, ordering kits, and planning future projects suggest impacts extending beyond the immediate course context. These students went beyond completing an assignment into developing genuine interest in hands-on aerospace work that might influence future course selections, career paths, or lifelong hobbies. Although enthusiasm alone does not guarantee learning, motivation is widely recognized as critical for persistence in aerospace engineering.

Conclusions

This study examined student reflections on learning from a low-cost, hand-launched glider activity that integrated construction, testing, and quantitative analysis within a compressed timeframe. Student responses indicate that the activity supported development of aerodynamic understanding, strengthened connections between theory and physical behavior, and fostered engagement and enthusiasm across experience levels. The combination of rapid feedback, inherent performance variance, and structured analytical verification enabled students to experience complete engineering cycles and analyze real performance differences using theoretical principles.

Importantly, the activity achieved these outcomes using simple materials, basic tools, and minimal cost, suggesting that meaningful hands-on engineering learning does not require complex systems or specialized facilities. By demonstrating how accessible construction-analysis activities can bridge theory and practice while supporting student motivation and belonging, this work offers design insights for engineering educators seeking scalable approaches to experiential learning early in the curriculum.

References

[1] J. S. Bruner, *Toward a theory of instruction*. Harvard university press, 1974.

[2] Y. Anzai, and H. A. Simon, "The theory of learning by doing." *Psychological review* 86.2 (1979): 124.

[3] National Academies of Sciences, Engineering, and Medicine. 2024. *Mentorship, Well-Being, and Professional Development in STEMM: Addressing the "Knowing-Doing Gap": Proceedings of a Workshop—in Brief*. Washington, DC: The National Academies Press.

[4] D. A. Kolb, "The process of experiential learning." *Culture and processes of adult learning*. Routledge, 2013. 138-156.

[5] M. O. Johansen, S. Eliassen, and L. M. Jeno. "“Why is this relevant for me?”: increasing content relevance enhances student motivation and vitality." *Frontiers in psychology* 14 (2023): 1184804.

[6] C. L. Dym, A. M. Agogino, O. Eris, D. D. Frey, and L. J. Leifer, "Engineering design thinking, teaching, and learning," *J. Eng. Educ.*, vol. 94, no. 1, pp. 103–120, Jan. 2005.

[7] S. D. Sheppard, K. Macatangay, A. Colby, and W. M. Sullivan, *Educating Engineers: Designing for the Future of the Field*. San Francisco, CA, USA: Jossey-Bass, 2008.

[8] J. Hattie and H. Timperley, "The power of feedback," *Rev. Educ. Res.*, vol. 77, no. 1, pp. 81–112, Mar. 2007.

[9] G. Bramesfeld, and M. D. Maughmer. "The Penn State Sailplane Project-The First Decade." *20th AIAA Applied Aerodynamics Conference*. 2002.

[10] T. F. Wheeler, "Learning Through Their Eyes: A Qualitative Analysis of the Student Experience of the Sailplane Class at Penn State." (2010).

[11] K. S. Jackson, M. D. Maughmer, B. T. Pipenberg, N. J. Grasser, and S. Van Wert. "The role of radio-controlled model airplanes in the education of aerospace engineers." *ASEE Annual Conference and Exposition, Conference Proceedings*. Vol. 122. No. 122nd ASEE Annual Conference and Exposition: Making Value for.... 2015.

[12] J. Cole, M. D. Maughmer, and K. Schmidt. "The Flight Vehicle Design and Fabrication Course: Two Decades of Project-Based Learning at Penn State." *10th AIAA Aviation Technology, Integration, and Operations (ATIO) Conference*. 2010.

[13] J. D. Anderson Jr., *Introduction to Flight*, Seventh Edition, McGraw Hill, New York, 2012.

[14] B. W. McCormick, *Aerodynamics, Aeronautics, and Flight Mechanics*, Second Edition, John Wiley and Sons, Inc., New York, 1995.

[15] J. J. Bertin, R. M. Cummings, *Aerodynamics for Engineers*, Seventh Edition, Cambridge University Press, New York, 2025.

Appendix A- Open-Ended Survey Questions

1. Prior to your time at Penn State, what experience did you have with building or flying model airplanes?

2. How much and in what ways did this activity contribute to your knowledge of flight?

3. If you could go back and do one thing to improve your design, what would it be?

4. What were the takeaways from this project?

5. How did this project affect your enthusiasm for aerospace engineering?

6. How do glide ratio and sink rate contribute to duration of flight?

7. Describe how the glider needs to be launched for longest duration of flight.

8. How does the glider need to be trimmed for the longest duration of flight?