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## **Integrating the "A" in STEAM: Enhancing STEM Learning Through Stop Motion Animation**

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### **ABSTRACT**

*This paper explores the integration of the arts ("A") into STEM education through stop-motion animation projects. Stop motion is a dynamic, hands-on medium for students to visually represent complex scientific, technological, engineering, and mathematical processes. By combining storytelling, artistic design, and scientific knowledge, students deepen their understanding of abstract concepts while enhancing creativity and collaboration. One project example illustrates how students model neuronal signal transmission using hand-built neuron models and stop-motion techniques. Additional project ideas are provided to demonstrate the broad applicability of stop-motion across STEM fields. This study highlights the benefits of incorporating artistic expression into STEM education, promoting deeper conceptual understanding and higher student engagement.*

**Keywords:** Interdisciplinary learning, Project-based learning, STEAM education, Stop motion animation, Visual storytelling

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## INTRODUCTION

Incorporating the "A" (Arts) into STEM education reshapes traditional STEM instruction into STEAM, which offers students greater opportunities to communicate, visualize, and internalize complex concepts. Artistic integration fosters creativity, critical thinking, and deeper learning by encouraging students to represent scientific processes through creative expression. This paper highlights stop-motion animation as a powerful medium for STEAM learning, enabling students to design, model, and animate STEM concepts with clarity and imagination. Stop motion projects require interdisciplinary skills, blending content mastery with artistic design, sequencing, collaboration, and technical production.

## LITERATURE REVIEW

Recent studies indicate that STEM attrition remains a significant issue, particularly during the transition from high school to college. Students with weaker academic preparation—often from socioeconomically disadvantaged backgrounds—are at the highest risk of dropping out of STEM majors. In a study of selective STEM programs, Dean and Chronicle (2024) found that these "marginal" students benefit significantly from program participation, but also face steep challenges without adequate academic support and mentoring.

Another 2024 study found that 32.5% of STEM college students reported changing their career plans after initially planning to study a STEM-related field, citing declines in intrinsic motivation, personal value, and personal confidence (Rosenzweig et al., 2024). These shifts in career intentions are linked with lower satisfaction and a decreased likelihood of completing a STEM degree. Additionally, national data indicate a decline in high school readiness for STEM college pathways. Between 2018 and 2022, the percentage of students meeting college-readiness benchmarks in mathematics dropped from 36% to 31%, and in science from 35% to 32% (National Center for Science and Engineering Statistics [NCSES], 2023).

Recent research continues to show that STEM and STEAM education play an important role in increasing student engagement by connecting learning to authentic, hands-on, and interdisciplinary experiences. Integrated STEM

instruction encourages students to actively participate in problem-solving, collaboration, and inquiry-based learning, which can improve motivation and a deeper understanding of academic content (Li, 2024). Research has also shown that students are more engaged when STEM learning includes meaningful real-world applications and opportunities for creativity and communication across disciplines (Perry, 2022). Additionally, recent studies suggest that collaborative and interactive STEM experiences can strengthen cognitive engagement, critical thinking, and student participation, particularly when technology and multimedia tools are incorporated into instruction (Zhu et al., 2023). These findings support the growing emphasis on STEM and STEAM education as effective approaches for creating engaging and student-centered learning environments.

These trends underscore the critical need for more inclusive STEM curricula, enhanced college preparation, and ongoing academic support for STEM students to ensure they not only enter STEM fields but also remain in them and succeed.

Integrating the arts into STEM education has been shown to enhance students' creativity, engagement, and critical thinking skills (Bequette & Bequette, 2012). STEAM curricula provide students with many avenues for exploring and representing knowledge, encouraging diverse learning styles and strengthening conceptual understanding. Art-based methods allow students to synthesize and personalize their learning, making abstract or technical content more accessible and meaningful (Henriksen, 2014).

Integrating the arts into STEM education—transforming it into STEAM—significantly enhances student engagement, creativity, and problem-solving skills. Kashaka (2024) emphasizes that blending artistic processes with scientific disciplines supports critical thinking and enhances motivation through project-based, interdisciplinary learning. These integrative approaches make STEM content more relatable and accessible, especially for students who may not initially connect with technical subjects.

The Rising Stargirls program further demonstrates the positive effects of creative arts-based approaches on middle school girls' engagement in astronomy. Participants, primarily from underrepresented backgrounds, reported improved science identity and deeper emotional investment in learning through arts-infused science activities (Silverman et al., 2025). Likewise, STEAM-based learning promotes systems thinking by helping students make connections across disciplines. A study published in the *Journal of Science Education and Technology* found that recontextualizing STEM through artistic expression enhances conceptual understanding and supports higher-order thinking (Henriksen et al., 2022).

These collective findings highlight how integrating art into STEM can help cultivate curiosity and creativity and foster a stronger sense of belonging in STEM classrooms, critical factors in expanding participation and persistence in STEM education.

## **Stop Motion Animation in Education**

Stop motion animation is a versatile tool for education, particularly in STEAM contexts. According to Hoban (2005), stop motion projects promote active learning by requiring students to design physical representations, plan sequences, and animate step-by-step changes in a system. This method supports visual and kinesthetic learning while reinforcing narrative construction and procedural understanding. Studies have shown that integrating animation projects into STEM education enhances student comprehension, motivation, and the ability to explain processes in their own words (Bers & Chau, 2010).

Recent studies have highlighted the effectiveness of stop-motion animation (SMA) as a tool to boost student engagement across various educational levels and subjects. For instance, Tang (2023) examined the integration of SMA into early childhood mathematics education and found that it significantly increased children's interest and enthusiasm for learning math concepts. Similarly, Muhammad et al. (2022) conducted a study with high school students, revealing that the use of SMA in physical education classes led to a 9.1% increase in learning motivation. These findings suggest that SMA not only makes learning more interactive and enjoyable but also promotes a deeper understanding of multifaceted subject matter by allowing students to visualize and manipulate concepts dynamically.

### **RESEARCH METHOD**

#### **Case of Study: Modeling Neuron Transmission through Stop Motion Project Overview**

In one project, students created a stop-motion animation to illustrate how an electrical signal travels through one neuron and jumps to another across the synapse. Students first constructed two neurons using clay, pipe cleaners, and string to model dendrites, axons, and the synaptic gap. They then storyboarded the sequence, photographing each step as the signal traveled down the axon, reached the axon terminal, and crossed the synaptic cleft to stimulate the next neuron.

Students edited the photographs into a short stop-motion video using free animation software, adding narration or text captions to explain each stage of the process. The project helped students visualize cell structures and functions more comprehensively, leading to a deeper understanding of complex concepts like neurotransmission.

Exit tickets were used at the conclusion of the activity to gather information about student understanding, engagement, and perceptions of the stop-motion modeling process. Students were asked short reflective questions such as: "How did the stop-motion activity help you understand neuron transmission?" "What part

of the neuron process was easiest or most difficult to model?”, and “What did you learn about how signals move between neurons?” Additional prompts may have included questions about creativity, collaboration, and scientific communication, such as “How did creating the animation help you explain the concept?” or “What skills did you use during the project?” Responses provided insight into student comprehension of neurotransmission as well as their experiences using multimedia and visual storytelling to communicate scientific ideas.

## **Learning Outcomes**

- Strengthened understanding of neuron structure and function
- Developed skills in artistic design, sequencing, and visual storytelling
- Practiced scientific communication through multimedia production

## **Alignment with STEAM Criteria**

This stop motion animation activity aligns with STEAM education criteria by seamlessly integrating all five domains. Students engage with science content by modeling biological systems, applying technology through digital animation tools, practicing engineering as they construct stable and functional models, exploring mathematical concepts such as sequencing and spatial reasoning during animation design, and expressing their understanding through artistic creation and storytelling. This comprehensive integration encourages holistic learning, fosters interdisciplinary connections, and reflects the authentic application of STEAM principles in a classroom setting.

## **Additional Stop Motion Project Ideas For Steam**

1. Cell Division (Mitosis and Meiosis)
2. The Water Cycle
3. Engineering a Bridge
4. Life Cycle of a Butterfly
5. Chemical Reactions
6. Planetary Motion

## **RESULTS**

Students consistently reported high engagement, excitement, and ownership of their learning when creating stop-motion projects. Informal feedback suggested that students retained complex information more effectively when it was visually represented through animation. Students demonstrated improved ability to explain

STEM processes in presentations and written reflections, indicating more profound conceptual mastery.

During a recent professional development session on this lesson, 50 middle and high school science teachers were introduced to stop-motion animation as an instructional strategy for enhancing student engagement and understanding of complex biological processes. Despite 42 of the teachers reporting that they had never heard of stop-motion animation before the session, 46 expressed strong interest in incorporating it into their classrooms. The overwhelmingly positive response highlights the potential of arts-integrated approaches to strengthen conceptual learning and make abstract content more accessible to students across grade levels. Teachers were given the following survey:

### Survey Questions

#### *Likert Scale (Strongly Agree–Strongly Disagree)*

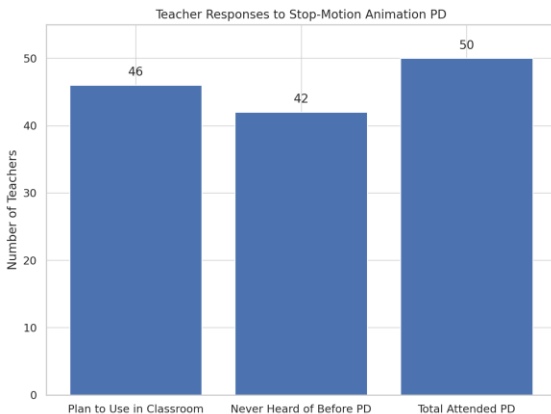
- The stop-motion activity would increase student engagement.
- The activity helped explain neuron transmission clearly.
- The project effectively integrated STEM skills.
- I feel confident using this activity in my classroom.
- The activity promoted creativity and collaboration.
- I plan to use stop-motion animation or this activity in my classroom.

#### *Open-Ended Questions*

- What was the most valuable part of this activity?
- What challenges might students face during the project?
- How could you adapt this activity for your classroom?

### Figure 1

Teacher Responses to Stop Motion Animation PD



## **Practical Lessons for Educators**

- Provide clear planning tools, such as storyboarding templates, to help students organize their animations.
- Emphasize process over perfection; encourage iterative design and problem-solving.
- Integrate discussions of the importance of artistic choices (color, movement, symbolism) to strengthen content and creativity.
- Offer simple, free digital tools (e.g., Stop Motion Studio app) to make animation accessible.

## **Sidebar: Ideas For Steam Stop Motion Projects**

- Model DNA replication using clay and string.
- Animate an ecosystem food web
- Depict tectonic plate movements leading to an earthquake
- Visualize mathematical transformations (translation, rotation, reflection)
- Tell the story of a historical engineering invention through models and animation

## **LIMITATIONS**

One limitation of this study was the small and localized sample size, which may limit the generalizability of the findings to other grade levels, schools, or educational settings. Additionally, much of the data was based on teacher observations, student reflections, and exit tickets, which are subjective forms of data collection and may not fully measure long-term content retention or academic achievement. The project also focused on a single instructional activity, making it difficult to determine whether improvements in engagement and understanding were directly caused by the stop-motion approach itself or by the novelty of the activity. Variations in student technology skills, artistic ability, and access to materials may have also influenced student performance and participation during the project.

## **DISCUSSION AND CONCLUSIONS**

The integration of art activities like stop-motion animation into STEM curricula enables students to blend creativity with scientific understanding. This encourages deeper engagement and critical thinking by allowing students to actively construct and visualize scientific processes rather than simply memorizing information. By making abstract concepts tangible and visual, stop-motion projects offer a rich, interdisciplinary approach to STEAM education. Through

visual storytelling, students learn STEM content more effectively and develop essential skills for communicating complex ideas creatively and collaboratively. Additionally, projects that incorporate multimedia production and hands-on modeling can increase student motivation, strengthen problem-solving abilities, and support multiple learning styles. These experiences help students see science as interactive and meaningful while also promoting communication, teamwork, and technological literacy that are valuable across academic and career settings.

Overall, the project demonstrated how STEAM-based instructional strategies can create engaging learning environments that support both conceptual understanding and creative expression. By combining science content with artistic design and technology integration, students were able to deepen their understanding of neuron transmission while developing important 21st-century skills. Activities like stop-motion animation may serve as effective tools for increasing engagement and helping students communicate scientific knowledge in innovative and accessible ways.

## **IMPLICATIONS**

The results of the stop-motion animation professional development propose several implications for classroom instruction and future professional development sessions for teachers. The high percentage of teachers who indicated that they plan to use stop-motion in their classrooms, despite the majority having no prior experience with the method, demonstrates its accessibility and relevance to STEM instructional practices. This implies the need for more frequent integration of creative, low-tech strategies in STEM education that foster active learning without requiring extensive resources. In the given case study, the use of stop-motion animation to model the transmission of a stimulus through a neuron not only reinforced content knowledge but also stimulated visual creativity, sequencing skills, and student collaboration. As a cross-disciplinary tool, stop-motion animation holds promise for bridging gaps between science and the arts, engaging diverse learners, and enhancing understanding of dynamic processes. Future professional development should continue to emphasize hands-on, arts-integrated techniques as a pathway to deeper student engagement and more inclusive science instruction.

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