

## Transforming Initial Wonder into Structured Understanding: Experiential Science Demonstrations to Foster STEM Pathways

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### INTRODUCTION & AIM

The transition from secondary education to STEM-related higher education is often hindered by students' perceptions of science as abstract, inaccessible, or disconnected from everyday experience.

**Beyond the Magic** is an educational outreach initiative designed for upper-secondary students that uses short, live, and participatory science demonstrations performed under controlled conditions and with appropriate safety measures.

The aim of the project is to transform initial surprise and curiosity into **structured scientific understanding** by encouraging observation, prediction, discussion, and explanation of everyday phenomena, thereby fostering interest in STEM pathways.

### METHOD

- **Participants:** Upper-secondary students (15–18 years old).
- **Setting:** Science outreach activities in schools and university extension events.
- **Approach:** Experiential, inquiry-based and participatory learning through live demonstrations.
- **Procedure:** Each demonstration followed a cycle of (1) prediction, (2) observation, (3) guided explanation, and (4) discussion.
- **Safety:** All experiments were performed under controlled conditions with appropriate safety measures for educational settings.
- **Duration:** 45–60 minutes per session.

### EDUCATIONAL APPROACH AND IMPLEMENTATION



Students participated actively by predicting outcomes, observing phenomena, asking questions and collaboratively constructing explanations.

### EXAMPLES OF SCIENCE DEMONSTRATIONS

**Invisible Message**  
(acid–base indicators)



Writing with sodium bicarbonate and revealing the message using turmeric, an acid–base indicator.

**Iodine Clock**  
(reaction kinetics)



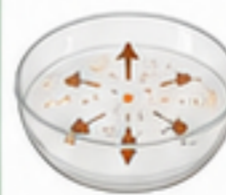
When reactants mix, iodine is released and forms a deep blue complex with starch after a characteristic time.

**Balloon in a Bottle**  
(gas pressure)



When the flame goes out, air cools, pressure drops, and the external pressure pushes the balloon inward.

**Surface Tension**  
(intermolecular forces)



Pepper moves away when soap solution reduces surface tension, revealing cohesive forces at the liquid surface.

**Elephant Toothpaste**  
(gas generation and foams)



Oxygen from catalyst decomposes hydrogen peroxide, producing foam stabilized by egg white proteins.

**Direct Spherification**  
(gel formation)



Calcium ions crosslink sodium alginate, forming a gel membrane around liquid droplets.

**Copper Plating with Silver Nitrate**  
(redox reaction)



Copper displaces silver from silver nitrate solution, forming metallic silver on the copper surface.

### DISCUSSION

The educational value of the activities does not lie solely in the visual impact of the demonstrations, but in the structured pedagogical process that follows the initial moment of surprise.

By combining inquiry-based learning with guided scientific explanation, the demonstrations become tools for promoting scientific reasoning, conceptual understanding, and positive attitudes toward science.

This approach may help reduce perceived barriers to STEM disciplines during a critical stage of educational decision-making.

### CONCLUSION

Experiential science demonstrations can serve as effective entry points for engaging students with scientific thinking.

The **Beyond the Magic** project illustrates how carefully designed demonstrations can transform initial surprise into opportunities for scientific reasoning, conceptual understanding, and interest in STEM-related educational pathways.

### FUTURE WORK

- Expand implementation to additional schools and educational contexts.
- Develop complementary educational resources for teachers.
- Explore the long-term influence of outreach experiences on students' perceptions of STEM careers.