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A Summary of Studies on Teaching Floating and Sinking

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OVERVIEW This work summarizes the findings of 69 studies on teaching floating and sinking. We found a large positive teaching effect and that hands-on experiments are more effective than virtual experiments.

AUDIENCE: Administrators (K-12), Assessment developers, District science coordinators, Instructional designers, K-12 science teachers, Professional development providers, Researchers/Researcher supervisors, Physics educators, Earth science educators, STEM educators, Elementary science teachers

KEY POINTS

- This meta-analysis summarizes 191 effect sizes from 69 intervention studies.
- Teaching floating and sinking is very effective with a mean effect size of g = 0.85.
- It requires multiple hours of instruction time to reach this large effect.
- Hands-on experiments are more effective than virtual experiments.

INTRODUCTION: Over the last decades many studies have investigated how floating and sinking could be taught effectively to students of different ages while using multiple teaching approaches. Yet the large number of studies and the diverse teaching approaches make it hard to identify effective teaching approaches that should be spread into classroom praxis. Thus, this paper aims to identify the average intervention effect and characteristics of effective intervention approaches. We utilize meta-analytical methods to calculate the average intervention effect and to investigate the effect of intervention characteristics, students' age, the study design, and assessment features on the mean intervention effect.

FINDINGS We extracted 191 effect sizes from 69 studies. Over all studies, we estimated a large mean effect size of $g = 0.85$ (95% CI = 0.71, 0.99). We found no relation between students' age and the study effect. This demonstrates that, although FS is a challenging concept, teaching floating and sinking is effective even in elementary school. We found two intervention characteristics that explain variance in study effect sizes: longer lasting interventions result in larger effect sizes and interventions where hands-on experiments are applied are more effective than those utilizing virtual experiments. Furthermore, studies with a treatment-control group comparison have significantly smaller effect sizes than studies with a pre-post design.

TAKEAWAYS

Our findings have straightforward implications for teaching floating and sinking. First, even though floating and sinking is related to challenging concepts like density and buoyancy, it is indeed very effective to introduce it. We found no evidence that the effectiveness of interventions depends on students' age, so it seems possible and effective to introduce the topic even in primary school. However, to achieve the high intervention effects that we have identified in this meta-analysis requires time. Teaching floating and sinking is effective, but it takes multiple hours to guide students to overcome their dominant preconceptions and to introduce scientific explanations. Moreover, it seems to be effective if students conduct hands-on instead of virtual experiments because the haptic feedback they get when they place objects into water helps them to understand the relevant concepts.

Full Title: Teaching and Learning Floating and Sinking: A Meta-analysis