A Mobile-Based Free-Body Diagram Application

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Motivation

Free-body diagrams (FBDs) are a key skill used by many of the 600,000 students who begin an undergraduate engineering program in the United States each year. Current opportunities to practice drawing FBDs are insufficient for some students because of lack of scaffolding and immediate feedback.

Although learning to reliably draw accurate FBDs is difficult for most students, women may be at a disadvantage when developing this skill for two major reasons. First, one of the largest gender-related differences in cognitive skill is related to spatial visualization techniques. Second, and perhaps more importantly, women consistently rate themselves as having lower confidence in their ability to formulate and solve engineering problems and may feel like they do not belong in engineering.

Goal

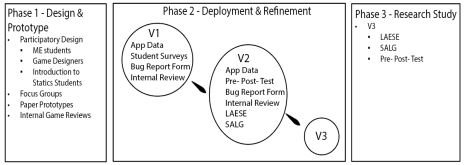
Develop a mobile-based application that helps students, particularly women, effectively learn to draw FBDs.

Through carefully structured tasks and immediate feedback the app creates an environment aligned with Vygotsky's concept of proximal development designed to maintain a learner's interest and emphasize aspects of the solution.

Advantages:

- asynchronous opportunities for practice
- scaffolding of practice with hints
- Immediate feedback
- gamification that encourages student engagement

Development Process



Current State

Three mini games are currently available:

System ID

Students trace around the body for which they need to draw a FBD. Designed to help students isolate bodies correctly.

Connection ID

Students swipe supports left of right depending on requirements. Designed to help students identify support reactions correctly.

Free-Body Game

Student place and orient forces and moments on a diagram. Designed to give students practice creating entire FBDs.

Methods

Participants

- 245 first- and second-year students in three sections of statics at two universities
- 37% women

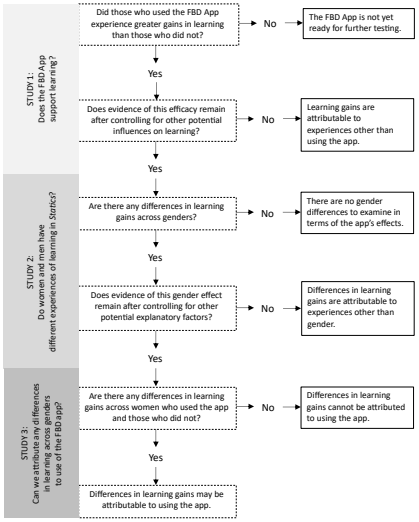
Experience with the app

Students were given the opportunity to use the FBD app during a class period and then to continue to use the app to support their learning outside of class.

Instrument

Student Assessment of their Learning Gains (SALG) - an NSF-funded and validated survey that asks students how much they learned for each of a set of learning objectives and the extent to which they attribute their learning to specific learning activities (pre- and post-intervention)

Study Design



Results

Independent sample t-tests and hierarchical multiple linear regression were used to assess learning outcomes and differences across genders and app use. We found that:

- Students who used the FBD App reported greater gains in content mastery than those who did not.
- Using the app closed the self-efficacy gap between men and women by boosting women's self-efficacy.
- Women who used the app reported greater gains in willingness to seek help.

Anecdotal student comments also support the app as being effective, with students making comments such as:

- "The FBD app helped me have a better understanding on what needs to be included in FBDs."
- "The FBD app was very helpful because it gave me examples and immediate feedback on my mistakes."

Conclusions

Based on our research, the app meets the goal of helping students learn to draw FBDs. It also helps improve the self-efficacy of women during an early, fundamental engineering course, which is critical for retaining women in engineering.

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