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Engineering Education Research Snacks

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How to Design an Intervention Study

Many engineering educators have attempted to improve their teaching practice and student learning using an intervention. An intervention could be the use of a new teaching tool, introduction of a new method, or a change to assessments in a course—anything that might potentially change the student experience. Many interventions have been reported in CEEA conference papers, but relatively few include a significant research element. This post will focus on how an intervention study can be designed and executed in an engineering education setting.

An intervention study examines the effect of an educational intervention. Typically, it asks a causal research question, for example: Does a utility value intervention influence student interest in a multidisciplinary engineering design course? (Turoski & Schell, 2020). The overall design of the study aims to identify and examine the causality, typically between the intervention and learning outcomes or student experience.

A powerful research design for identifying a cause-and-effect relationship is an experimental study (Gravetter & Wallnau, 2013). Two equivalent groups are created using random assignment and then the intervention is applied to one group (known as the treatment group) but not to the other (known as the control group) under controlled conditions.

There are several ethically appropriate ways to group students into the experimental group and control group for an intervention study. You can use the existing student groups—for example, using two different courses or the same course taught in two different terms—and apply the intervention to one of these classes. Often a pre-test/post-test design is used, in which both the treatment and control groups are given a "pre-test" assessment to identify the baseline, and after the intervention they are given the same assessment, to measure improvement.
You can run a study without a control group, by comparing the results from the pre-test and post-test assessments. This allows you to report the "gain", but this does not allow you to evaluate the intervention specifically because other factors may contribute to the change in students' performance[1].

Alternatively, you can randomly assign students to the treatment and control groups. If you split students in the same class into two groups (treatment and control) you need to give both groups an opportunity to be exposed to interventions that you believe have an equal benefit for the students for ethical and equity reasons. A common way to do this is

[1] This type of study design may make sense for a short, specific intervention where other factors or experiences have limited influence on outcomes. For example, in a safety training session, you might measure the students' appreciation for the value of safe practices before the training session and then measure it again afterwards to see if it has gone up.

a “cross-over” study where each group experiences the same intervention but at different points in time: e.g., Group A experiences the intervention before the midterm, and then Group B gets it after the midterm. In any experimental design, you need to identify the elements in the environment that possibly confound the effect of the intervention and try your best to minimize their influence or control for their effects using statistical methods.

You can also consider establishing “process causality” (Anderson & Scott, 2012) by identifying the “generative mechanisms” that can explain how the changes took place, which can include individuals’ belief, reasoning and action in response to the intervention. You can do this by asking your research participants to explain how the intervention made a difference to the outcome of interest (e.g., student learning) via open-ended survey questions, interviews or focus groups. Then you can analyze the qualitative data by using methods such as causation or pattern coding (Saldaña, 2016). When you include this component in your pre-test/post-test quantitative design, you have conducted a mixed-methods study.

There are some good references for designing an intervention study (Harackiewicz & Priniski, 2018). An intervention study starts with identifying and assessing the specific problem, population and context targeted by an intervention. You also need to consider what measurement you will use to assess particular academic outcomes, which serve as a measure of intervention efficacy. These outcomes can be course-specific (e.g., motivation for taking a course), school-specific (e.g., graduation rate) or field-specific (e.g., retention rate of female engineering students), depending on the scope of the intervention. The outcomes can be cognitive (e.g., development of problem-solving skills) or affective (e.g., self-efficacy). Some outcomes can be demonstrated shortly after the intervention and others may be more appropriate for a longer-term. So, you also need to decide when to measure the outcomes.

A study design that follows these principles can provide a substantially enhanced level of quality to your research, and your papers, because it uses a rigorous research process to assess your intervention.

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Turoski, S.A., & Schell, W. J. (2020, June). *Advancing student motivation and course interest through a utility value intervention in an engineering design context.* Paper in the proceedings of the annual Canadian Engineering Education Association conference.

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