Tools for assessing student learning in mechanical design courses

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Introduction

Efforts to improve design education require assessment instruments that can provide feedback on students' design skills and knowledge. However, there is a lack of such instruments for design education, resulting in difficulties in evaluation [1]. This poster describes the ongoing development of a set of concept questions for use in mechanical engineering design courses.

Assessment tool design

An ethnographic study of student design teams, a set of student questionnaires, and a review of the literature on expert and novice design performance was used to identify the design skills that engineering students struggle to learn and apply. Four major categories of skills were identified:

- **Problem definition;**
- **Communication and comprehension;**
- **Evaluation of concepts;** and
- **Prototyping strategies**

These results will be used to inform future curriculum design. However, in order to evaluate the effects of attempted improvements in these areas, assessment tools will be required. For each of the skills identified a set of questions was designed, some examples of which are provided here.

Problem definition	Problem decomposition
	Estimation
	Modelling
	Evaluating information
Communication and comprehension	Visual and spatial reasoning
	Visual communication
Evaluation of concepts	Assessing feasibility
	Understanding of mechanisms
	Analogical thinking
	Design of experiments
	Failure mode analysis
Prototyping strategies	Part selection
	Manufacturing process selection

Examples

If gear A turns clockwise at a constant speed of 10 rpm, how fast and in what direction does gear B turn?

You are designing a wearable device to assist with lifting tasks. Create a mathematical model of the arm in the position shown and use it to estimate the torque that must be applied at the shoulder to hold the arm in this position.

You are designing a device which includes the part shown, which will be made from stainless steel. What manufacturing process would you use to produce a prototype of this part to scale?

Sketch a mechanism that converts continuous circular motion into intermittent circular motion.

Estimate the quantity of oil imported to the USA annually. Show your calculations or provide a rationale for your answer.

You have been given the design brief below, and asked to think of as many analogies as possible that could be used as inspiration for the design. Please list any useful analogies you can think of (e.g. from nature, from other industries, from existing devices, etc.).

Design brief: Chain wear indicator. Chain hoists are used for lifting and lowering movable loads. The lifting is done by an electric motor. Over time the chain wears, and the chain must be replaced if any of the following conditions are observed: cracks, visible distortion, severe corrosion, or a 2% increase in length. Currently chain wear is measured by hand with a calliper. The aim is to design a better method for monitoring chain wear.

Pilot study

A pilot test was conducted with 11 participants, ranging in experience from undergraduate students to post-doctoral researchers with several years of design experience in industry. All answers were given a score of either pass or fail. Conventional item analysis, guided by classical test theory, was used to identify the discrimination and difficulty of each question [2].

The most difficult questions, based on the item analysis, were those related to part selection and guessing quantities. The easiest question types on the test were those related to evaluating information and identifying failure modes. These questions also had the lowest discrimination values. The question types with the highest discrimination values were those focused on visual communication and manufacturing process selection.

References

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