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Exploration of expert and novice reasoning in mechanics of solids

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Exploration of expert and novice reasoning in mechanics of solids

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Introduction

Mechanics of Solids (MOS) has become the bridge and bond between elementary and specialized knowledge for engineering students. MOS has been regarded as one of the most difficult undergraduate courses across the country and specifically at Rutgers University. A central concern for engineering educators is how to get students to master so many equations and definitions while also understanding the physical mechanisms in such a limited time[2]. The purpose of this study is to identify patterns in the way expert and novice engineers approach problems to better inform future research in the field of engineering mechanics.

Research questions:

1) How do experts approach demanding engineering problems?
2) How do students approach demanding engineering problems?

Theoretical Framework

In general experts are more successful at choosing the appropriate strategies to use than novices[13].

Experts:

- Work forward, starting from the given state to the goal state.
- Spend a great deal of time analyzing a problem qualitatively by developing a problem representation that include many domain specific and general constraints of the given problem.

Novices:

- Work backwards, from the unknown to the givens rather than try to understand the questions conceptually.[14] .
- Rush into quantitative manipulations and plug-in formulas[13] .
- Find it difficult to make connections between what they have learned, and the information provided in the questions[21].

Procedure

Participants

Experts:

Academia- Professors from Rutgers Department of Civil Engineering who have taught MOS.

Industry- Practicing engineers from local civil engineering firms in the tri-state area that have at least three years of working experience.

Novices:

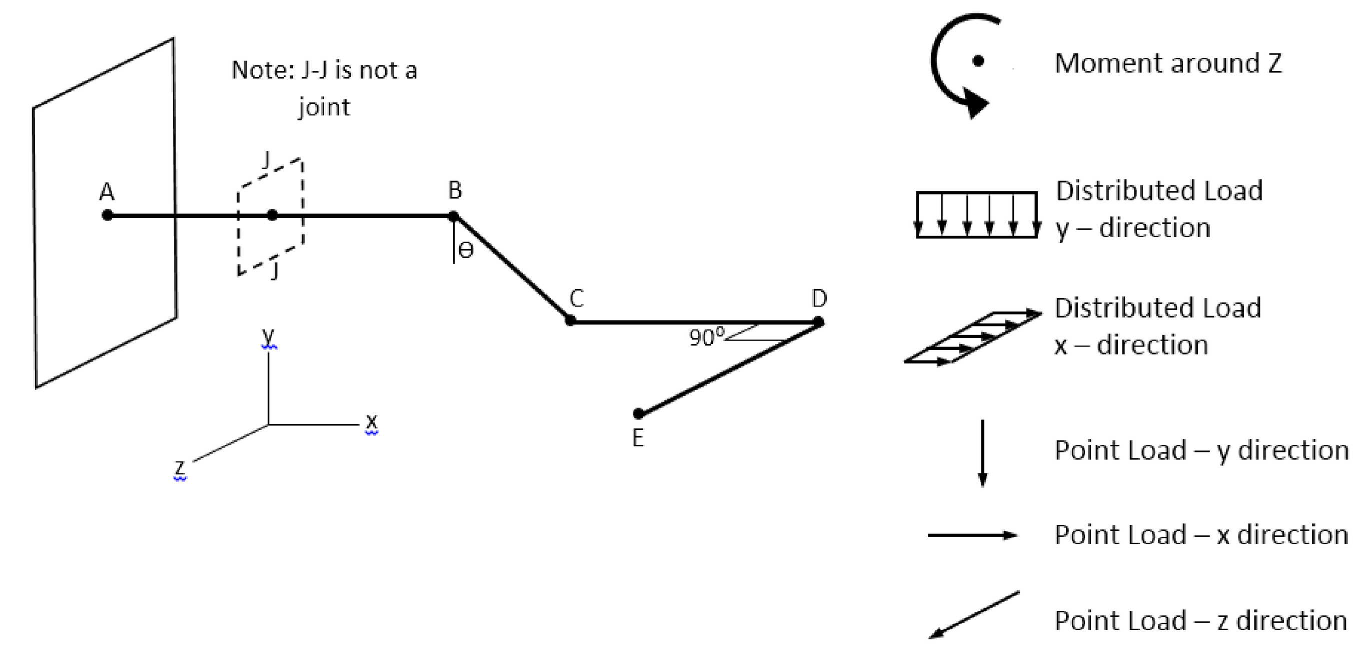
Students- Enrolled in a civil engineering specific mechanics of solids course.

Problem Solving Session-

A complex and unique engineering problem was created with the following qualities:

1) Include basic engineering concepts found in a mechanics of solids course
2) Be presented in a way in which an expert's intuition alone cannot be used to formulate a solution.

During the problem-solving session, subjects will work in a quiet comfortable setting and will be instructed to think aloud as they work on the problem seen below. The entire session is audio and video taped in order to aid in transcription.



Place 4 of the 6 loading situations on the above structure to result conceptually in the maximum value at plane J-J for each of the following stresses. Loads can only be added to joints and can be either in the positive or negative direction. Distributed loads must be applied to the total length of the member. All joints are rigid.

1) $\sigma_{\text{bending stress}}$
2) $\sigma_{\text{axial stress}}$ (tension or compression)
3) $\tau_{\text{shear stress due to bending}}$
4) $\tau_{\text{axial shear stress}}$
5) $\tau_{\text{torsional stress}}$

Interviews-

Subjects will be individually interviewed directly after their problem solving session and will be asked questions based on their recent problem solving experience. Interviews will be video and audio recorded in order to aid in transcription.

Analysis

A combination of thematic analysis and the analysis procedure outline by the think aloud method will be used.

Thematic Analysis-

Phase	Description of the process
1. Familiarising yourself with your data:	Transcribing data (if necessary), reading and re-reading the data, noting down initial ideas.
2. Generating initial codes:	Coding interesting features of the data in a systematic fashion across the entire data set, collating data relevant to each code.
3. Searching for themes:	Collating codes into potential themes, gathering all data relevant to each potential theme.
4. Reviewing themes:	Checking in the themes work in relation to the coded extracts (Level 1) and the entire data set (Level 2), generating a thematic 'map' of the analysis.
5. Defining and naming themes:	Ongoing analysis to refine the specifics of each theme, and the overall story the analysis tells; generating clear definitions and names for each theme.
6. Producing the report:	The final opportunity for analysis. Selection of vivid, compelling extract examples, final analysis of selected extracts, relating back of the analysis to the research question and literature, producing a scholarly report of the analysis.

Phases of thematic analysis. Reprinted from Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. Qualitative Research in Psychology, 3(2), 77-101.

Think Aloud Method-

Pre-develop a coding scheme based on a procedural psychological model (i.e. problem-solving procedure). Since the model describes which cognitive processes will occur and in which order they will occur, it will be possible to create a coding scheme that specifies how elements of the model can be identified in the data

Research Status

The following is in progress

- Raw data collection
- Transcription
- Preliminary coding of the transcripts using thematic analysis
- Creation of preliminary coding scheme using think aloud method

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