Design Processes in an Upper-Level Design Course: An Evaluation of Design Heuristics

Julia Kramer, Shanna Daly, Seda Yilmaz, Colleen Seifert, Rich Gonzalez

University of Michigan — CENTER FOR RESEARCH ON LEARNING AND TEACHING IN ENGINEERING — CRLT ENGIN
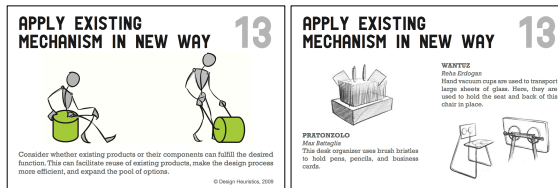
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1. MOTIVATION

- Successful concept generation as the source of successful innovations,
- Lack of instruction on systematic approaches to idea generation and innovative thinking

Cognitive challenges of concept generation in engineering

1 Engineers form an early attachment to their initial ideas and stop considering alternatives

2 Engineers are unable to break away from known examples or solutions

- Multiple methods for concept generation
- One systematically derived from engineering design and designers' processes and empirically validated in scientific studies: Design Heuristics
- Impact of Design Heuristics on student teams throughout a design process has not been researched

APPLY EXISTING MECHANISM IN NEW WAY — 13

Consider whether existing products or their components can fulfill the desired function. This can facilitate reuse of existing products, make the design process more efficient, and expand the pool of options.
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APPLY EXISTING MECHANISM IN NEW WAY — 13

WANTUZ
Reha Erdogan
Hand vacuum cups are used to transport large sheets of glass. Here, they are used to hold the seat and back of this chair in place.

PRATONZOLO
Max Battaglia
This desk organizer uses brush bristles to hold pens, pencils, and business cards.

2. RESEARCH QUESTIONS

1 Evidence of Design Heuristics Use

What evidence of Design Heuristics use during a heuristic-guided ideation session can be seen in later team designs?

2 Outcomes of Design Heuristics Use

How do Design Heuristics contribute to the practicality and overall quality of designs across different contexts?
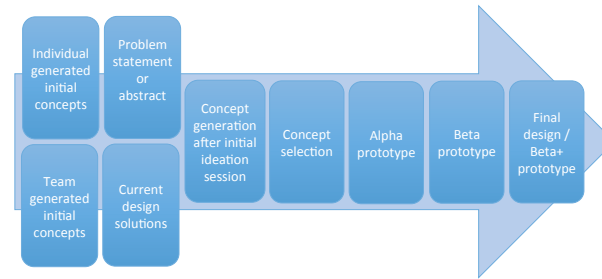
3 Impacts of Design Heuristics Use

What are the impacts of Design Heuristics on solutions generated by design teams?

REFERENCES

Daly, S. R., Yilmaz, S., Christian, J. L., Seifert, C. M., & Gonzalez, R. (2012). Design heuristics in engineering concept generation. *Journal of Engineering Education*, 101(4), 601-629.

Yilmaz, S. (2010). Design Heuristics. PhD Thesis, University of Michigan, Ann Arbor, MI.

3. METHODOLOGY

- Created timelines based on information pulled from team reports and ideation sessions

Individual generated initial concepts → Problem statement or abstract → Concept generation after initial ideation session → Concept selection → Alpha prototype → Beta prototype → Final design / Beta+ prototype

Team generated initial concepts → Current design solutions

- Analyzed timelines for evidence of heuristic use and to explore how heuristic-inspired ideas evolved throughout students' design processes. Sought to uncover patterns in:
    1. Degree of heuristic use
    2. Synthesis of the concepts present at various phases in the design process
    3. Nature of transformation in moving from one design phase to another
- 43 participants in eight design teams. 3 to 5 members per team

4. FINDINGS

- Each individual generated an average of 3.7 concepts, each team generated an average of 3.3 concepts.
- Most team-generated concepts different than individually generated concepts (2.6 concepts during the team ideation session **not** the same as those generated during the individual ideation session)

Team	Evidence of heuristics in final designs	Heuristic driven initial concept synthesis into team concepts	Heuristic driven initial concept synthesis into later stages	Heuristic driven initial concept direct transformation	Heuristic driven initial concept abstract transformation
A	Yes	Yes	Yes	Yes	No
B	Yes	No	Yes	Yes	Yes
C	No	No	Yes	Yes	No
D	Yes	No	No	Yes	No
E	Yes	No	Yes	No	Yes
F	Yes	No	Yes	Yes	No
G	Yes	Yes	No	Yes	No
H	Yes	Yes	Yes	Yes	Yes

5. DISCUSSION

- Evidence of heuristic-driven concepts in all phases of design shows that heuristics support practicality
- Heuristics are applicable in a variety of design contexts
    o All teams studied working on different design problems they chose themselves

Direct transfer
- Prevalent in 7 teams
- Suggests that student design teams may prefer design processes that are less advantageous to their design outcomes

Abstract transformation
- Prevalent in 3 teams
- Teams revisited original ideas of each Design Heuristic card and recast it to have a novel meaning

Synthesis
- Prevalent in 7 teams
- Synthesis was straightforward "sum of the parts" solution
- Kept essence of original heuristic-driven concepts same

Limitations:
- Qualitative work meant for transferability; study not designed to provide generalized findings across the board
- Did not consider how each team's relative success was influenced by Design Heuristics
- Did not consider how Design Heuristics' instructional protocol impacted students' choices to use Design Heuristics

6. CONCLUSIONS and FUTURE WORK

Design Heuristics supported practical ideation, where ideas developed initially were often incorporated into the final design prototypes.

Design Heuristics proved useful across multiple and diverse problem contexts.

Student teams tended to favor straightforward approaches to the design process and may benefit from building skills to successfully iterate on their ideas and to bring multiple ideas together.

- What approaches do teams use to develop their initial concepts using Design Heuristics?
- How can teams be most successful when using Design Heuristics?
- In which stages of design are Design Heuristics most useful?
- When do they lead to more creative, practical, useful solutions?
- How can we improve the integration and implementation of Design Heuristics into design courses?