Development of an instrument to measure engineering undergraduate students’ leadership skills and their abilities to embrace change and to synthesize multiple perspectives

Professional Practices Forum
Student Innovation Center

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Background

• Importance of leadership development in engineering education
  – ABET
  – STEM Education Policy Reports

• Development of leadership skills in engineering students will require understanding of **content**, **assessment**, and pedagogy
  – Content \(\rightarrow\) Definition of leadership
  – Assessment \(\rightarrow\) Tool to measure leadership (or related) skills
The present study purpose

• To examine, operational definition of leadership, change, and synthesis from engineering professionals via one-on-one interviews. (Content)

• To identify constructs to develop a survey instrument that measure three attributes: leadership, change, and synthesis in undergraduate engineering students. (Assessment)

• To develop and implement a survey instrument that examine students’ embodiments of three targeted attributes (Assessment)
Research questions

Phase I: Qualitative Study
• What do engineering experts within academia and industry identify as the outcomes for leadership, change, and synthesis abilities?

Phase II: Quantitative Study
• Which set of outcomes should be included in the final instrument tool that measures leadership/change/synthesis abilities in engineering undergraduate students?
Overview: Survey Development Process

Qualitative Study
- Professionals from academia and industry

Data Analysis
- Constant Comparative method
- Development of a codebook

Constructs
- Themes from Industry and Academia
- Survey development

Survey Items
- Leadership, change, and synthesis items reduced
Phase I – Qualitative Study

Data Collection
• In-depth semi structured interviews

Selection of Interview Participants
• Sampling criteria for interview participants are engineers in academia and industry
  – Who are working or researching in an engineering discipline
  – Who have led engineering teams
Phase I – Interview Questions (Sample)

Leadership
- How would you define leadership as an observable attributes?
- Can you give an example of a situation where an engineer would have to use leadership skills?

Change
- How do you define change in an engineering context?
- How do you think one can assess the ability of an engineer to recognize and manage change?

Synthesis
- Do you think that an engineer should be able to possess the skills to synthesize engineering, business, and social perspectives? Why is it important or not?
- Can you provide some real-life examples where a synthesis of engineering, business, and social perspectives occurred?
Phase I – Data analysis

Open-coding and constant comparison method will be used

1. Read transcripts (write ideas and memos)
2. Select passages and generate labels
3. Determine relationships among labels
4. Compare similarities and differences in the (provisional) labels
5. Examine the labels and collapse them under a construct
6. Meet with collaborators to discuss and revise construct definitions
7. Develop a codebook (analyze the rest of the transcripts)
8. Code all interviews
9. Identify the constructs
### Phase I – Results (Leadership Constructs)

<table>
<thead>
<tr>
<th>Construct</th>
<th>Summary of Construct Definition (Leadership)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motivation</td>
<td>Refers to leaders’ abilities to inspire people with good relations, to share their visions, and to energize people to achieve that vision.</td>
</tr>
<tr>
<td>• Proactive</td>
<td></td>
</tr>
<tr>
<td>• Empowerment</td>
<td></td>
</tr>
<tr>
<td>• People skills</td>
<td></td>
</tr>
<tr>
<td>• Outcome-driven</td>
<td></td>
</tr>
<tr>
<td>• Communication</td>
<td></td>
</tr>
<tr>
<td>• Technical competence</td>
<td></td>
</tr>
<tr>
<td>• See big picture</td>
<td></td>
</tr>
</tbody>
</table>
## Phase I – Results (Change Constructs)

<table>
<thead>
<tr>
<th>Construct</th>
<th>Summary of Construct Definition (Change)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Different Areas of Competency</td>
<td>Refers to an engineer’s ability to work on different kinds of jobs, across disciplines, and across diverse technologies.</td>
</tr>
<tr>
<td></td>
<td>• Technological advancement</td>
</tr>
<tr>
<td></td>
<td>• Change management</td>
</tr>
<tr>
<td></td>
<td>• Flexible</td>
</tr>
<tr>
<td></td>
<td>• Awareness</td>
</tr>
<tr>
<td></td>
<td>• Organizational change</td>
</tr>
<tr>
<td></td>
<td>• Social change</td>
</tr>
<tr>
<td></td>
<td>• Economic change</td>
</tr>
</tbody>
</table>
Phase I – Results (Synthesis Constructs)

<table>
<thead>
<tr>
<th>Construct</th>
<th>Summary of Construct Definition (Synthesis)</th>
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</thead>
<tbody>
<tr>
<td>Holistic Thinking</td>
<td>Refers to engineers’ abilities to make decisions based upon multiple points of view or considerations.</td>
</tr>
<tr>
<td></td>
<td>• Business perspectives</td>
</tr>
<tr>
<td></td>
<td>• Customer orientation</td>
</tr>
<tr>
<td></td>
<td>• Politics</td>
</tr>
<tr>
<td></td>
<td>• Cost</td>
</tr>
</tbody>
</table>
I motivate my team members to accomplish predefined goals...

I like participating in projects that incorporate aspects of other engineering disciplines...

I believe engineering design is affected by issues related to social and business environments...

Item 59
Phase II – Item development

• A four-point rating item format used (more reliable and stable)

• Developed items to be checked by experienced psychometrician, targeted audience
Phase II – Instrument Creation

Data Collection
• Compiled items using an online survey program
• Collect 750 data points

Data Analysis
• Item analysis
  – Check the accuracy of the data entry
  – Check for missing values and outlines
• Exploratory factor analysis
  – Identify the factors
  – Determine the correlations among measured variables
# Timeline

<table>
<thead>
<tr>
<th>Tasks</th>
<th>Study phase</th>
<th>Methods</th>
<th>Products</th>
<th>Instrument development</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase I</td>
<td>(1) Qualitative data collection</td>
<td>In-depth interviews</td>
<td>Interview transcripts</td>
<td>Determine what to measure</td>
</tr>
<tr>
<td></td>
<td>(2) Qualitative data analysis</td>
<td>Individual and group discussion</td>
<td>Constructs identified</td>
<td></td>
</tr>
<tr>
<td>Phase II</td>
<td>(3) Beta version of survey</td>
<td>Individual and group discussion</td>
<td>Items generated and refined</td>
<td>Design measurement format</td>
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<tr>
<td></td>
<td>(4) Quantitative data collection</td>
<td>Survey administered (Online based)</td>
<td>Survey completed</td>
<td></td>
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<tr>
<td></td>
<td>(5) Quantitative data analysis</td>
<td>Factor analysis, item correlation</td>
<td>Results available</td>
<td>Evaluate items and factors</td>
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</tbody>
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Questions?

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