The Many Homes of Engineering Education Research: Historical Analysis of PhD Dissertations

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CONTEXT

Engineering education is portrayed as an emerging discipline and several new PhD programs have been established. While it is undisputed that engineering education is currently forming itself as a discipline, there are indications that there is a longer history of research that address specifically engineering education topics than commonly perceived (in this paper as evidenced by Ph.D. theses).

The aim of this paper is to provide insights into the history of research in engineering education, by analyzing Ph.D. dissertations, which undertook engineering education research. The study employs bibliometric and scientometric methodologies, developed in the field of information and library science.

The long-term goals for this line of research are to produce a database and methodological tools to research emerging questions about engineering education and elucidate on evidence pertaining to the following:

* Limited number of researchers in the field/discipline
* Field/discipline dominated by women
* Limited fundamental understanding in the field/discipline, i.e., few theory-based or theory-building studies

RESEARCH QUESTIONS

The principal research questions are: (1) to what extent can we track and map the development of engineering education as a discipline by studying Ph.D. theses that emphasize engineering education, (2) who was studying engineering education at the PhD dissertation level?

This line of research is important for a number of reasons:
(a) To map past research on engineering education will reveal visible and invisible colleagues and may accelerate growth and recognition.
(b) To learn about and from the research of invisible colleagues can reaffirm the reasons why this new emerging discipline is necessary (i.e. to provide visibility).
(c) To know the roots of a discipline and "academic ancestors" provides a continuous line and can install a sense of tradition even into a young discipline.
(c) To know an existing and relevant body of research provides the community with a rich database to draw on and equips novices into the discipline with major contributions.

THEORETICAL FRAMEWORK

A developmental framework, adapted analogically from Developmental Science (Petermann, Niebank & Scheithauer, 2004) and Organizational Development (Senge, 1990), guided the research team. Developmental Science is an interdisciplinary approach to research the development of individuals and communities over their life-span. Organiza-

tional Development is the process through which an organization develops the internal capacity to most efficiently and effectively serve its mission through work and sustain itself over the long term.

Our adapted framework can best be described by the following attributes and assumptions (a) no human activity begins from a 'tabula rasa' (empty slate), (b) the developmental process assumes systematic and successive change over time including visible and less visible precursors, (c) development is characterized by both (1) evolutionary (cumulative) steps and (2) revolutionary (transformative) steps (see for revolutionary primarily Kuhn, 1979).

METHODOLOGY

Our methodology is grounded in bibliometric and scientometric analysis (Rehn & Ulfmann, 2006). As more digital data become publicly available new opportunities for researchers in education are arising, particularly in the application of information science and scientometrics. Scientometrics is the science of measuring and analyzing science. In practice, scientometrics is often done using bibliometrics that is measurement of (scientific) publications (ISSI, 2008).

Data source

Our primary source for Ph.D. theses was the dissertation database, Dissertations and Theses (PQDT), for the USA, Canada and Western Europe (coverage of Western Europe very limited). According to the publisher (Proquest, 2008), this database is the world's most comprehensive collection of dissertations and theses. This database contains over 2.4 million citations and over one million full-text PDFs, which cover dissertations from 1841 to current (with the last year (2007) not yet fully indexed).

Our process of can be described as follows:
1. Searching for theses/dissertations using Boolean search logic: Example: Title search "engineering education"; Title search "science education" AND engineering; "math(ematics) education" AND engineering; extension into abstracts (abstracts only available since 1980).
2. Verifying manually if the topic covers engineering and education
3. Cleaning the database to exclude master theses (main focus were doctoral theses).
4. Exporting the references to a reference visualization tool (refviz) and to a statistical analysis tool (excel) to perform descriptive statistics (distribution of frequency).

A typical record of a dissertation might include (level of details varies greatly):
Author, title, year, university, department, advisor, committee members, abstract, keywords and subject terms. For partial records, which did not include full information (for example on gender), we conducted follow-up searches screening the acknowledgement section of the dissertation and web-sites of faculty.

Analysis

In our preliminary analysis, we utilized descriptive statistics to reveal:
(a) Number of dissertations per year

(b) Number of the universities with highest number of Ph.D. theses
(c) Universities with a higher distribution of Ph.D. theses throughout different colleges

Additional qualitative coding was and is still performed to reveal (a) how many theses adhere to rigorous research standards and (b) how core or peripheral the dissertation topic was to engineering.

1. Criteria for core, comparative and peripheral topics of the dissertation
a) For a thesis to be declared "core" engineering education, either one of the following criteria had to apply: (a) research participants are engineers, (b) research within an engineering environment, or (c) topic "about engineering"
b) For a thesis to be declared "comparative", engineering had to be separated/singled out/compared amongst/along with other STEM disciplines.
c) For a thesis to be declared peripheral, the thesis had to be (a) STEM focused and (b) engineering as integrated/not separated out of STEM.

2. Criteria for rigorous research: A thesis was declared rigorous, if all of the following criteria were applicable: (a) Research questions present, (b) research questions derived from prior literature, (c) deliberate choice of research framework/methodology, (d) documented procedure of data analysis, and (e) discussion of results in light of prior research.

Expansion of the research to code the dissertations based on the following criteria will continue:

- Engineering Education Research Colloquia areas (JEE)
- Topic-cluster analysis of the dissertation to reveal major areas of existing research
- Cross-disciplinary committee members
- Shifts on research topics throughout time
- Overlay of pivotal events in engineering education.

All qualitative coding was using interrater-based methods to ensure reliability of the coding. After an initial coding of 20 dissertations by all researchers, the team continued with dyad-coding, meaning each theses was coded by two researchers who compared and calculated the interrater reliability co-efficient.

FINDINGS AND CONCLUSIONS

A search of the dissertation database resulted in 452 matches congruent with our search and verification strategies as outlined in the methodology section. To reiterate, these dissertations are all documenting educational research with a clear emphasis on engineering context. Furthermore, the research team wants to stress here, that at this stage of our research project, the search is not inclusive of all dissertations on engineering education. There are likely more studies in other disciplines, which are researching engineering education. Additional searches will be performed to harvest the rich literature in (a) design, (b) management, (c) architecture, (d) history, (e) sociology of science, and (f) more technologically oriented but related areas. Searching this pool of possible candidates will

prove more difficult, since the definition of engineering lays in the hands of the researchers, not in the hands of the authors of the Ph.D. theses.

Having created a searchable and reliable database from the available records, bibliometric analyses enabled us to map research production from 1841 to 2007. Our earliest dissertation was from 1929: Mann, C.V. (1929) Objective Type Tests in Engineering Education as Applied to Engineering Drawing and Descriptive Geometry, University of Iowa.

The following two graphs indicate the direction of our preliminary findings:

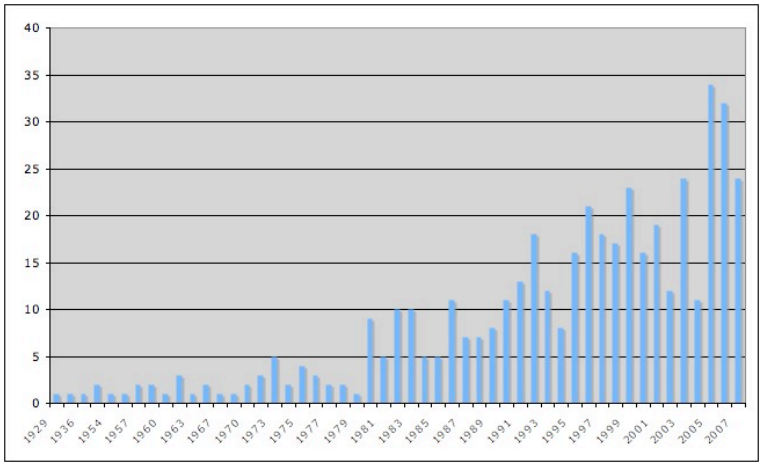

Figure 1: Ph.D. theses in engineering education topics over years

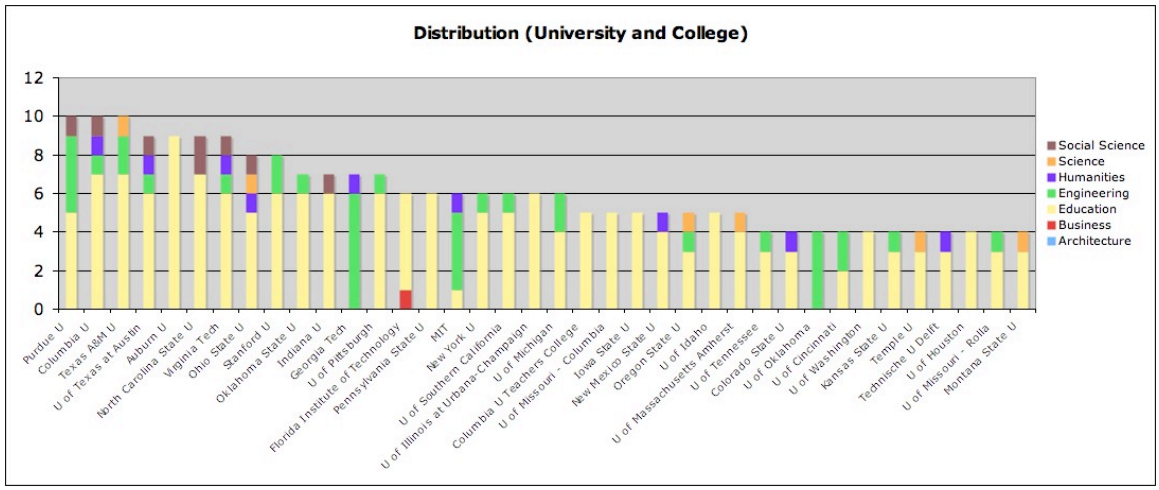

Figure 2: Distribution by University and College (only institutions with 4 or more theses reported)

RECOMMENDATIONS

Our recommendations pertain particularly to the education of the next generation of researchers in engineering education. Engineering education research does not happen in a vacuum: Our study indicates that engineering education research has a long, scattered, and as compared to science education, a relatively small and rather invisible history.

Nevertheless, a body of research literature exists, which Ph.D. students should be aware of. In addition, since most all of the Ph.D. studies are conducted at a variety of academic homes, reading the past research in engineering education can introduce the next generation of researchers to a wide variety of conceptualizations, theoretical frameworks and methodologies

This is an early sketch of existing literature on research in engineering education. Additional work will be done to (a) expand the library to underrepresented areas in which engineering education could be seen rather implicitly (i.e. design, management, history, sociology of science etc.), (b) extent the dissertation search to other countries. Databases for Australasian, Chinese, Latin- and South American, and European theses are already identified, (c) conduct citation analysis to find not only institutional powerhouses in engineering education but influential literature and citation clusters to see the intellectual influence, roots, and progression on the research in engineering education, and finally (d) to determine emerging themes and areas of engineering education.

In addition to these four immediate goals, future plans include (a) the study of the life-stories of engineering education researchers to track their career path and the variety of academic homes in which they pursued their research areas.

The research team is looking forward to the session of the symposium to receive feedback on additional categorization and codes, and additional research questions (and so to provide a form of "service discovery" for the emerging community).

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