

The Engineering Learning Environment and its Level of Complexity in an American Mechanical Engineering Program

Nadia N. Kellam and David K. Gattie

Faculty of Engineering, University of Georgia

Context: Current concerns within engineering education regarding low numbers of underrepresented minorities in engineering, serve as the basis for this research study which seeks to develop a deeper understanding of the engineering learning environment. Future studies will explore the contribution of the engineering learning environment to the underrepresentation of women and minorities within the engineering field. This paper explores the state of the current engineering learning environment, which may contribute to this unintended, yet glaring social inequity (Vogt, Hocesvar & Hagedorn, 2007). The level of complexity of the learning environment may be an important indicator of the diversity within a specific discipline and may help engineering educators address the issue of why underrepresented minorities are not choosing to pursue educations and careers in engineering (Jacobs, 2005). More importantly, intervention efforts that specifically address the complexity of the learning environment could prove to have systemic effects to engineering education programs internationally. Prior to implementing intervention efforts rigorous research must be conducted on the current state of the learning environment within engineering educational programs. This particular research study will focus on a typical mechanical engineering department at a Research I university in the United States to better understand 1) the relationships among and between faculty and students, and 2) the simplicity or complexity of the learning environment.

A basic contention will be put forth that the current engineering learning environment is flat, sequential and disjointed, (National Science Board, 2007) which gives rise to equally flat, sequential, and disjointed social fields and relationships among students. A connected, robust, culturally inclusive learning environment is proposed here as one approach for attracting a more diverse group of constituents (Gattie & Kellam, 2008; Kellam et al., 2007; Kellam, Maher, & Peters, 2008; Kellam & Gattie, 2008;). The current study will explore a mechanical engineering program in America to assess the robustness of the engineering learning environment based on the degree to which social fields of learning overlap and connect.

A healthy, robust learning environment can be classified as socioecological, including people and their multiple social fields, and is appropriately situated within a psychosocial context where student learning occurs within a person and not simply within a built environment. In learning environment research, the meaning of learning environment is based on Moo's three dimensions of human environments: Relationship, Personal Development, and System Maintenance and Change (Moos, 2002; Dorman, 2002). The learning environment is comprised of people, relationships among people, and climate or ambience within a setting (Johnson, 2002) and is the environment as perceived by the individual; therefore it is different for each person with their specific antecedents (Sergiovanni, 1986) or stream of life events (Aviolo, 1999). Moreover, disparate, unconnected learning environments may lead to a limited coping ability and inadequate decision making skills (Fredrickson & Branigan, 2005). Although some individuals learn quite well in, or in spite of, the current traditional engineering learning environment, such an environment should not be assumed as an acceptable general model (Moos, 2002).

Research Questions: The purpose of this study is to explore the engineering learning environment in a mechanical engineering program at a Research I University in the US and explores the following research questions:

1. How do faculty and undergraduate students perceive relationships among themselves and other faculty and students within their mechanical engineering program?
2. How simple (i.e. flat, disjointed, linear, sequential) or complex (i.e. textured, connected, robust, networked) is the engineering learning environment?

Theoretical Framework: The theoretical background of this work draws from Lewin's field theory, Murray's needs-press theory, Emery's open systems theory, and Bandura's social cognitive theory. Field theory postulates that behavior is not only a function of the individual person, but is also a function of their environment (Lewin, 1936). Years later, Murray developed the needs-press theory, which extended field theory by connecting the individual's needs and the environment's press (Murray, 1938) where the environment's press is the pressure that the environment exerts on the individual. Open systems theory extends the needs-press theory to study the system and environment exerting pressures on each other (Emery, 1959). Open systems theory is socioecological; it does not separate people from their environment, rather it conceptualizes people within environments. Lastly, social cognitive theory takes into account a person's behavior, personal factors, and the environment as a way to better understand and even predict a learner's success or failure (Bandura, 1986).

This study is approached from an underlying phenomenological philosophy, meaning that the intention is to develop a contextual understanding of the engineering learning environment, not to make sweeping generalizations. The intention was to develop a deeper insight into the learning environment as perceived by the specific sample of people interviewed and through analyzing artifacts of the engineering program. This preliminary research on an engineering learning environment allows for discovery to take place to inform future research. The theoretical framework underlying this research is an interpretivist one that attempts to develop an understanding of this specific mechanical engineering educational program.

Methodology: This study attempts to understand the engineering learning environment at different scales and different grain sizes through a secondary analysis of data collected through interviews, focus groups, and document analysis in a mechanical engineering program at a Research I University in the US (Denzin & Lincoln, 2005). This preliminary study of the engineering learning environment at one mechanical engineering educational program in the US will be used as a benchmark for developing future understanding of the simplicity or complexity of the engineering learning environment.

At the American Research I University, interviews were conducted with ten faculty, three focus groups were conducted with 11 undergraduate students, documents were collected from the departmental, college, and university websites and documents were collected concerning the program and curricular requirements. Moreover, documents were collected from Accreditation Board for Engineering and Technology (ABET) specifying accreditation requirements for mechanical engineering programs. Transcripts of interviews and focus groups, and field notes from the interviews, focus groups, and campus visits were analyzed to uncover emergent patterns in the data using a constant comparative method (Bogdan & Biklen, 2007).

Findings: The findings of the research are summarized as:

- 1) Most of the students indicated they are connected to a few students in their program. Their connections to students from outside of their program of study have diminished since they entered the engineering program. Some suggested that this is in part due to the less demanding workload for students in other majors.
- 2) Many of the interviewed students indicated that there is little connection between the current mechanical engineering program and engineering practice.
- 3) The interviewed faculty are not connected with their colleagues, as was demonstrated through their discussion of other faculty members' courses and research.
- 4) Many of the interviewed faculty indicated that the current mechanical engineering curriculum encourages students to think about each subject individually, without understanding connections between the subjects.
- 5) A review of the accreditation requirements indicated that the engineering learning environment is simple (disparate, disjointed, linear, and sequential), because of the focus on the desired outcomes instead of a focus on the process for attaining these outcomes. There also is little mention of other social fields of the students (i.e. prior experiences, professional experiences, or extracurricular activities).
- 6) The mechanical engineering program is linear and sequential with multiple prerequisite requirements, a maximum number of allowed courses, and an overall rigid, prescribed curriculum (little room for extra courses and little time for extracurricular activities).

As with any interpretivist study, there are multiple other findings or conclusions that could emerge from these data (Crotty, 2003). By analyzing the data as a team, we provided a check and balance system within the analysis, providing reliability of the findings.

Recommendations/ Future Research: Future research will explore how the retention and attraction of women and underrepresented minorities are affected by their perception of the engineering learning environment. More specifically, future research seeks to determine whether students are more likely to continue in an environment if that environment's complexity matches the students' perspective of the world, which is itself complex and living. The current study has taken initial steps to understand the engineering learning environment so that future studies can explore the relationship of the complexity of the engineering learning environment with the underrepresentation of women and minorities within engineering. These studies have promise for informing future intervention efforts that will change not only the perception of engineering, but the sociocultural engineering education system, i.e. the engineering learning environment.

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