Multidimensional Comparison of Project-Based Learning Programs

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Abstract – **In response to the nation-wide call for reform in STEM education, a number of universities are introducing non-traditional experiences in their engineering curricula as early as the freshman year. Although many of these experiences can be characterized as "project-based," they vary widely in their implementation. These variations hamper meaningful research on the relative impact these pedagogies have on student learning outcomes. In this paper, we will describe a tool that allows a multidimensional comparison of disparate non-traditional pedagogies. The tool will be used to first characterize and then quantitatively compare and contrast five different freshman-level engineering classes. This tool could provide a common basis for discourse regarding the relative effectiveness of other non-traditional STEM pedagogies regardless of the "labels" that might be affixed to them.**

Index Terms – Pedagogy, Comparison, freshman, non-traditional, project-based learning, STEM education

INTRODUCTION

In recent years, the drive for educational reform has come to support the implementation of non-traditional classroom instruction in an attempt to connect college curricula with more real-world applications. Studies have shown that inductive teaching contributes further to student understanding and intellectual development than traditional deductive methods of teaching [1]. In particular, project-based learning is included as an inductive teaching style because it involves the analysis and interpretation of an assignment, application of previous knowledge, and implementation of systems design concepts for the formation of a final product.

Project-based learning classes are structured to support student-centered, cooperative learning methods and aid in the association of existing knowledge with unfamiliar concepts through active learning. Defining characteristics of these programs include: complex and open-ended problems relevant to real-world context, major projects that prompt students' learning, non-professor lead discovery of course content, and independent, self-directed learning as well as collaborative, group learning [2].

Though this pedagogy has certain defining characteristics, it is implemented differently between universities. As a result, researchers have encountered a great deal of difficulty when attempting to compare different project-based learning courses at different sites. Prince & Felder [2] expand upon these complications that are encountered when assessing and effectively evaluating inductive approaches to learning. Their framework falls short however in that it views the universe of possible pedagogies as a finite set of discrete points. For them, every instantiation of what they call "inductive teaching" falls into one of eight specific categories. In our view, each implementation of a particular pedagogical approach can be described in terms of its position on a continuous spectrum.

Other researchers did recognize the need to characterize various approaches on a continuum. For example, Sheppard & Jenison [3] created a continuous two-dimensional space in which freshmen university programs were categorized into four discrete areas to compare different project-based pedagogies. In their framework, a course could be defined based on team versus individual content and process. However, we believe that the complex and elaborate workings of a course cannot be solely defined in a two-dimensional space. The differences between the myriad of approaches being employed today call for the use of a space with far greater dimensionality in order to accurately distinguish between various examples.

In this work we attempt to break new ground by proposing a multidimensional tool for characterizing the myriad of non-traditional pedagogies that are currently being employed across the country. In doing so we move beyond any debate about the "label" which should be affixed to each approach. In using this tool the labels become irrelevant and we open the door to quantitatively describing the degree of difference between specific approaches, regardless of the names that may have been assigned to them.

THE TOOL

This paper will define a multidimensional spectrum in which to map the various occurrences of pedagogies within Science, Technology, Education, and Mathematics (STEM) education at the undergraduate level. By first characterizing each program based on a rubric (Table I), the programs will be plotted in a multidimensional space and consequently standardize the classification of these courses.

The first step in developing this tool involved choosing the dimensions for comparison. We initially considered including several different characteristics of courses as the dimensions of our space, including the enrollment process for a course, the transition of power from the instructor to the student, budget, prerequisites, and credit hours. Other course characteristics were also analyzed as we developed this space, but it needed to be expressed more concisely if we could achieve any usability for this tool.

The final categories that were chosen are power distribution, multidisciplinary, utilization of time, evaluation, size of class, interaction between students, and equipment/materials.

- **Power Distribution**: Power distribution refers to the role of the students and the instructor in terms of who leads the class during class sessions, who assigns projects and homework, who assigns grades to students, and who holds students accountable when they do not complete their work. In other words, power distribution in our rubric is the degree of autonomy of the student. A traditional (rank of 1) course would give the instructor control over grades, assignments, and day-to-day proceedings. When the instructor holds most of the power but the students hold some (rank of 2), this means that students have the power over smaller assignments and due dates or exam dates. To have power distributed evenly between students and the instructor (rank of 3) means that students are able to control some day-to-day proceedings or assignments, such as choosing certain assignments of interest or choosing group work over lectures for certain class periods chosen by the professor. To receive a rank of 4, students control most of the day-to-day proceedings, but the professor still guides the class and keeps a structured formatting of class time. To receive a rank of 5, the students must have autonomy, though the instructor may still assign grades.
- **Multidisciplinary**: This category is meant to describe whether the class spans multiple fields of study, or if it is meant for a single specialized field. For instance, a ranking of 1 would be a class devoted solely to electrical engineering, but a ranking of 5 would involve electrical engineering, mechanical engineering, systems engineering, and software engineering.
- **Utilization of Time**: The utilization of time refers to the time spent in class sessions and whether it is devoted to lecture, lab, project work, or mixtures of these.
- **Evaluation**: Evaluation can come in the form of exams, quizzes, homework, and projects, but it can also come in the form of feedback from instructors and peers.
- **Size of Class**: The size of the class is fairly straightforward; it is based on the number of students in the class and the amount of opportunities for individual student interaction with the instructor. We think of large as a lecture hall, and small as 5-10 students.
- **Interaction Between Students**: Interactions between students refers to how students collaborate to get through the class; students might tend to collaborate extensively outside of class, or students could tend to work individually on assignments.
- **Equipment/Materials**: Finally, the equipment and materials category is to measure the monetary scope of the course, since some courses simply require textbooks, while other courses require an entire lab with expensive materials.

Table I shows the rubric for classifying programs into a multidimensional space that represents the non-traditional aspects of a class. The goal of this rubric is to compare the scope of the courses in terms of these categories and to use the resulting scores for quantitative comparison.

TABLE I
NON-TRADITIONAL RUBRIC USED TO PLOT PROGRAMS ONTO MULTIDIMENSIONAL SPACE

	1 (Traditional)	2	3	4	5 (Non-traditional)
Power Distribution	All power is held by the instructor.	The instructor holds most of the power but students hold some influence.	Power is distributed evenly between students and instructor.	Students mostly control the class but the instructor still has control.	Power is in the hands of the students. The instructor acts as an advisor and resource.
Multi-Disciplinary	Only spans one main discipline.	Can be applied to a couple of disciplines.	Spans a few related disciplines.	Spans many disciplines but in limited ways.	Spans multiple disciplines.
Utilization of Time	Time is spent in lecture alone.	Most time is spent in lecture with the occasional lab or group activity.	Time is split somewhat evenly between lab/project time (e.g., lab period) and lecture.	The majority of class time is spent doing labs or a large project but there are still lectures.	No strict schedule exists and class is used to get work completed.
Evaluation	Students are graded using assessments (especially exams) and homework.	Grades are based on assessments (mostly exams, few projects) and homework with some consideration of effort.	Students are graded with exams, projects, and homework as well as a consideration of effort.	Grades take effort into account and may include project and/or homework grades. Few if any exams.	Grades are based on how much effort students put into the class/projects. Basically no exams or homework.
Size of Class	Classes are large and impersonal (e.g., large lecture hall).	Classes are typically large but there is some personalized attention.	Medium class size with some personalized instruction.	Classes are typically small with close student-teacher relationships.	Class sizes are small with close student-teacher relationships.
Interaction Between Students	Small amount of interactions. Little to no group work.	Students occasionally interact with each other in class.	Students interact regularly within class.	Students interact regularly in class and sometimes out of class.	Constant interaction between students inside and outside of class.
Equipment/ Materials	Textbooks and manuals are the materials needed for the course.	Textbooks and manuals are needed as well as a few lab pieces.	Textbook and lab equipment is needed for this course.	Lab materials and project-specific materials are used.	Most of the materials are project-specific and purchased throughout.

EXAMPLES

In this section, we will discuss several examples of classifying programs using this rubric. These examples were chosen because they are first-year STEM classes that contain at least some elements of a project-based class. After about fifteen programs were found, programs that exhibited different levels of our rubric were chosen and five of these are discussed in detail here to give a well-rounded example of how to use the tool without extending it unnecessarily. Utilizing this rubric to its full potential, after all, depends on one's knowledge of the course being analyzed. Therefore, for the following examples we will use what information is readily available, but, again, the purpose of this rubric is to be easily used and understood so that those with first-hand knowledge of a course can analyze it themselves, resulting in a more accurate data point.

I. Colorado School of Mines

Located in Golden, Colorado, the Colorado School of Mines is a public engineering college with a special emphasis on geosciences and natural resources. This university requires all undergraduate students to take two design-related courses during their first year. The sequence is known as EPICS (Engineering Practices Introductory Course Sequence). EPICS I 151 is required during the first semester. This class introduces the concepts of design and communication through the use of an open-ended design problem that students work on for a whole semester. The class is divided into 3 days. They have a project day in which they work on their project (2 hours), a graphics day during which they receive traditional instruction (2 hours), and a workshop day for an hour in which they listen to guest lecturers and discuss what they are learning. There are 2 sections of 25 students, and each class has a mentor. Students work on projects in teams of 4 to 6 students. The second semester simply builds upon this first semester if students continue with EPICS II 251.This would be ranked using our rubric as follows:

- **Power Distribution**: EPICS receives a rank of 4 in this category since each class section has a mentor, suggesting that the students mostly lead their projects. However, the class is still divided into three days, meaning the instructor still controls the general teaching and order of the class.
- **Multidisciplinary**: EPICS receives a 3 in this category since there are guest lecturers and some graphics as well as communication instruction. However, specific multidisciplinary activities are not stated directly.
- **Utilization of Time**: This class has a 4 in this category because there are several hours devoted to a design project. However, there are still lectures.
- **Evaluation**: This receives a ranking of 4 because, although it is not specifically mentioned on the course website, it seems as though there could be some, homework and exams in the lecture component of the course, however, there is probably also some evaluation of effort and participation in the design project portion of the course.
- **Size of Class**: This also receives a ranking of 4 because there are two sections with 25 students each with 4 to 6 students to a team.
- **Interaction Between Students**: EPICS gets a 4 again since these are design projects. Although it is not stated directly, it is probably safe to assume that the student teams interact a fair amount at least in class.
- **Equipment/Materials**: This class receives a 4 for this category as well because it seems as though there are some required pieces of equipment, though some may be bought to further the design projects throughout the design process. It is unknown whether this is true or if there is a textbook based on the course website [4].

II. Drexel University

This university, located in Philadelphia, Pennsylvania, also has several beginning engineering classes devoted to freshman. This, however, is a sequence that continues throughout the whole year (3 quarters). It is known as Freshman Design I, II, and III. In the first ten-week class, students study camera and accelerometer modules. The first five weeks, students disassemble a disposable camera and analyze its components. They then study the shutter mechanism, create a computer model of it, modify this model, print a new shutter with the rapid prototyping machine, place the new shutter in the camera, and measure the shutter speed of the modified camera. During the second five-week period, students connect an accelerometer sensor to a Data Acquisition Board with MATLAB to control the motors of the platform in order to illustrate orientation sensing in mobile devices. Freshman Design II "introduces students to sensor operation and algorithm design through a hands-on experiment using a LEGO Mindstorms NXT robot" [5]. Groups are given a robotics kit, and they build and program these robots to compete in a class competition. In Freshman Design III, "students apply what they've learned, and independently explore new topics, to design and fabricate an original prototype with the help of fellow students and faculty" [5]. Students propose their own project or choose projects proposed by faculty or fellow students, and groups of three to five students are paired with a faculty advisor to create their prototype. This would be ranked using our rubric as follows:

- **Power Distribution**: Freshman Design I and II receive a rank of 2 for this category because the instructor is very much in control of the structure of the class. Students complete projects and labs that have been given to them by the instructor. However, Freshman Design III is slightly more balanced and receives a rank of 3 since students are given the power to choose their own design project.
- **Multidisciplinary**: Freshman Design I and II receive a rank of 2 because there seem to be some topics covered that could span several disciplines, though it is not stated directly in the syllabus. For Freshman Design III, students can choose a design project in biomedical applications, environmental applications, robotics, game

and mobile app design, or materials. This is somewhat multidisciplinary, but since only a single project (field) is chosen, it receives a rank of 3.

- **Utilization of Time**: Freshman Design I, II, and III receive a rank of 3 because each class is divided into lecture periods (1 hour per week) and into lab periods (2 hours per week).
- **Evaluation**: All three classes receive a 4 because effort/participation is taken into account for grades, there are project and homework grades, and there are no exams.
- **Size of Class**: Freshman Design I and II receive a 3 since they are slightly more traditional classes with labs and lectures. Freshman Design III receives a 4 because students are in groups of 3 to 5 people with a single advisor when they work on their design projects, though lectures are still likely the same size as Freshman Design I and II.
- **Interaction Between Students**: Freshman Design I, II, and III receive a rank of 4 because students are placed in lab groups and must maintain a lab notebook. This likely requires at least some communication outside of class. Students in Freshman Design III must also maintain a website to track their progress.
- **Equipment/Materials**: Freshman Design I, II, and III receive a rank of 4 because students must keep a lab notebook and students use project-specific materials, including kits [5].

III. University of Michigan

This university, located in Ann Arbor, Michigan, has a very unique program for engineers in their first year. Students are given the chance to select from fourteen design challenges based on their interests. Categories of these challenges include alternative energy, biomedical technology, computers and programming, vehicle design, engineering and the arts, and engineering for humanity.

We are going to look at two examples of these classes. The first is called Solar Cells: Renewable Energy Section 400. The project for this is to "Design, build, and test a new product powered by solar energy" [6]. In this project, students first start by building a solar-powered model car to race against other teams and conduct laboratory experiments to learn about energy conversion in polycrystalline silicon solar cells, Ni-Hydride batteries, and LEDs. For the second half of the semester, students propose, design, build, and test a prototype of a new solar-powered product. Students must consider economic, environmental, and societal impacts of their products as they work, and the semester ends with a presentation of the product at an expo. This would be ranked using our rubric as follows:

- **Power Distribution**: This class receives a 3 because the course still seems to have a large amount of structure, with labs and lectures in the beginning. However, students have a large project at the end of the semester over which they most likely have control.
- **Multidisciplinary**: The Solar Cells class receives a 4 because some entrepreneurship is taught in addition to communication, photovoltaics, and other engineering concepts.
- **Utilization of Time**: This class receives a 4 because the majority of the class is spent doing labs and a large project, but there are still lectures in the beginning of the semester.
- **Evaluation**: This class receives a 3 because it seems as though there may be some exams and homework, especially towards the beginning of the term. However, this information is not explicit on the class website.
- **Size of Class**: Again, this information is not explicit, but since there are two faculty instructors, it is likely that students are able to develop close student-teacher relationships. Also, to accomplish a group project, it is probably a relatively small class. Therefore, this class receives a 4.
- **Interaction Between Students**: Since this class involves labs and a project at the end, students must collaborate and therefore this class receives a 4.
- **Equipment/Materials**: This class receives a 4 because lab materials are required, as well as materials for the project.

The other University of Michigan program that we will look at is the Underwater Vehicle Design Section 600. This project is to "Design, build, and test an underwater vehicle, steered by a video game controller-type control box of your own design, that is fast and highly maneuverable [6]." Students work in teams of five with a student who has previously taken this course to design, build, and test a Remotely Operated Vehicle (ROV) designed for ocean or lake exploration. They are provided building spaces, equipment, and lab times. An additional week of testing is provided at the Marine Hydrodynamics Laboratory in West Hall so students can test their ROVs in water up to 12 feet deep. Then, there is a competition held at Canham Natatorium. This would be ranked using our rubric as follows:

- **Power Distribution**: This class receives a rank of 4 because students are given few requirements for their design project in terms of size and function. This seems to mean that students have more control over their project, but the instructors are still in control of the class.
- **Multidisciplinary**: This class receives a rank of 3 because it offers background in several engineering topics, such as "…3D modeling, pressure, buoyancy, stability, ship resistance, basic electric circuits, systems design, probability, statistics, risk, ethics, technical documentation, and team communication and collaboration".
- **Utilization of Time**: This class receives a 4 because students are given this project to complete during regular lab times, which take place 6 hours per week.

However, it seems as though some lectures may be present.

- **Evaluation**: This class receives a rank of 4 because there is likely an emphasis on effort and participation in the project portion of the class, but there is definitely the main project and there are reports that are required after the project is completed.
- **Size of Class**: This class receives a rank of 5 because there are two instructors for the class and peer mentors for each group of 4 to 5 people. This means the class is relatively small and that students have the opportunity to develop relationships with instructors and mentors.
- **Interaction Between Students**: This class receives a rank of 5 because teams of students are required to complete this project. Students have a lab devoted to them with open lab times, meaning they are able to work on this project outside of class and likely communicate both outside and inside of class.
- **Equipment/Materials**: This class receives a rank of 4 because materials are provided to students to create an ROV [6].

IV. Rochester Institute of Technology

This technical university situated in Rochester, New York, offers an undergraduate degree in Imaging Science. Imaging Science is "…a field of study that uses physics, mathematics, computer, and cognitive sciences to better understand the many factors that influence and make possible the capture and analysis of imagery" [7]. For freshman in this program, the Innovative Freshman Experience (i.e., Freshman Imaging Project) is required for both semesters. In this class, a project is given to students the first day of the class. The goal is to design and build an imaging system for the innovation festival, ImagineRIT, at the end of the year. There are no lectures, textbooks, or exams. Students must simply work together and ask faculty for help in order to succeed by ImagineRIT. This class is multidisciplinary. Although Imaging Science students are required to take it, students from other majors often join as well, including students of Motion Picture Science, Systems Engineering, Software Engineering, Computer Science, and undecided students. The class takes place in a lab devoted solely to this class, and students are given a large budget. The instructor serves as a guiding force to help point students in the right direction, especially at the beginning. This would be ranked using our rubric as follows:

- **Power Distribution**: This Freshman Imaging Project receives a 5 because the instructor is purely a guiding force. Decisions are left up to the students.
- **Multidisciplinary**: The Freshman Imaging Project receives a 5 because the project requires knowledge in several fields, such as Imaging Science, Motion Picture Science, Computer Science, Systems Engineering, and Electrical Engineering.
- **Utilization of Time**: The Freshman Imaging Project receives a 5 because class time is devoted solely to the project. There are no lectures.
- **Evaluation**: The Freshman Imaging Project receives a 5 because there are no exams or specific homework. There is only the project, and grades are based on effort and participation in the project.
- **Size of Class**: The Freshman Imaging Project receives a 4 because, in the past few years, there have been approximately 20 students enrolled in a class devoted to one project. There are plenty of faculty members to help, but this is probably not the smallest class that could be found.
- **Interaction Between Students**: The Freshman Imaging Project receives a rank of 5 because students are required to work on the project both inside and outside of the classroom. There is also communication via text and Facebook.
- **Equipment/Materials**: The Freshman Imaging Project receives a rank of 5 because the students are given a budget to control and use to buy materials for their project as needed. Students are not asked to buy certain materials before the class, and there are no textbooks [8].

V. Western New England University

At this Springfield, Massachusetts university, there is another engineering sequence. In the fall semester, students take Introduction to Engineering. In this class, students are broken into teams of four to design and build a Fully Autonomous Multitasking Robot. At the end of the course, teams compete against each other. Throughout the course, students learn to program a microcontroller, to read wiring diagrams, and to optimize energy. They also learn skills such as soldering and assembling metal parts. They then design real-world products to exhibit at the end of the semester [9]. This would be ranked using our rubric as follows:

- **Power Distribution**: This course receives a 2 because there seems to be a large amount of traditional lecture with the instructor fully in charge with only some real-world design projects that students can call their own.
- **Multidisciplinary**: Since this a course of general introduction to engineering, it spans several disciplines related to engineering and this course receives a rank of 3.
- **Utilization of Time**: The majority of the class time seems to be devoted to lecture, but there is a design rank of 2.
- **Evaluation**: The grades in this class are based on projects, exams, quizzes, homework, written reports, and oral presentations. This class therefore receives a 1.
- **Size of Class**: Class sizes are small and there are only 4 people per team for group activities [9]. This class therefore receives a 5.
- **Interaction Between Students**: Since this class does not seem to be focused on the design project or group projects, communication between students is probably slightly less and probably focused on in-class activities. Therefore, this class receivies a 2.

- **Equipment/Materials**: This class may require a textbook and a laboratory kit, so it is ranked at 3.

MULTIDIMENSIONAL SPACE

Now that each of these example programs have been described and ranked on the rubric, it is time to plot them onto the multidimensional space and compare them. As it is most convenient to display a graph in two-dimensions, a two-dimensional slice of this space is shown in Figure 1. This particular slice shows that the Rochester Institute of Technology class is the most non-traditional class in terms of the utilization of time, the power distribution, and the evaluation, whereas Western New England University has a more traditional class.

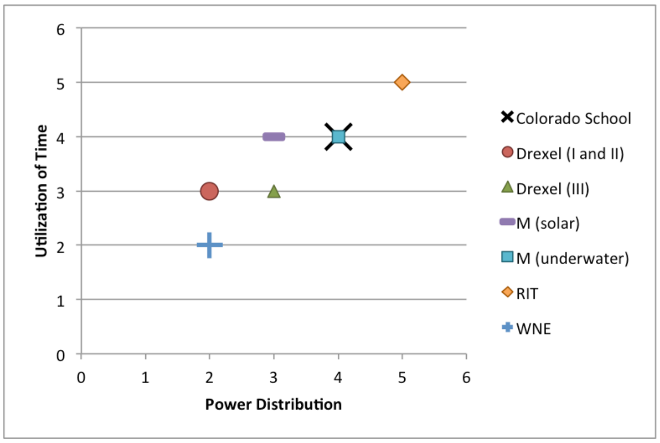

FIGURE 1
TWO-DIMENSIONAL SLICE OF MULTIDIMENSIONAL SPACE

In another example (Figure 2), the evaluation method and the size of the class were plotted against each other. The distribution looks slightly different than it does in Figure 1. In this case, the most non-traditional courses are the University of Michigan underwater course, the Colorado School of Mines EPICS course, and the Rochester Institute of Technology course since these are all closest to the point (5, 5), which would correspond to a course that was the most non-traditional it could be in terms of the size of the class and the evaluation. The most traditional courses are the University of Michigan solar course and the Drexel University Freshman Design I and II courses because they are closest to the point (0,0), which would correspond to the most traditional course possible in terms of evaluation and size of class.

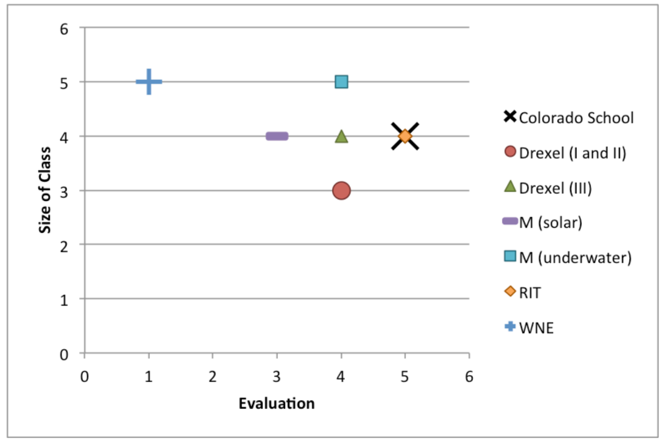

FIGURE 2
TWO-DIMENSIONAL SLICE REGARDING EVALUATION AND SIZE OF CLASS

To compare the programs with a more quantitative metric, distance calculations between different programs will be done in order to find numerical differences between programs. Equation 1, the Euclidean distance equation, will be used to do this. In this case, d represents the distance between two points in multidimensional space, or the difference between the two programs. The variable a represents the first program, and the variable b represents the second program. The subscript 1 represents the first category of the rubric, power distribution.

$$d = [(a_1-b_1)^2 + (a_2-b_2)^2 + \ldots + (a_7 - b_7)^2]^{1/2} \quad (1)$$

The two universities to be compared for this example are Rochester Institute of Technology, which will be a, and Western New England University, which will be b. The subscript of 1 represents the first category of the rubric, which is power distribution. The subscript of 2 represents multidisciplinary, and the subscript of 7 represents equipment/materials. Therefore, in this example, $a_1 = 5$, $b_1 = 2$, $a_7 = 5$, and $b_7 = 3$. The scores for the third through sixth categories were also included in the calculation. This produced a distance between them of about 7.2 units. The difference between Rochester Institute of Technology and the University of Michigan's Underwater Section, however, is 3.0 units. This means that Rochester Institute of Technology and the University of Michigan's Underwater Section are more similar than Rochester Institute of Technology and Western New England University.

CONCLUSIONS

A multidimensional space has been created in order to allow for quantitative comparison between academic programs nation-wide. In the future, if this could expand and become an open source tool, STEM instructors everywhere would be able to add their classes to an online database. Then, comparisons of different approaches could ensue, and in that manner, we as a nation could begin to determine the most effective manner of teaching STEM.

References

[1] Prince, Michael & Richard Felder. "The Many Faces of Inductive Teaching and Learning." March/April 2007. *Journal of College Science Teaching.* http://www4.ncsu.edu/unity/lockers/users/f/felder/public/Papers/Inductive(JCST).pdf. Accessed: February 17, 2014.

[2] Prince, J. Michael & Richard Felder. "Inductive Teaching and Learning Methods: Definitions, Comparisons, and Research Bases." http://www4.ncsu.edu/unity/lockers/users/f/felder/public/Papers/InductiveTeaching.pdf. Accessed: February 17, 2014.

[3] Sheppard, S., & Rollie Jenison. 1997. "Examples of Freshman Design Education." *The International Journal of Engineering Education*, *13*(4), pp. 248–261.

[4] "EPICS 151." 2012. http://epics.mines.edu/EPICS-151. Accessed: January 18, 2014.

[5] "Freshman Engineering Experience." 2013. http://www.drexel.edu/engineering/resources/prosp_students/FreshmanEngineeringExperience/. Accessed: January 18, 2014.

[6] "Engineering 100: Introduction to Engineering." 2013. http://www.engin.umich.edu/courses/eng100. Accessed: January 18, 2014.

[7] "B.S. Imaging Science." 2013. http://www.cis.rit.edu/undergraduate. Accessed: January 18, 2014.

[8] "What is IFE?" 2013. http://www.cis.rit.edu/IFE/whatis. Accessed: January 18, 2014.

[9] "First Year Program in Engineering." 2013. http://www1.wne.edu/engineering/index.cfm?selection=doc.421. Accessed: January 18, 2014.

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