# AC 2011-2166: PROPOSING A STRUCTURED GRAPHICAL MODEL USING IDEF THAT CAN BE USED FOR STORING, ORGANIZING AND STUDYING FACTORS THAT INFLUENCE GIRLS AND YOUNG WOMEN TO CONSIDER A CAREER IN ENGINEERING

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# Proposing a Structured Graphical Model Using IDEF that can be used for Storing, Organizing and Studying Factors that Influence Girls and Young Women to Consider a Career in Engineering

**Abstract**

Many factors contribute to achieving a successful, lifelong career in the engineering field. Because of the extremely diversified and specialized areas of engineering that have emerged during the last couple of decades, people of different backgrounds, races and especially women have more opportunities than ever. Although there are cases of universities increasing female enrollment and retention around the U.S., many universities continue to experience a very low number of female students that decide to study engineering. For example, at the Oregon Institute of Technology (OIT) during the past 5 years, the percentage of first year females in the orientation classes for engineering has been less than 10%. To understand better how these trends and statistics can be changed, tools must be developed to help gather, organize and study the factors that influence and impact K-12 age group girls. The purpose of this poster/paper project is to describe a model developed by OIT professors and students based on the ICAM Definition (IDEF) graphical language that can be used to record data and responses collected while working with local K-12 students on a Department of Defense (DOD) youth program called Starbase2.0. The paradigm proposes a multi-tier approach that looks at different phases of life, from late elementary and middle school to adult, working women engineers.

**Introduction and Background:**

By talking with professional women engineers, one starts to recognize the wide variety of factors that contributed to their success. A common thread that ties most of the group together is the fact that they had to overcome barriers and stereotypes from a very early age. Another reason for choosing a career in engineering is the influence of a mentor or other adult that encouraged them to take part in a project or class that had components of engineering. By being exposed to situations and tasks that challenged them and fit with their personalities and interests, many decided at an early age that engineering was a definite possibility. Whether it was because of an influential professor, a family member, participation in an after school, or exposure by joining a branch of the military, many women engineers point to early and middle childhood as the time when their eyes were opened to an exciting future in engineering.

Many efforts are currently underway to increase female enrollment in university engineering programs. There is also a lot of work being done to engage young girls in activities and projects that expose them to technology and tasks related to design, research and building new products. Furthermore, the traditional scope of engineering as being Civil, Mechanical, Electrical and Chemical has now expanded to include many other and related areas. Careers in energy, biomedical, industrial, design and management might also fit for the interests, skills and personalities of some young women and appeal to their creativity, artistic ability, critical thinking as well as involve helping others and making the world a better place, which are reasons that apply to all areas of engineering and can attract more women to these fields.

Researchers and professionals interested in acquiring a better understanding of why and how things are changing for future generations are looking at marketing, recruiting, retention, and how to attract more young women into engineering programs are making a difference. Although there are examples of progress and successful initiatives, the low numbers of female enrollment in K-12 pre-engineering and undergraduate engineering programs continues to be worrisome. There is also a big change going on in the demographics and minority populations around the country. Table 1 provides data on engineering enrollment in undergraduate engineering programs and provides statistics based on sex, race/ethnicity and citizenship. These changes introduce another layer of complexity to the problem that will continue to grow and affect our society. Universities that are located in small, rural areas and communities with high minority populations are especially affected by this dilemma because it requires a paradigm shift from many perspectives including cultural, gender and society in general.

TABLE 1: Undergraduate enrollment in engineering programs, by sex, race/ethnicity, and citizenship: 2007

| Sex and status | All undergraduates | White | Asian | Black | Hispanic | Native American | Foreign national |
|---|---|---|---|---|---|---|---|
| | Number | | | | | | |
| All enrolled | 399,429 | 274,742 | 43,487 | 21,898 | 35,256 | 2,315 | 21,731 |
| Male | 330,110 | 232,509 | 34,115 | 16,228 | 27,752 | 1,776 | 17,730 |
| Female | 69,319 | 42,233 | 9,372 | 5,670 | 7,504 | 539 | 4,001 |
| Full time, first year | 110,558 | 76,071 | 11,200 | 7,224 | 9,452 | 729 | 5,882 |
| Male | 91,941 | 64,501 | 8,885 | 5,444 | 7,641 | 556 | 4,914 |
| Female | 18,617 | 11,570 | 2,315 | 1,780 | 1,811 | 173 | 968 |
| | Percent distribution | | | | | | |
| All enrolled | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Male | 82.6 | 84.6 | 78.4 | 74.1 | 78.7 | 76.7 | 81.6 |
| Female | 17.4 | 15.4 | 21.6 | 25.9 | 21.3 | 23.3 | 18.4 |
| Full time, first year | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Male | 83.2 | 84.8 | 79.3 | 75.4 | 80.8 | 76.3 | 83.5 |
| Female | 16.8 | 15.2 | 20.7 | 24.6 | 19.2 | 23.7 | 16.5 |

NOTE: Race/ethnicity/citizenship categories are those used in the survey's data collection.

SOURCE: Engineering Workforce Commission, *Engineering & Technology Enrollments: Fall 2007* (Washington, DC, 2008).

## Description of the ICAM Definition (IDEF) Graphical Language Methodology

The graphical language used in this project to create a model for identifying characteristics and factors that influence females to consider engineering as a viable career choice is based on the Structured Analysis and Design Technique (SADT) invented by Douglas T. Ross and first used in the Airforce in 1973. During the 1970s, the U.S. Air Force Program for Integrated Computer Aided Manufacturing (ICAM) sought to increase manufacturing productivity through systematic application of computer technology. [2] The ICAM program identified the need for better analysis and communication techniques for people involved in improving manufacturing productivity. As a result, the ICAM program developed a series of techniques known as the IDEF (ICAM Definition) techniques which included the following:

1. IDEF0, used to produce a "function model". A function model is a structured representation of the functions, activities or processes within the modeled system or subject area.

2. IDEF1, used to produce an "information model". An information model represents the structure and semantics of information within the modeled system or subject area.

In 1983, the U.S. Air Force Integrated Information Support System program enhanced the IDEF1 information modeling technique to form IDEF1X (IDEF1 Extended), a semantic data modeling technique. Currently, IDEF0 and IDEF1X techniques are widely used in the government, industrial and commercial sectors, supporting modeling efforts for a wide range of enterprises and application domains. [7] The techniques are used to provide a modeling technique that has the following characteristics:

- Generic (for analysis of systems of varying purpose, scope and complexity);
- Rigorous and precise (for production of correct, usable models);
- Concise (to facilitate understanding, communication, consensus and validation);
- Conceptual (to represent functional requirements rather than physical implementations);
- Flexible (to support several phases of the lifecycle of a project). [7]

Although the technique/language was originally designed for manufacturing applications, the generic nature and characteristics provide a flexible tool that can be applied in many areas.

**Description of the Department of Defense Sponsored Starbase2.0 Youth Program**

STARBASE 2.0 combines STEM (science, technology, engineering, and mathematics) and inquiry based activities with a relationship-rich, school-based environment to provide the missing link for at-risk youth making the transition from elementary to middle school. It extends the positive impact of STARBASE through a team mentoring approach which solidifies students' attachment to school and engagement in STEM.

**Vision Statement**:
The vision of DoD STARBASE is to raise the interest and improve the knowledge and skills of at-risk youth in science, technology, engineering and mathematics (STEM), providing for a highly educated and skilled American workforce that can meet the advanced technological requirements of the Department of Defense.

**Mission Statement**:
STARBASE 2.0 combines STEM activities with a relationship-rich, school-based environment to provide the missing link for at-risk youth making the transition from elementary to middle school, It extends the positive impact of STARBASE through a team mentoring approach which solidifies students' attachment to and engagement with school.

**Goals & Objectives**
- Increase student interest in and knowledge of STEM disciplines
- Reduce students' high-risk behavior
- Increase engagement with schools
- Increase STEM career awareness
- Provide opportunities of service for STEM professionals

## Development of Methodology and Model

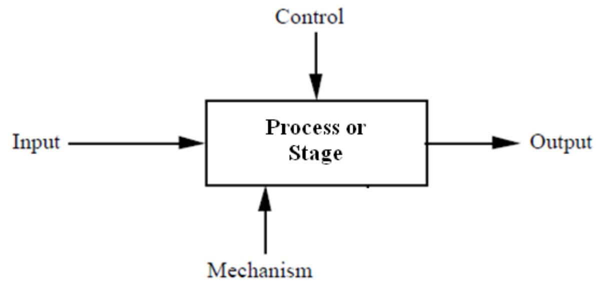


**Figure 1: Basic IDEF Building Block**

The building block of an IDEF model is shown in Figure 1: Inputs come in from the left, outputs go out from the right and the controls and mechanisms are shown on the top and bottom respectively. The model proposed in this project connects 4 of the basic blocks in a configuration that represents stages in the life of girls. First is the elementary /middle school phase, second is the high school, third is university age and forth is women professional engineers. By representing these stages in a connected model, relationships, cause/effect, and critical factors can be stored in the same consistent format. It will be useful from a standpoint of viewing the "big picture" as well as providing a medium to break down each stage and study factors and details related to each area. The model below represents the final structure for this project.

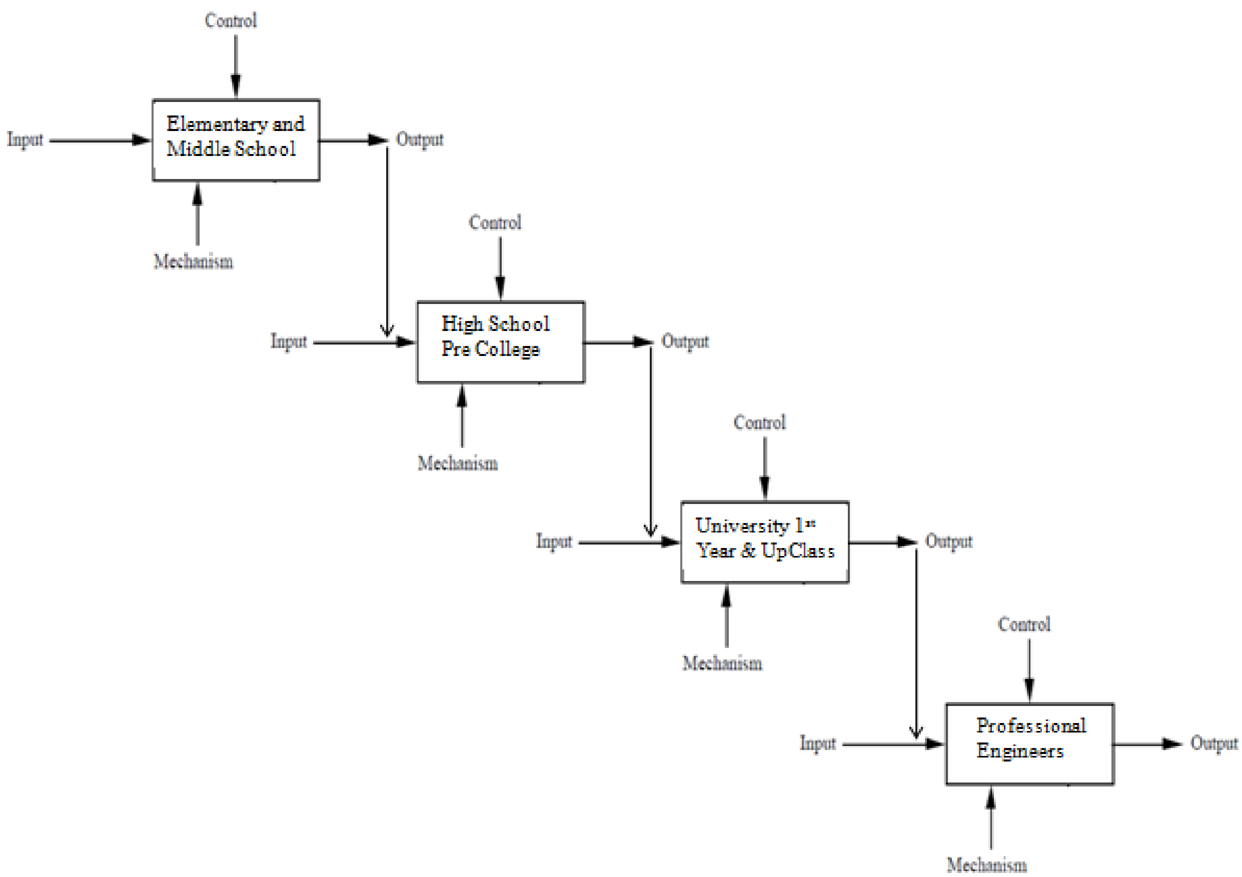


**Figure 2: IDEF Model For Studying Factors Related to Stages of Women in Engineering**

As is customary when using an IDEF model, each stage or process can be expanded into sub processes and information stored with each stage. The model will be used to demonstrate how responses to questions listed in the following section can be incorporated in the model. Figure 3 shows how the topic of this paper can be mapped to a typical IDEF block relating the following ideas; 1) Inputs and outputs represent the girls as they come into and go out of each stage of their academic career, 2) Controls and Mechanisms represent the tools and experiences that could influence their development of an interest in engineering and science related activities and the inside of the block can be used to store the questions and pertinent information as it relates to their background, skills, interests and barriers to continuing toward a career in engineering or related fields.

At this time, there have been some surveys distributed and collected from 3 of the 4 age groups. Elementary and middle school, high school and university students from the local area were asked questions and some of that data will be incorporated into the poster presentation to take place at the ASEE 2011 conference. The purpose of this paper and poster is to present the idea of a modeling technique and graphical tool that can be used for future work and help to understand the cause/effect relationship between experiences at one stage in life and how that can impact a person's decision to pursue a career in fields related to engineering.

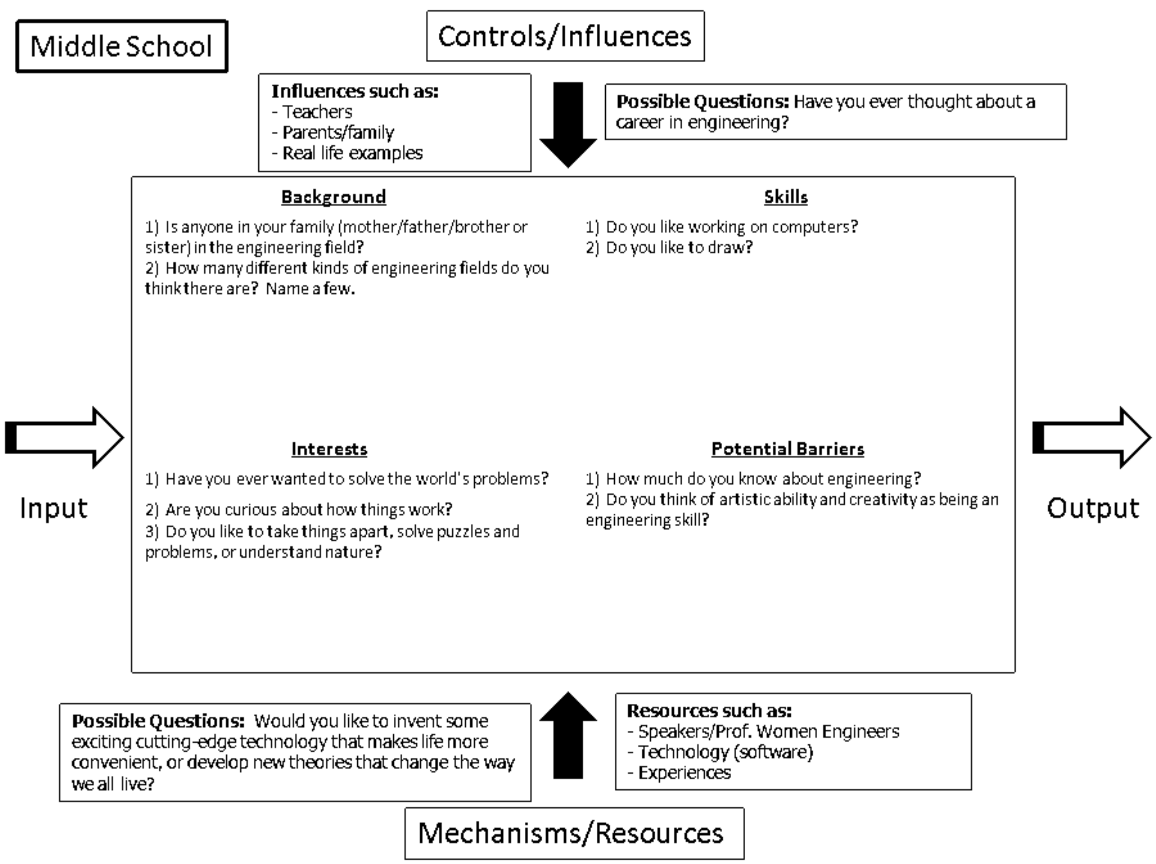


**Figure 3: IDEF Block showing how information can be stored and documented for study**

## Sample Questions Used For Surveys

### Elementary/Middle School Aged Girls

How much do you know about engineering?
If you wanted to save the world or make it a better place to live, where would you begin?
Is your mother/father/brother or sister in the engineering field?
Have you ever thought about a career in engineering?
How would you like to be the engineer that designs and develops technology for commercial aviation, national defense, or space exploration?
Do you want to be on an engineering team that designs the space shuttle?
Would you like to create a new product that helps kids learn or be healthier?
How about designing new toys? Or improving sports equipment?
Have you ever thought about designing a theme park?
Do you like to draw?
Are you curious about how things work?
Do you like to take things apart, solve puzzles and problems, or understand nature?

### High School Level Young Women

How much do you know about engineering?
Is your mother/father/brother or sister in the engineering field?
Have you ever thought about a career in engineering?
How many different kinds of engineering fields do you think there are?
Have you ever wanted to solve the world's problems or make it a better place to live?
Do you think through problems in order to solve them?
Do you like working on a computer to design new things?
Do you think of artistic and creativity as being an engineering skill?
Would you like a career that is a lifelong learning experience?
Do you have ideas on what transportation could be like in the future?
Did you ever think you could design or help build a better car? Or that doesn't run on gas? Or can fly? Or that drive its self?
Do you like to take things apart, solve puzzles and problems, or understand nature?
Invent exciting cutting-edge technology, make life more convenient, or develop new theories that change the way we all live?
Can you imagine designing a medical device that seems to breath life into someone? Or one that helps people hear better?
Have you ever thought about designing a theme park that stimulates all five senses: sight, hearing, touch, smell, and taste?
Do you have the ability to be analytical as well as creative?

### University Students

Why are you studying engineering?
Is your mother/father/brother or sister in the engineering field?
How long have you thought about a career in engineering?
Why don't we have more girls in engineering?
What are your advantages as a girl in engineering?
Did you take middle/high school classes in science/engineering?
Are you treated differently or equally?
Do you like welding, machining or fabricating things?
Have you ever wanted to solve the world's problems?
Do you like solving complicated analytical problems?

Do you always come up with new ideas on everything?
Do you like doing experiments or working in a laboratory?
Would you like a career that is a lifelong learning experience?
How would you like to be the engineer that designs and develops technology for commercial aviation, national defense, or space exploration?
Would you like to invent exciting cutting-edge technology, make life more convenient, or develop new theories that change the way we all live?
Can you imagine designing a medical device that seems to breath life into someone? Or one that helps people hear better?
Did you know that Chemical Engineers have worked on creating a purple rose that has no thorns, the caramel on a caramel apple, and even your tennis shoes?
How would you like to make food tastier, more convenient to fix, and healthier for everyone?

### Professional Working Women Engineers

What challenges you?
What inspired you to get into engineering?
Did you have a mentor?
Why are you happy you chose engineering as a career?
How do typically “girl” traits help you in your creativity, artistic abilities, or detail orientation?
Have you ever thought about inventing exciting cutting-edge technology, make life more convenient, or develop new theories that change the way we all live?
Can you imagine yourself designing a medical device that seems to breathe life into someone? Or one that helps people hear better?
As a little girl, how were you different?

## Conclusions

This poster/paper presents a new way to look at issues related to increasing the percentages of women in professional engineering jobs.  Many people have recognized that with the increasing availability and access to technology and youth projects related to STEM, the efforts can start very early in a young girls’ development.  As these girls grow up there must be mechanisms put in place to identify them and put them on a track to study areas related to science and engineering, their potential contributions to the workforce and national economy in immeasurable.  By using data formatted and structured in the proposed variation on an IDEF model, a better understanding of what can be done to affect the process can be identified.

By extending and continuing the work outlined in this poster/paper, very important changes occurring to our society and workforce can be studied.  In addition, the authors propose that this idea could be used to study international differences in women’s roles and the future of engineering.  Other regions and particular countries are currently experiencing a large growth of females both in engineering schools and in the workplace.  It is believed that there are cultural and gender differences that can be identified and studied that would be helpful if understood here in the United States.  The model proposed here could be used to compare and contrast similarities and differences for the purpose of increasing diversity and addressing the low representation of minorities of all types in engineering and related fields.  It is also a tool that can be used as a data repository, linking different models and a more extensive database to classify and relate characteristics and aspects of the topic to be studied.

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