

Attitudes and values in engineering students: the Human Development Scale

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Abstract – Success of college engineering education is determined by more than the achievement of theoretical knowledge and the development of practical skills. It means a more complex process of change in the person which, most desirably, will lead to the development of maturity, responsibility, and commitment with the social and the natural environments. This paper presents the results of a study conducted at the Iberoamericana University, Mexico City, dealing with the design and application of an instrument for evaluating several aspects of Human Development in engineering college students (Openness to Experience, Responsibility, Congruence, Satisfaction, Security and Relationship Closeness). The main goal of this research was to provide a helpful tool for the researcher on Human Development and/or Education and to diversify the current engineering evaluation methods.

Index Terms - engineering evaluation, engineering students behavior and feelings, engineering students values and responsibility.

INTRODUCTION

Engineering education encompasses basic sciences, technology and human studies in a complex mixture to create new products, machines, structures and processes. Such a holistic point of view of the world makes it evident that we cannot forget the promotion of wholeness of the person, and his state of continuous change and growth. It is a requirement not only to inspire educational actions towards the academic objectives per se, but moreover, to promote engineers with a successful and committed professional practice and a fulfilling life, since any educational process should take care of the aspects that complete the person, such as the social and emotional dimensions and the efficiency of relationships with oneself and with others in more satisfactory and productive ways. What we are searching for is helping students to be more efficient in the use of their creative potential in order to find and chose, with flexibility, the best option in any given situation. Such an evolution on the engineering education objectives has been assessed by several authors [20]–[25].

Even though many colleges and universities include in their curricula several strategies to promote the harmonic development of several qualities and potentials of students, they usually lack of a practical technique of evaluation of such qualities in order to confirm if the educational strategies supposed to promote them are really working or

not. This text presents the results of a study aimed to address this necessity. The paper covers some background theory on Human Development, it then presents the evaluation instrument and its results followed by the discussion of the findings.

BACKGROUND THEORY

The term Human Development is conceived by the researchers at the Iberoamericana University in Mexico City, as the nomination for the scientific approach that encompasses philosophy, psychology, sociology and anthropology towards the understanding of the fully functioning being, and the mechanisms that encourage personal growth. Human Development emerges from the theoretical basis of Humanistic Psychology, Phenomenological Philosophy and the Person-Centered Approach [2]-[10]-[23]. Such knowledge areas have many years of research and have proven results in different realms. Human Development includes the personal, educational, organizational, social and transpersonal fields of study. The basic principle sustaining this scientific approach is the belief of an ever changing state of growth that leads the person to actualize his full potential. This implies fully experiencing feelings and reactions to perceive reality, what is happening inside and outside of one's body, and, with this information, taking the best course of action in every given situation [6]-[10]. Better decision making is, in fact, a product of the way reality is perceived and understood. Barriers to accessing information are frequently built upon one's own mind, as a product of fear or misconceptions, and poor information is related to poor decision-making. Free access of information, on the other hand, leads to finding more mature meanings of the experience and making decisions on a better basis.

Given this knowledge on Human Development, some constructs have been found helpful for improving the educational experience for engineering undergraduates. Such constructs, derived from the Person-Centered Approach conceived by Carl Rogers are: Self-actualization, Openness to experience, Empathy, Congruence and Acceptance [10].

Self-actualization

The term self-actualization was developed by Abraham Maslow and is defined as the basic organismic tendency to move towards the realization of the inherent potentials of the human being [23]. It means that there exists a basic

potentiality in every person that leads him towards completing or actualizing his full being. Under this principle, given some facilitating conditions, a person can find by himself the best alternatives of functioning that will lead to wholeness and optimal results in life, or what is also known as optimal psychological adequation. Self-actualization is related to the term *intrinsic motivation*, also defining the force that leads movement towards realization [7].

Every person is intrinsically motivated to actualize his potentials. In particular to our discussion, every engineering student is called, by an internal motivation, to develop his critical and analytical skills, to learn to give the best of his knowledge to the achievement of new products, processes, and ways of doing things. When the conditions are not set to promote this actualization of potentials, frustration might arise in students, leading to professional and personal failure.

Openness to experience

A person that is open to experience functions better because he perceives situations and events in complex and rich forms that lead to the realization of his inner potential [17]. It is the openness to experience that allows the potential of the human being to flourish, and leads to social learning, emotional intelligence and true education towards the action with liberty and responsibility [11]. This would be a richer conception of the educational experience.

Professors have to be considered not only as a knowledge source but also as counselors, models of action, and most of all people in interaction with students. Professors are to create the facilitating conditions that lead to a more fluid fulfillment of the self-actualizing force, they are called to be promoters of the experiencing ability that will provide students with the elements to be able to acquire information in its full and complete sense. Recently graduated engineers can live in a more productive and satisfactory way if they feel that, in any given situation, they can be perceiving the more subtle details and use this information to make better decisions for themselves and the company which they work for.

Empathy

The attitude of empathy shown by professors leads to more confidence in students and to a more mature and communicative relationship. Students need to be empathetically understood in order to promote a better relationship, which is the basis of cooperative work and promotion of healthy group dynamics, two aspects that are nowadays of major importance in the engineering practice.

Congruence

Congruence is defined as the harmonious and integrated functioning of the organism, within which, the person can attend to his needs of development [15]. Congruence has been broadly studied by Behr and Becker [23] and can be defined as the attitude of genuineness. It means a transparent

experiencing, with no alterations of reality; it encompasses honesty with one's self and lessening discrepancy on what one thinks and feels. Congruence is also understood as the transparency in the actions. From a phenomenological point of view, the person needs to be aware of his liberty and his responsibility of living the life he chooses. He is committed to assume the consequences and achievements of his actions.

Acceptance

Acceptance is understood as the openness to the own experience as well as such of others in an environment of warmth and recognition of reality and life circumstances. Acceptance is not ignoring reality, nor willing to deform it or change it to our will. Acceptance means a positive regard of one's self, people, and the world [15]. Better engineering professionals are those that manifest an acceptant attitude towards people in complex situations, with no denial of the point from which they start, which enables them to work more efficiently from there.

DESIGN OF THE EVALUATION INSTRUMENT

Even if human behavior is extremely complex, it is possible to quantify, to certain extent, some variables that could denote the degree of development of attitudes, values and feelings in college students. The basic elements in the section above were considered in the variable selection for the evaluation instrument and, although all of them relate in one way or another to several of the constructs within, two of them were selected to be included as specific subscales. These are: Openness to Experience and Congruence.

After the study of the variables related to educational experience and outcomes, several interviews to students and professors were conducted and existing measurement techniques were analyzed [1]-[5]-[9]-[13]-[18]-[19]-[21]-[22]. Then, some specific steps towards the achievement of the scale were taken:

1. Statement of the elements that could identify the degree of Human Development of a specific group of college students.
2. Design of the questions or items that would adequately measure these elements.
3. Assessment of the statistic reliability and validity of the items and the instrument.
4. Administration of the instrument, scoring, and interpretation of the results.

The instrument design process and the statistical reliability and validity tests were conducted following the procedures suggested by leading authors [3]-[4]-[8]-[12]-[14]-[16]-[18]. The items were all reviewed by experts in the field of Human Development. The preliminary version was tested with a sample of 90 engineering students and the final instrument was administered to a sample of 240 during the spring term of 2004. The instrument was named Human Development Scale for Engineering Students (EDHAI, for its name in Spanish). It contains six subscales that evaluate: the values of Openness to Experience and Responsibility,

the attitude of Congruence, the feelings of Satisfaction and Security, and the behavior of Relationship Closeness, with good reliability and validity values.

The EDHAI contains 55 items that appear in a two-page structured questionnaire with a 4 point likert scale where 1 equals to "Almost Never" and 4 equals to "Almost Always". Some sample items from the survey are the following: "When I disagree about something, I say so", "I easily adapt to change", "I feel I am a failure", "I do not do all the things I said I would", "I am interested about taking care of my health".

The instrument comprehends the following subscales:

- **Openness to Experience:** This variable is thought to promote divergent thinking and allows to capture reality in its full complexity, helping the decision making process.
- **Responsibility:** In this instrument, Responsibility covers the acceptance of commitment towards the achievement of personal goals, as well as the free election of constructive responses to external demands.
- **Congruence:** For the purpose of this research, Congruence is understood as the coincidence between what is thought, felt and expressed. Congruence has not been assessed before on engineering students.
- **Satisfaction:** This research states that satisfaction motivates the student to achieve new goals that bring fulfillment, helping the satisfied person to show promoting attitudes towards his own development (to be a self-promoter of Human Development). While evaluating Satisfaction, the EDHAI pinpoints one of the most important aspects of Human Development which is cause and effect of a fulfilling life. Feelings of wholeness derived from the recognition of good performance are specifically evaluated.
- **Security:** In the EDHAI, this variable is related to the feelings of worth and confidence in who we are, what we know and what we feel we are good for.
- **Relationship Closeness:** This subscale comprehends the capacity of interrelating in satisfying ways, showing interest, empathy and care for others.

Each one of the subscales of the EDHAI may be helpful for researchers or consumers of research in promoting and understanding student development. The instrument as a whole derives from a rigorous methodological procedure which enables it to produce meaningful results.

RESULTS

The EDHAI was administered to a sample of 240 college students from several engineering majors (Food Technology, Biomedical Engineering, Chemical Engineering, Industrial Engineering, Systems and Computer Science and Mechanical Engineering) during the spring term of 2004 at the Iberoamericana University, Mexico City. The distribution by gender in this study showed that Female were 27.1% of the sample while Male were 72.9%. The age distribution showed that the respondents aged between 17-19 years were 41.6%, those aged 20-23 were 53.4%, and those aged 24-27 accounted for the 5%.

To statistically test the reliability of the instrument, a quantitative analysis of inquiry was performed using the SPSS program. Pearson Correlation Coefficients were computed to determine the significant relationship between variables. Two-way-analysis of variance ANOVA was employed to test the relationships between variables and respondent's academic profile and gender with a statistical significance set at $p < 0.01$. The average Cronbach's alpha value of 0.6883 was obtained which shows a strong reliability of the instrument.

At the completion of the assessment, the results were first grouped in each subscale and then analyzed in each of the demographic categories. The results obtained by subscale are as follows:

Openness to Experience: Higher results on this scale for women ($I = 3.38$ compared to $I = 3.21$ for men).

Responsibility: Women in the study appeared to be more responsible ($I = 3.40$) than men ($I = 3.08$). Students in Food Technology and Biomedical Engineering (both $I = 3.44$) scored higher in this subscale than students in other engineering majors ($I = 3.16$ on average).

Congruence: The assessment shows a moderate lack of congruence in the sample as a whole ($I = 3.24$).

Satisfaction: Satisfaction correlates to engineering major and age group but does not correlate to gender. Older students showed a lower level of satisfaction ($I = 3.07$ for students 24 years old and $I = 3.42$ for students 18 years old). The biggest difference between satisfaction levels was between students majoring on Biomedical Engineering ($I = 3.60$, the most satisfied) and those on Systems and Computer Science ($I = 3.29$, the least satisfied).

Security: Older engineering students showed a somewhat lower level on this scale (comparing students 21 years old, $I = 3.5$, and 25 years old, $I = 3.11$), but the difference was non-significant. Major field correlates significantly with this scale being Biomedical Engineering the area with the most secure students ($I = 3.43$) and Chemical Engineering the one with the least ($I = 3.17$).

Relationship Closeness: Women were found to be closer in their relationships ($I = 3.51$) than men ($I = 3.27$), as well as the students in the majors of Food Technology ($I = 3.47$), Chemical Engineering ($I = 3.46$), and Mechanical Engineering ($I = 3.49$).

DISCUSSION

The results show that age group of the student does not make a significant difference on the degree of Human Development of most of the characteristics evaluated in the present study, hence it could be inferred that, on average, students maintain certain characteristics in about the same level regardless of the time they have spent in Engineering Education Programs. Nevertheless, it was found that the older the student, the less satisfied he appears to be. The fact that more years are spent in college without being able to graduate is a clear source of dissatisfaction, but there could be other reasons for students discontent, for example frustration in a highly demanding intellectual environment, inefficient administration procedures, lack of one-on-one

relationship with professors, fear from an uncertain career in the near future, and so forth.

There are only two subscales of the EDHAI whose results are affected by the major field of the student which are: Relationship Closeness and Responsibility. Students from the majors of Food Technology, Chemical Engineering and Mechanical Engineering scored significantly higher in the Relationship Closeness subscale. That means that students in engineering majors that include more intensive academic load in laboratories showed a tendency to make stronger relationships, compared to students in fields such as Computer Science who spend many hours working alone. It could be concluded that the fact of working together under pressure requires better group-work strategies and promotes communication and meaningful relationships among students. Another result from this research is that students in the fields related to health and physical wellbeing (Food Technology and Biomedical Engineering) are more responsible than the rest. The interpretation of these findings could be centered on the hypothesis that some students have a personal profile that makes them choose a field related to the health and care for others. It could be inferred that such a profile is inherent of the person and not a consequence of higher education because in the Mexican higher education system, students choose their major field before entering college and no difference was found on the assessment of this subscale by age group. Even if many activities and projects are designed to help future engineers to develop the abilities to apply concepts and techniques to real situations in which they come up with original proposals to make things work better for the individuals and the community, the efficiency of such activities has not been assessed.

The findings about gender were noticeable. Being a man or a woman does make a difference in the EDHAI's results. It could be said that women have a tendency to be significantly more developed in the personal aspect in general. They are more open to experience, responsible and closer in their relationships. The explanation beyond could be that women approach the emotional and sensible issues in a more natural and easy-flowing way which promotes a better handling of situations and, therefore, a greater tendency toward self-actualization.

CONCLUSIONS

Even if engineering education is traditionally oriented to the practical, hands-on side of science, this does not mean that it has to be confined to the technical efficiency of use of resources, from a pure mechanical or materialistic point of view. Better, engineering education is to be understood as the way to nourish the capacity of understanding the world's functioning as a whole, with a deep comprehension of the human experience and the consequences of one's actions as professionals and agents in the world. In fact, it is higher education's responsibility to aim for engineering skills but not to forget personal and social consciousness. We ask ourselves how can this be achieved, what makes an engineering student a successful engineer. Experience has revealed that good grades do not guaranty social responsibility or professional and personal success; that

traditional knowledge and skills-oriented study plans and assessments are not sufficient. Institutions are expected to be not only sources of knowledge, but also promoters of significant learning and harmonious functioning, such that students may efficiently access their internal resources in order to act in more creative, autonomous, congruent and fulfilling ways.

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