Summer 2006

Does SH&E Education in High Education Institutes Lead to a Change in Cognitive Patterns Among Graduates?

Nir Keren
Iowa State University, nir@iastate.edu

Steven A. Freeman
Iowa State University, sfreeman@iastate.edu

Charles V. Schwab
Iowa State University, cvschwab@iastate.edu

Does SH&E Education in High Education Institutes Lead to a Change in Cognitive Patterns Among Graduates?

Abstract

Attending higher education institutions affects graduates in a variety of dimensions. Among these dimensions are gaining knowledge, acquiring skills, and developing academic and professional independence; however, the most important dimension in which a change should be introduced is the acquirement of appropriate patterns of thinking. Does safety education lead to a change in cognitive patterns among graduates?

This work presents initial results of a larger comparative study addressing the change in cognitive patterns among junior and senior students in the occupational safety program, students in non-safety programs, and safety professionals with at least 5 years experience in the industry. The three groups of subjects participated in a computerized decision-making simulation, in which their information processing was monitored and traced.

The Safety Decision Making Laboratory was recently established in the Agricultural and Biosystems Engineering Department at Iowa State University. The occupational safety program in the department consists of four faculty, 50 undergraduate students and 11 graduate students. The program also houses an industrial outreach and research center, Safety Training Instruction and Research (STIR).

Disciplines

Agriculture | Bioresource and Agricultural Engineering | Engineering Education | Occupational Health and Industrial Hygiene

Does SH&E Education in High Education Institutes Lead to a Change in Cognitive Patterns Among Graduates?

Nir Keren, Ph.D.
Assistant Professor

Steven A. Freeman, Ph.D., CSP, CSIT
Associate Professor

Charles V. Schwab, Ph.D.
Professor

Department of Agricultural and Biosystems Engineering
Iowa State University
Ames, IA 50011

Overview

Attending higher education institutions affects graduates in a variety of dimensions. Among these dimensions are gaining knowledge, acquiring skills, and developing academic and professional independence; however, the most important dimension in which a change should be introduced is the acquirement of appropriate patterns of thinking. Does safety education lead to a change in cognitive patterns among graduates?

This work presents initial results of a larger comparative study addressing the change in cognitive patterns among junior and senior students in the occupational safety program, students in non-safety programs, and safety professionals with at least 5 years experience in the industry. The three groups of subjects participated in a computerized decision-making simulation, in which their information processing was monitored and traced.

The Safety Decision Making Laboratory was recently established in the Agricultural and Biosystems Engineering Department at Iowa State University. The occupational safety program in the department consists of four faculty, 50 undergraduate students and 11 graduate students. The program also houses an industrial outreach and research center, Safety Training Instruction and Research (STIR). More information on STIR is available at www.stir.iastate.edu.

The Simulation

The Decision Mind platform (the simulator) is a programmable simulator that is utilized to create decision-making scenarios as described below. Participants are working in front of a computer terminal. During the simulation, the participants are asked to review information on alternative lines of action and the implications of each alternative on variety of decision factors.

The simulator was programmed with a variety of scenarios, addressing several levels of risk, uncertainty, complexity, and several other variables. The results of a simulation of one of the basic scenarios are presented herein.

The sections below present the following items:

> Decision Process Tracing Methodology,
> Decision Mind Platform,
> The Scenario,
> Analysis, and
> Summary.

Decision Process Tracing

Process tracing is a methodology designed to identify what information is accessed during the decision process and the order in which the information is viewed. Data gathered from process tracing can then be used to make inferences about which decision strategies were employed en route to the selection of the final choice.

To facilitate process tracing, Decision Mind 4.0 software is utilized in this study. The computerized Decision Mind records key features from the decision-making process:

A. The sequence in which participants acquire information;
B. The number of items that the participants view for each alternative along each dimension;
C. The amount of time elapsed from the time the participants begin the task until they make the final choice; and
D. The final choice.

Using process tracing techniques, Decision Mind displays decision portraits of subjects and calculates indices about the information search for each of the four decision process characteristics described above.

The Decision Mind Platform

The core structure of the Decision Mind Platform is a matrix of decision alternatives (A_i) and decision factors (D_j), as presented in Figure 1. The participant is seated in front of a computer terminal and is asked to choose an alternative from a set of alternatives based on information s/he acquires from the Decision Mind, by "clicking" on information buttons V_{ij}. The information available in V_{ij} represents the evaluation of a given alternative (A_i) on a given dimension (D_j). V_{ij} consists of an evaluative descriptive statement and a summarizing numeric value (on a scale from -10 to +10), where a low score refers to a negative evaluation, and a high score to a positive one. The platform allows users to add relative weights to the decision factors. This feature was utilized as well in this simulation.

Scenario: Buying a Car

The participants are asked to review information on three cars. In order to avoid biases associated with personal preferences, xXx, yYy, and zZz were designated as car brands. The following four decision factors were employed in the decision process:

1. Gas Mileage,
2. Insurance Costs,
3. Safety Performance, and
4. Mechanical Reliability.

The following instructions are presented to the participants prior to the initiation of the simulation:

"*You have decided to buy a new car. Your search narrowed the options to three models: xXx, yYy, and zZz. Your decision will be based on examining the options according to the following set of decision factors: 1) gas mileage; 2) insurance costs; 3) safety performance; and 4) mechanical reliability*".
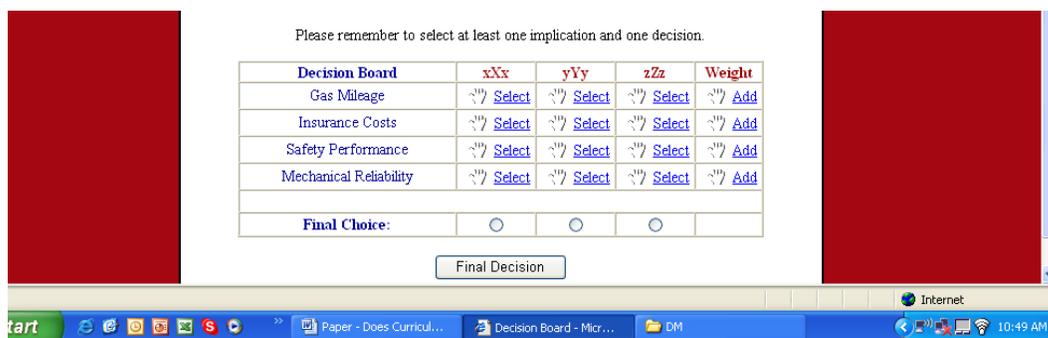
Figure 1. Matrix of decision alternatives and decision factors

In addition, the simulator requests that the participants will assign weight to each one of the decision factors on a scale of 0–10, 0 being not important and 10 being very important. Finally, the participants are asked to select the best alternative.

Table 1 presents the scenario details, including the information and rating of each alternative on each one of the decision factors:

Decision Factors	Alternatives		
	xXx	**yYy**	**zZz**
Gas Mileage	28 miles per gallon +8	14 miles per gallon - 7	21 miles per gallon +1
Insurance Costs	The car is very attractive and is a target for burglars; thus, insurance rates are high. -7	The car does have a reputation of one that is often stolen; therefore, insurance rates are reasonably low. +4	An average car, with average insurance rates. +1
Safety Performance	The light body weight introduces good gas mileage performance. The tradeoff, however, is a light body frame whose integrity is jeopardized when a significant impact introduced -5	While the integrity of the body frame is reasonably good, sometimes the Antilock Breaking System (ABS) does not kick-in when needed. +1	Crash tests, accident records, and information in professional car magazines pointed out that this model is considered among the safest vehicles on the road. +9
Mechanical Reliability	Considered reasonably reliable car. +4	This car requires occasional repairs. +2	This model is known as one that requires relatively frequent repairs. -7
Table 1. "Buying a Car" Scenario			

Analysis

The analysis in this study focused on three variables:

1. The Safety Search Index (SSI), as described in the following paragraph,
2. The weight assigned to the variety of decision factors, and
3. The final choice.

Safety Search Index
The information processing is used here as an indicator of cognitive pattern. The SSI is an index developed for the purpose of this study. SSI is used to measure the differences in cognitive patterns among the three groups of participants.

SSI is defined as follows:

$$SSI = \frac{N_S}{\frac{1}{3}\sum_{i=1}^{3} N_i}$$
(1)

Where,

N_s is the number of times Safety Performance cells have been visited

N_i is the number of times decision factor i cells (other than safety performance) were visited

Thus, SSI measures the number of times Safety Performance cells were visited relative to the average of number of times other decision factors cells have been visited.

The first hypothesis in this study is that students in the safety program and safety professionals will have an average SSI that is greater than one; i.e., the number of times Safety Performance cells have been visited by these two groups will be higher than the average of number of times other decision factors cells have been visited by them.

The second hypothesis is that the average SSI of students in the safety program will be higher than non-safety students.

Figure 2 presents the average SSI values for each of the group of participants. As can be seen from the figure, the average SSI values for safety students and safety professionals are higher than one. The average SSI for safety students is 1.18, which indicates that these students, on average, reviewed 18% more information on safety performance than on other decision factors. Similarly, safety professionals reviewed 11% more information on safety performance than on other factors.
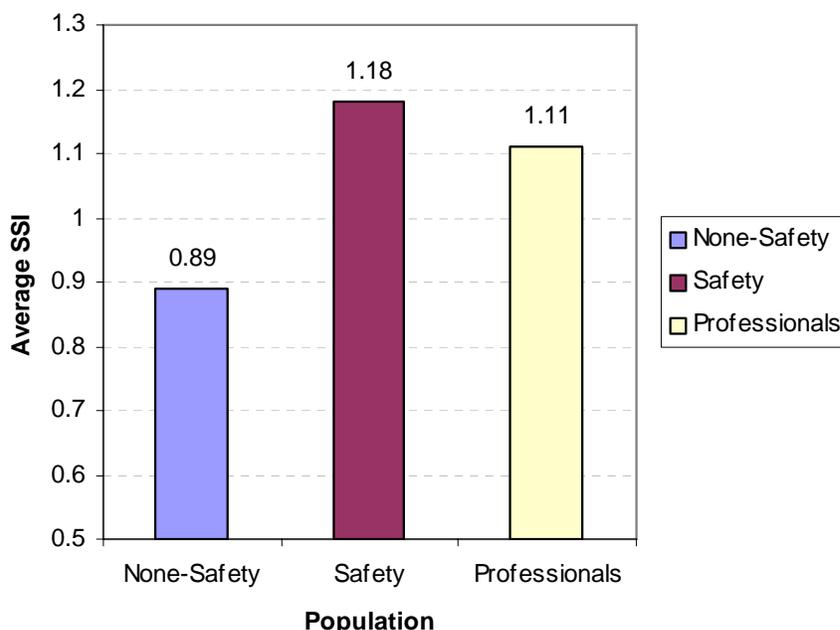

Figure 2. Average Safety Search Index values

The average SSI values for safety students and safety professionals support the first hypothesis above.

The average SSI value for non-safety students is 0.89., i.e, non-safety students reviewed approximately 12% more information on other decision factors than on safety performance. The ratio between the average SSI values of safety students and non-safety students is calculated as follows:

$$SSI - Ratio = \frac{Average(SSI_{Safety\ Students})}{Average(SSI_{non-Safety\ Students})} = \frac{1.18}{0.89} \cong 1.33 \qquad (2)$$

The SSI-Ratio reveals that on average safety students reviewed 33% more information on safety performance in comparison to by non-safety students. This value supports the second hypothesis above.

<u>Weights</u>
As mentioned earlier, the participants have been asked to assign relative weights to each of the decision factors. Figure 3 present the average weights assigned:
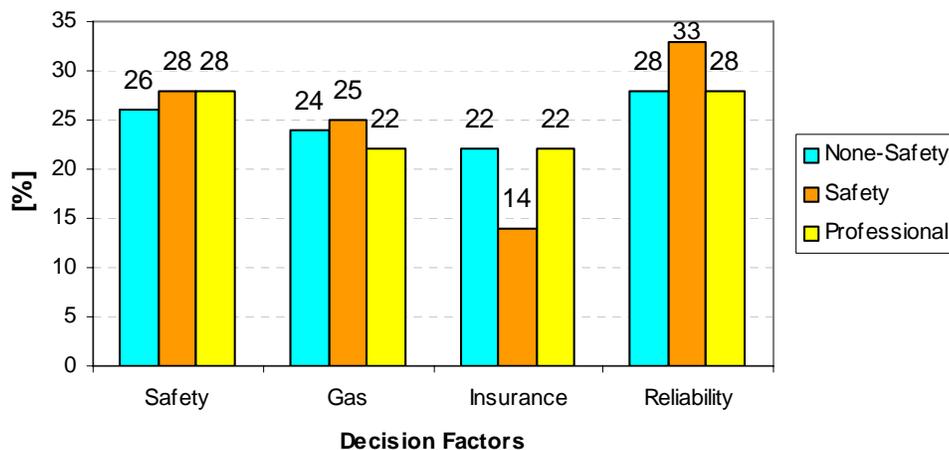
**Figure 3. Average decision factors weights**

Intuitively it was expected that the "safety performance" decision factor would be overwhelmingly 'heavier' in safety students and safety professionals. However, these groups designated only 2% more to this factor than the designation by the non-safety group. It is possible that sensitivity to gas mileage and mechanical reliability are so significant in the current economic environment that the effect of type of education was minimized. No major conclusion could be drawn from analyzing the assignment of weights.

Final Choice

Safety performance rating was assigned to each one of the alternative: xXx was assigned a rating of -5, indicating unfavorable safety performance; yYy was assigned a rating of +1, indicating somewhat favorable safety performance; and zZz was assigned +9 rating, indicating extremely favorable safety performance.

Figure 4 presents the final choice by each one of the groups as a function of safety rating.
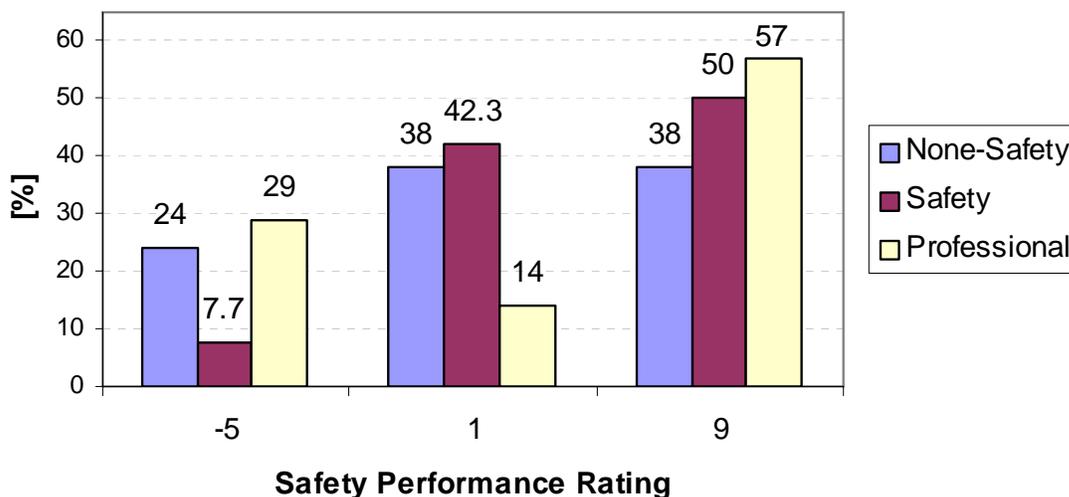
Figure 4: Final choice.

Summary

The Safety Search Index is the major cognitive pattern indicator in this study, since it is focused on information processing. The SSI values of safety students and safety professionals indicate that participants from these two groups are more safety oriented in their information processing.

The SSI-Ratio presents the ratio between the average SSI values of safety students and that of non-safety students. SSI-Ratio of 1.33 reveals that safety students employ 33% more safety-oriented information processing than non-safety students. This is the major indication that safety education in high education institutes does lead to a change in cognitive patterns among graduates.

Analysis of the weights assigned to the variety of decision factors did not demonstrate any significant orientation toward safety. It is suggested that decision factors, such as gas mileage and mechanical reliability, are a significant concern in the current economical climate, leading to a minimization of the importance of safety when weights are assigned directly. Employing methodology,

such as the Analytical Hierarchical Processing, which gains the weight indirectly, might be of a better use in revealing the weights without biases, such as these described herein, being so dominant.

More than 50 % of the Safety students and safety professionals have selected the car with the best safety performance. Additional encouraging information is that only 7.7% of the safety students selected the car with the unfavorable safety performance rating, in comparison to 29% of the safety professional and 24% of the non-safety students.

The information documented in this paper presents only the initial results of a larger project addressing cognitive patterns and safety decision-making. Final results will be published upon completion of this research project.