Improving student’s value in technical education

S S Duicu<sup>1</sup>

<sup>1</sup>Manufacturing Engineering Department, Faculty of Technological Engineering and Industrial Management, Transilvania University, Colina Universitatii nr. 1, 50036 Brasov, Romania

*E-mail: simonaduicu@unitbv.ro

Abstract. This article is about value engineering, a method to improve the relationship between the function and the cost of a product. Industrial engineers can provide a better value of their products only if their own value becomes better and better, meaning not to reduce the cost of their education, but to increase their role in designing products and processes. The purpose of this analysis is to generate simple principles for understanding, modelling and optimizing this problem. The interaction between the components of the value provides the definition: the special relation between utility and cost catalysed by the wishes and resources of the employers at a specific moment. The article analyses the components that have effects on student’s value and proposes a model harmonized with the growing ratio of the industrial area.

1. Introduction
The value engineering is a method to improve the relationship between the function and the cost of a product. Industrial engineers can provide a better value of their products only if their own value becomes better and better, meaning not to reduce the cost of their education, but to increase their role in designing products and processes.

Minimum cost is not the goal in technical education. If the term of „product” is assimilated to a student, then all the components of this notion will be analysed in consequence, including notions like „price” and „cost”. The purpose of this analysis is to generate simple principles for understanding, modelling and optimizing this problem.

2. Value’s components
It can be agreed that the components of a product value are: the market and the utility value given by the wishes and expectation of the employers, the rarity or the difficulty, the total cost to obtain the right product, and the possibility of the employer to choose, meaning the competition. Employers want to pay as little as possible for a good, useful, rare product not only against their competitors, but also in competition with their own resources. This is why, the interaction between these five components drive us to the simplest definition of the value: the special relation between utility and cost catalysed by the wishes and the resources of the employers at a specific moment.

This first classification appears to be the most realistic regarding the product „student”. But talking about a continuing changing and alive product, different features of values must be taken into consideration. A “graduate” is considered to be the final form of the product “student” from the point of view of university education. But the educational process must never stop.
2.1. Utility and exchange values
One of the most formal and at the same time old classification was done in the antiquity by Aristotle. Understanding ancient Greeks’ disapproval for trading and their love for individuality, it can be summarized that a useful engineer is more valuable than a well paid one. This exchange value linked with price can be measured only when the work market is flooded by specialists with the same education and/or qualification. Only in this moment a level of competence can be fixed and starting from this level a clear evaluation can begin.

Utility and exchange values substantiate the economic value. In modern time, new more interesting aspects are highlighted: the estimation value and the trading value. The estimated value can be isolated from the industrial context. All those components must interfere to create a living and functional model. Maynard says that [1] the most common mistake is to isolate the estimated value. The utility of a proper technical education and accessibility of a well prepared workforce contribute to a high reputation of the graduates.

2.2. Reputation value
In our days, this reputation value gives a competitive advantage to any product. It serves as a guide to the employers when the moment of choosing between different candidates comes. Finally, the utility value becomes firstly and mostly what counts in the CV. Employers will choose first from a CV database (which is more or less like a shape of the product named engineer), but the final decision will be made according the utility, so the shape will be subordinated to the function. A good example is the „swimmer illusion”. Employers can make a confusion between selection factors and results and they become victims of an illusion. Students have a tendency to apply for very high reputation universities hoping they will get the best education possible and forgetting that top universities accept only the best candidates. It’s understandable that after graduation the reputation of the university is borrowed by its graduates [2].

2.3. Market value
Employers have the possibility to choose from the human resources market the candidate they want. So, employers have the possibility to express their preferences, „buying” the work force. On a dynamic market, employers act like customers expressing their wishes by absorbing the graduates. Utility value and reputation value are linked with all the other physical features that make the product „engineer” what it has to be. But the market value and the exchange one reflect better the economic aspect of a product. Value engineering makes this connection between the economic characteristics and the real, physical ones such the number of graduates, gender and availability.

It is very clear that employers will set the criteria on economic evaluation and not on the educational system. There are two different points of view regarding student’s value: one of their future employers and one of their educational system.

The educational system will examine this value quantitative and qualitative. Quantity means how many students are in the first year of study and how many of them graduate. Transilvania University is a state institution, so the ratio between investment and profit is not an issue because the profitability of the educational act is difficult to be approximated in money. Quality means the ratio of absorption on the workforce market and, sometimes, the degree of acceptance.

The employers will highlight the utility and the cost of engineers. The value engineering reflects the point of view of the employer, because all the aspects of the value starting with the profile and the cost, ending with the market value and the degree of workforce exploitation depend on his point of view.

Finally, the economic value of our students can be composed of:

- **Utility value** - how useful is the education of the graduates (not only their technical knowledge) to their future employers?
- **Exchange value** – beyond their technical education, how can graduates achieve better position or better jobs?
- **Market value** - how much can the employers pay for the graduates?
- **Estimation cost** – how can the market and exchange value be balanced when research, design and workmanship are very well established in the final cost of an industrial origin product?

### 3. Working model on value

The value’s working model proposed by Carlos Fallon in Maynard’s industrial engineering handbook combines five components that have effects on the graduate’s value (figure 1).

The working model about the graduate’s value needs: to ensure clear standards to evaluate the product “graduate”, to provide all necessary information to the educational system and to ask questions to the employers.

![Figure 1. Value working model.](image-url)

The value analysis team has to collect all information to be combined into a viable model. On the one hand we have the future graduates and on the other hand we have the future employers. A modality to compare different models is explained in table 1. The “criteria” are listed in the columns and the “choices” are listed in the rows.

- **Possibilities**: What are the possibilities? How much does the improvement cost?
- **Possibilities to put into practice**: What is the probability in % to put into practice the proposal according to the model? The measurement is made in % of accomplishment.
- **Information**: Is there enough information to create the model? How much in % can be accessed to establish the best model?
Time: Is there enough time to put into practice the model? How much in % it is given to each optimization proposal?

Professional level: Is the professional level reached so as to put into practice the model? How much in % it is offered to each level of education?

Probability: Probability in % to put into practice the model.

The first three options are based on the point of view of the educational system, the last two, on the point of view of the employers.

Table 1. A modality to compare different models.

| Possibilities | Real possibilities | Information | Time | Professional level | Earning |
|---------------|--------------------|-------------|------|-------------------|---------|
| Improving curricula |                    |             |      |                   |         |
| Combine theory with practice |                |             |      |                   |         |
| Increase requirements |                 |             |      |                   |         |
| Training in the company |                   |             |      |                   |         |
| Involvement in the educational system |             |             |      |                   |         |

The best idea is to propose interdisciplinary models combining different choices. The advantages are: criteria must be adequate to both sides (educational system and employers), criteria must be written in the same language for both sides (in the language of “cost”, “number of graduates”, “payment of the trainee” etc), choices to make a dependency between sides.

For a better understanding of the actual situation, some data from Transilvania University report are connected with the technical workforce market.

A number of 6996 students from all technical faculties were enrolled at Transilvania University (which is a state university) in 2017, bachelor level (budget and fee), all forms of education: frequency, low frequency and distance learning [3]. The distribution of these students is: 6122 students with frequency, 528 low frequency, 346 distance learning. The total number of students in the last year of study in technical faculties, frequency form of study is 1167, in the following structure: 75 from Product Design (144 in the first year), 147 from Technical Engineering and Industrial Management (264 in the first year), 217 from Mechanical Engineering (305 in the first year), 43 from Wood Engineering (42 in the first year), 50 from Material Science Engineering (77 in the first year), 235 from Electrical Engineering and Computer Science (369 in the first year), 129 from Forestry and Forest Exploitation (194 in the first year), 109 from Construction Engineering (110 in the first year) and 162 from Food and Tourism (233 in the first year). If in the first year of study there are 1740 students, in the last one there are only 1167. Of course the comparison is not the best one because of the newly introduced programs of study in 2017, but 33% of those enrolling are lost. This study doesn’t take into consideration the number of students enrolled in distance learning or low frequency because it is presumed that they are already working. Starting from the premises that 90% of these students will graduate, about 1000 engineers will enter the technical workforce market. Transilvania University is the most important regional university centre specialized in technical education, meaning, it prepares engineers coming from related areas. If only 25% of the graduates will decide to
stay in Brasov area, then, 250 engineers must meet the requirements of the technical workforce market.

Not only new graduates from Transilvania University technical faculties can be absorbed. An interesting variable in this problem can be the number of graduates from other universities, master degree graduates or already employed engineers moving from a company to another.

At the same time, the growing ratio of the industrial area is minimum 10% (for an organic grow) and the number of the job offer is of about 150 engineers. Starting only from these two numbers it can be imagined the dynamics of the employment market. Facing new issues in education, a simple model of the student’s value must take in consideration a lot of variables to harmonize demand and offer.

Finally, the educational process must ensure the progress of the existing situation. Strong competition in delivering good specialists becomes a catalyst in any value analysis team.

The effects of these components over the student’s value are represented in figure 2.

Figure 2. Effects on the student’s value.

4. Working Plan
All models must have some goals mainly in the development of the educational process, not only in universities, but in the companies’ training compartments. The key principles are [4]:

- to understand the end-use requirements;
- to select appropriate development approach;
- to establish for best methods;
- to measure the work;
- to apply allowances;
- to document standards and conditions;
- to validate standards.

Benefits can be adjusted for product “student”: 
increase in productivity and elimination of waste – Increase the number of graduates, reducing the number of repeaters and abandons,
• basis for staffing, planning and scheduling production – Staffing, planning and scheduling educational process;
• basis for determining and controlling costs – Quality management system ARACIS;
• basis for managing performance – Performance quality system, number of innovations, brevets and research reports.

4.1. Proposal on the working plan
The steps of the working plan on the value model are the following.

Information step
• Identifying the choice or the combination of choices (table 1);
• Defining the lifetime of the product: 35 to 40 years;
• Defining the required qualities: technical, managerial, research, etc;
• Marketing conditions: how to promote and/or sell the workforce;
• Data about the cost: workforce cost linked with exchange, estimation and market value;
• New information: update information regarding employers, study programs in the University;
• Important aspects and features.

Analysis step must answer two questions
What is the function of the product “student”?
How is identified the beneficiary of this product?
• Defining the cost of the product “student”: the cost of the education, the cost of the training in the companies, the cost of the change of the career path, social costs etc;
• Establishing how much should the product “student” cost: evaluation in comparison with other educational systems, the cost of imported workforce, cost per potential employee (given by the calculation of the price of an object produced by the future employee).

Creation step
• How can the student's value be improved? How can a proper atmosphere of study be installed, how can inventive personalities and inventive actions be encouraged, how can conditions for research and innovation be created?
• Identifying obstacles against innovation and remove them, improving the creation of mechanisms, creating the climate for change and adapting to change, looking for analogies, anchoring in the objective reality, finding the best solution;
• Optimization;
• Simplification.

Evaluation step
Because it is about a living product, none of the existing methods can be ad literam applied. A combination between the existing methods can be obtained.
• Choosing the educational system: establish anticipated benefits like graduation ratio, employment ratio or successful employment; advantages and disadvantages of the chosen educational system.
• The beneficiaries’ criteria, superior and inferior limit for the student’s value, correction for utility and efficiency, advantages and disadvantages for the employers.

Verification step
• What is the improvement brought by the new value to the employers? Do the employers accept the new value?
• How much is the cost of the improvement? Is there a syncope in the study program or delays?
• What are the risks? Could there exist problems in the performance of the educational system? Could there be risks in the acquisition of new educational means or other kinds of risks?

Recommendation step
• Making a full report with recommendations.
• Establishing levels of action.
• Authorization and approval.

Practice step

This last step must harmonize beneficiaries and the educational system. The factors that determine the acceptance must be keep in mind: what are the normal costs of the education and what unexpected costs could appear? Also, it is very important for both parts to make the right choice: what kind of education do the graduates need and is this training needed by the employers?

Another aspect that might influence putting in practice the model is represented by the conditions of acceptance. Both parts must be well informed about costs, risks and earnings, be honest with themselves about expectations and objectives and understand the final effect of the change on their structure.

The mechanism of putting the model into practice must be clear, simple, well documented, keeping in mind all the time the function of the product “student”. For every case, some other features can be important and unexpected situations can appear.

The mechanism must establish:
• Tasks: Who is executing/ teaching/ responsible with practice or training; who is verifying and who is coordinating the educational program, who gives the funds and who controls the costs, who is centralizing the reports and establishes the priorities
• Affected areas: What are the modifications in the educational program and who will be affected?
• Deadlines: When does the action begin and how long will it be? Is it a continuous project and curricula will be affected? How long will it take until the first results will appear?
• Follow-up: Can follow-up procedures be established? Can some reports be done from time to time (establish the period)? Are there some landmarks or goals to be reached established by the future employers?
• Results of measurements: Can all earnings in time and money be measured? Can all costs in time and money be calculated? Can we make some comparisons of the total earnings with the total cost regarding the final effort?

4.2. COMBINEX Method

The well known COMBINEX method establishes a matrix that combines different advantages given by several input conditions. What must be taken into consideration:
• the analysis of the objective to establish demands and anticipated benefits;
• an evaluation method based on the existed resources;
• a scale with a specific measurement unit;
• measured factors whose contribution will affect the available solutions;
• final scoring table.

COMBINEX method may evidence the area in which an effort can bring a maximum advantage. A scoring table choosing different conditions on the horizontal lines, and different choices on the columns can be proposed.

Hypothesis: Better absorption of the graduates on the technical workforce market

Conditions: strong technical education, flexibility and adaptation capacity, decrease the cost of employment.

Choices: improve technical education by modifying curricula, decreasing university dropout, increase the capacity of Transilvania University to face the competition with other universities.

The next step is to find out the combinations between conditions and choices, and this must be done through the idea of satisfaction and not to obtain maximum. This is the difference between well balanced effort and the maximum one. A good example in this direction: a strong technical education
may be done by modifying the curricula, but the cost on short term and the effort could be maximum and ineffective.

It is very difficult to transform the combinations into numbers. This can be done only if a common property that can be mirrored in numbers can be found.

For example, for a future engineer, some technical skills can be measured in their grades: 5 for passing the exam, 9 very good, 10 for perfect. This scale can be approved by the university and by the employers, too. Obtaining 10 can be significant or not regarding the effort and the costs. Also, maybe a 10 grade is not so important regarding the competition between different universities when high standards do not allow to get a 10 grade so easily.

Another measurement unit can be the cost, but not all the time a higher cost of the education will reflect a proper education. Sometime, a higher cost means too high for a state university and too expensive for the employers to buy (meaning to employ) a graduate.

Finally, a graduate from a technical faculty can value more for an employer than for another, or his utility can be bigger for one than for another. In the context of industrial growing, the economic value increases at the same time with the number of employers. There are a lot of theories regarding the mathematical approximation of the utility, but John von Neumann and Oscar Morgenstern [5] combine all the theories and create the modern analysis of the value. The main idea is that the product, in this case, the graduate must do something useful for the employer and this can be measured in the satisfaction degree produced to the employer.

A new hypothesis is translated into practice: technical universities must offer to the employers something more valuable than the price paid for its graduates.

In this case, innovation, modernization, simplification and a better use of the staff involved in education may offer to the future graduate employers something more valuable for a smaller price. So, the choices for the university are: to improve the efficiency of the staff using staff recalibration and qualification improvement.

Going back to the measurement scale, grade 5 can represent the lowest condition to be accepted by the employer, grade 7 can be equated with favourable, grade 9 with optimum and above grade 9 with additional benefits offer, and grade 10 with absolute maximum. Everything above 9 can be accepted by both parts only if the graduate’s education does not involve excessive costs.

Table 2 proposes a COMBINEX matrix. “Conditions” are listed in the columns and “choices” are listed in the rows.

| Conditions                        | Powerful technical knowledge $w=0.5$ | Flexible thinking $w=0.2$ | Cost employment $w=0.3$ | Relative results |
|----------------------------------|--------------------------------------|---------------------------|-------------------------|-----------------|
| Modify curricula                 | 9                                    | 4.5                       | 7                       | 1.4             | 2.1             | 8               |
| Decrease dropout                 | 7                                    | 3.5                       | 5                       | 1               | 9               | 2.7             | 7.2             |
| Improve the efficiency of the staff | 4.5                              | 1.6                       | 8                       | 9               | 2.7             | 8.8             |

Conditions are assimilated with the benefits for the future employers of the technical faculty graduates. Grades from 5 to 9 were assigned as in the example given above. An essential aspect in the COMBINEX matrix is the importance of the factors or conditions. The total importance can be established to 1, so, if all conditions have the same importance, based on the presumption of summation, every condition will count as an equal percentage. If the relevance of the conditions is different the weights could be different but summing 1. In this case, each grade was multiplied by its
weight “w” and the related value “Rv” was obtained specified in the next cell of the matrix. Finally, in the last column, there are the “relative results”.

This is a very simple simulation for COMBINEX matrix. For each benefit obtained by the future employer, the university has to make a choice by improving something. Behind the grades, there is another submatrix or a chart that suggests or establishes (in the case of clear instruments like costs valuable in money) the relation between the variables. For example, when curriculum is modified, the costs of the university are very big at the beginning, and drops down in the following years (linear or asymptotically). This will have a big impact from the beginning on the technical knowledge, but the graduates will also be expensive. Decreasing dropout will affect mainly the employers because the number of the graduates will increase, and their cost will decline, and even the university will be more productive. As for the last choice, it is very clear that all variables are optimal.

For the studied matrix, in the last column there are the “relative results” obtained like sum, and it seems that the last choice could be the answer to the required problem.

The model is only a simple simulation to make a hierarchy of options. It is very important to also understand if the choices bring a plus value for the university, too (like increasing the prestige). It is important to split the question of funds: who is funding the employers and who is funding the university? Transilvania University is a state university, but important industrial companies for the related area fund in different forms the educational process.

5. Conclusions and personal contributions
In the value engineering the main question is: “What is the function of the product?” The idea of “function” will always be linked with the utility. If the educational system is a provider of human value, the principle of utility must be rewritten.

There are two important tasks: first, to establish the desire of the society in general and the desire of the employers in particular, and second, to design, to build and to apply a viable model based on which to relay the educational process. This complex and dynamic model has to fulfil the requirements of the workforce market in a rational proportion with the educational effort. Because no matter who will use the workforce, the product “student” or “graduate” must have a higher value for the society than the employer can pay. Otherwise, the employers will never be interested in making the exchange: money versus workforce.

My personal contribution to this paper is the adaptable model and working plan on the student’s value. It is very difficult to put in a box this product. There are significant and sensible features that differentiate a material product from a living one: reputation, estimate, time delivery, personal features and personality may influence the whole educational project. The selling price of the workforce will remain the ultimate measurement, but how can the equitable value for utility be established? How can the function be defined? Can the abstracting degree of the model be increased and ask: why must the product “graduate” answer to a specific demand? Or, can the degree be decreased by asking: How must the product “graduate” do a specific job? Between these two questions there are a lot of possibilities to create models of evaluation.

This study was not concentrated on finding formulas but it puts important concepts like value, function and method into another context.

References
[1] Maynard H B1975 Manual de inginerie industriala (Bucuresti: Tehnica) p 250
[2] Duicu S S 2015 About changing the paradigms in the technical education J Ind. Design Eng. Graph. JIDEG 13
[3] Raportul anual privind starea universitatii Transilvania Brasov 2018 https://www.unitbv.ro/documente/despre-unitbv/regulamente-hotarari/hotarari/senat/HSnr.21
[4] https://www.hbmaynard.com/workforceperformance/wpm_engineeredstandards.asp
[5] Neumann J Von, Morgenstern 2007 Theory of games and economic behaviour (Princeton ed.)