

Improving student's value in technical education

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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 analyse 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 over the 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 we assimilate the term of „product” to a student than all the components of this notion will be analysed in consequence, including notions like „price” and „cost”. The purpose of this analyse is to generate simple principles for understanding, modelling and optimizing this problem.

2. Value's Components

We can agree 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 less possible for a good, useful, rare product not only against the competition between them but also in competition with their own resources. This is why the interaction between these five components drives 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.

2.1 Utility and exchange values

One of the most formal and old in the same time classification was done in the antiquity by Aristotle. Understanding ancient Greeks disapproval for trading and their love for individuality, we can resume

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 can begin a clear evaluation.

Utility and exchange values substantiate the economic value. In the modern time new aspects more interesting are highlighted: the estimation value and the trading value. We can't isolate the estimate value from the industrial context. All those components must interfere one to another to create a living and functional model. Maynard says that [1] the most common mistake is to isolate the estimation 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 like a guide to the employers when the moment of choosing between different candidates comes. Finally, the utility value becomes first but most of the time CV counts. 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 subordinate to the function. A good example in 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 makes the product „engineer“ what it has to be. But the market value and the exchange one reflect better the economical aspect of a product. The value engineering makes this connection between the economical characteristics and the real, physical one such the number of graduates, gender and availability.

It is very clear that employers will set the criteria on economical evaluation and not 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 graduates. Because we are talking about state institution we are not talking about the ratio between investment and profit, we can't count the profitability of the educational act in money. Quality means the ratio of absorption in the workforce market and, sometime, the degree of acceptance.

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

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

- **Utility value** - how useful is the education of our students (not only their technical knowledge) to their future employers?
- **Exchange value** – beyond their technical education, how can our students achieve better position or better jobs?
- **Market value** - how much can the employers pay for our students?
- **Estimation cost** – how can be balanced the market and exchange value 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 combine five components that have effects over the student's value (figure 1).

The working model about the student's value needs: to ensure clear standards to evaluate the product „student”, to provide all necessary information to the educational system and to put questions to the employers.

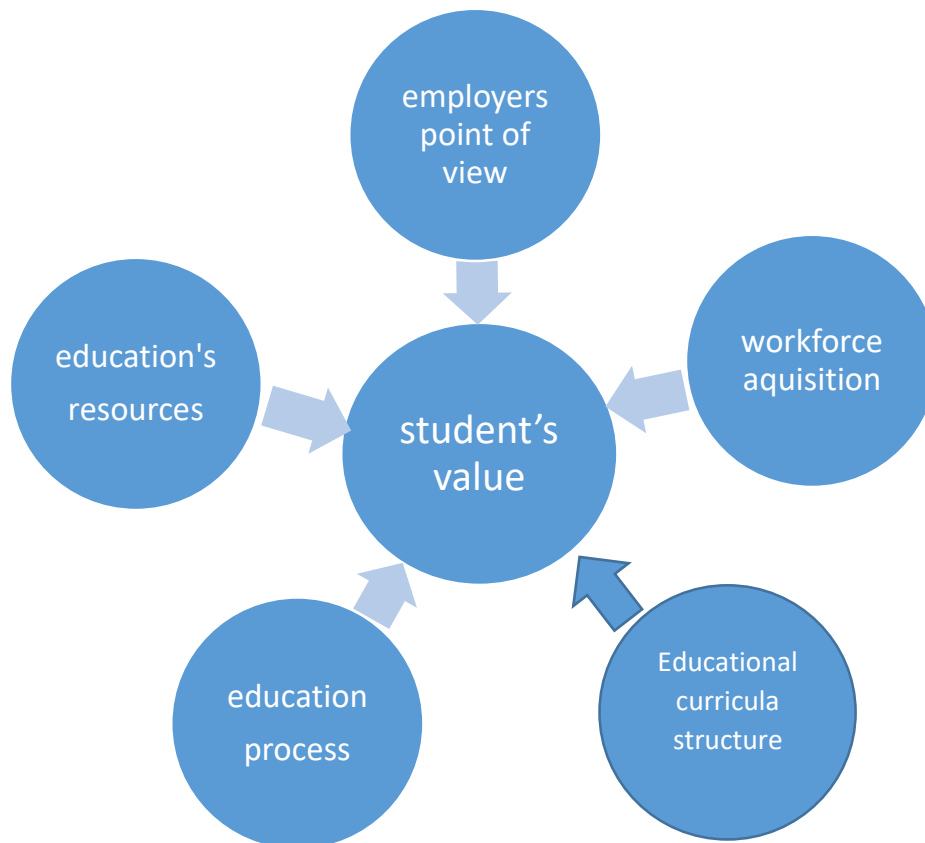


Figure1. Value working model

Value analysis team has to collect all information to be combined into a viable model. In one hand we have the future graduates and in the other hand we have the future employers. A modality to compare different models is explained in table 1.

Possibilities: What are the possibilities? How many cost the improvement?

Possibilities to put into practice: What is the probability in % to put into practice the proposal according to the model? Measurement is made in % of accomplishment.

Information: Do we have all information to create the model? How much in % we can access to establish the best model?

Time: Do we have enough time to put into practice the model? How much in % we give to each optimization proposal?

Professional level: Do we have the professional level to put into practice the model? How much in % we offer to each level of education?

Probability: Probability in % to put in practice the model

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

Table 1. A modality to compare different models

Criteria/ Choices	Possibilities	Real possibilities	Information	Time	Professional level	Probability	Earnings
Example: Student's value							
Improving the 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 found enrolled at Transilvania University (which is a state university) in the 2017, bachelor level (budget and fee), all forms of education: frequency, low frequency and distance learning [3]. The distribution for these students is: 6122 students with frequency, 528 low frequency, 346 distance learning. 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 new introduced programs of study in 2017, but 33% of those entering is lost. This study doesn't take into consideration the number of students enrolled in distance learning or low frequency because it is presumed they are already working. Starting the premises that 90% of these students will graduate, about 1000 engineers will enter in the technical workforce market. Transilvania University is the most important regional university center 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 answer to 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.

In the same time, the growing ratio of the industrial area is minimum 10% (for an organic grow) and the number of the jobs offer is about 150 engineers. Starting only from these two numbers we can imagine 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.

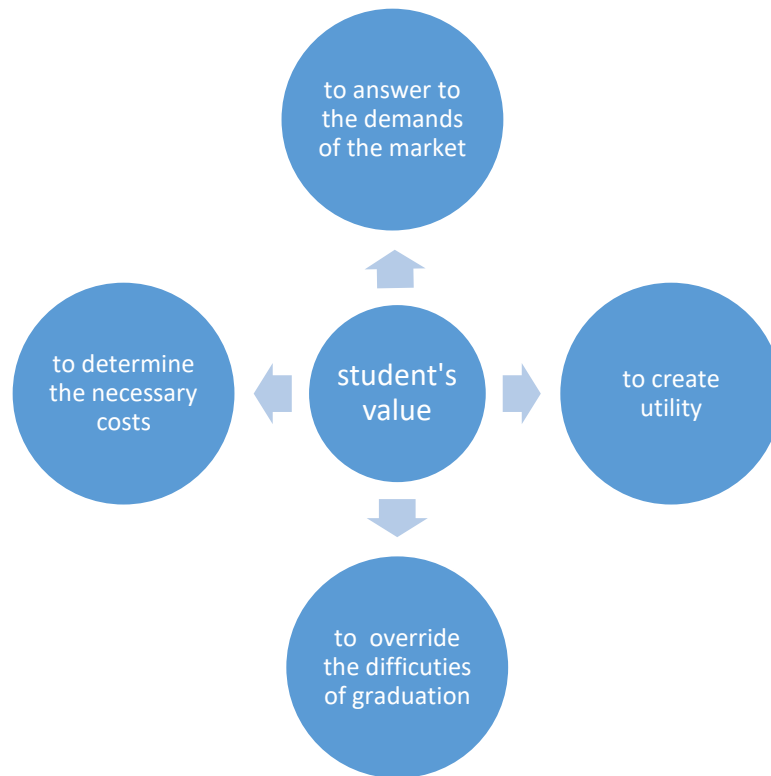


Figure 2 Effects over the student's value

4. Working Plan

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

- Understand the end-use requirements
- Select appropriate development approach
- Establish for best methods
- Measure the work
- Apply Allowances
- Document standards and conditions
- 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 innovation, brevets and research reports

4.1. Proposal on working plan

The steps of the working plan on the value model must have several steps.

4.1.1. 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

4.1.2. Analysis step must answer at 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
- Defining how much should the product “student” cost: evaluation in comparison with other educational systems, the cost with imported workforce, cost per potential employee (given by the calculation of the price of an object produced by the future employee)

4.1.3. Creation step

- How can be the student’s value improved? How can be installed a proper atmosphere of study, encouraged inventive personalities and inventive actions, create conditions for research and innovation.
- Identifying obstacles in front of innovation and remove them, improving the creation mechanisms, creating the climate for change and adapt to changing, looking for analogies, anchoring in the objective reality, finding the best solution.
- Optimization
- Simplification

4.1.4. 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 ration, employment ratio or successful employment; advantages and disadvantages of the chose 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.

4.1.5. 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 exist problems in the performance of the educational system? Could be risks in acquisition of new educational means or other kind of risks?

4.1.6. Recommendation step

- Making a full report with recommendation
- Establishing levels of action
- Authorization and approval.

4.1.7. Practice step

This last step must harmonize beneficiaries and the educational system. It must keep in mind the factors that determine the acceptance: what are the normal cost of the education and what unexpected costs could appear? Also is very important for both parts to make the right choice: what kind of education needs the students and if this training is needed by the employers?

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

The mechanism of putting into practice the model must be clear, simple, well documented, keeping in mind all the time that the function of the product "student". For every case, some other features can be important and unexpected situation 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 establish the priorities
- Affected areas: What are the modification in the educational program and who will be affected?
- Deadlines: When is begins the action and how long it will be? Is it a continuous project and curricula will be affected? How long it will take until the first results will look?
- Follow-up: Can be established follow-up procedures? Can be done some reports from time to time (establish the period)? Are some landmarks or goals established by the future employers to be reached?
- Results measurements: Can be measured all earns in time and money? Can be calculate all costs in time and money? Can we make some comparisons of the total earns with the total cost regarding the final effort?

4.2. COMBINEX Method

The well knew COMBINEX method establishes a matrix that combines different advantages given by several input conditions. 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 whom contribution will affect the available solutions
- Final scoring table.

COMBINEX method may evidence the area in which an effort can bring a maximum advantage.

It can be proposed a scoring table choosing different conditions on the horizontal lines, and different choices on the columns.

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 we can find a common property that can be mirrored in numbers.

For example, for a future engineer, some technical skills can be measured in its 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, may be a 10 grade is not so important regarding the competition between different universities when high standards do not allow to reach a 10 grade so easy.

Another measurement unit can be the cost, but not all the time a higher cost of the education. But some time 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 employee than for another, or his utility can be bigger for one than for another. In the context of industrial growing the economic value increases in 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 for the employer.

We can translate this into a new hypothesis: technical universities must offer to the employers something more valuable than the price paid for its graduates.

In our case, innovation, modernization, simplification and a better use of the staff involved in education may offer to the future graduates 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, lower limit can be instead of grade 5 the lower condition to be accepted by the employer, grade 7 can be equated with the 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 from both parts only if the graduate's education does not involve excessive costs.

Table 2 proposes a COMBINEX matrix, with the same weight for all choices and conditions. Conditions are assimilated with the benefits for the future employers of the technical faculties graduates. Grades from 5 to 9 were assigned as in the example given above. Each grade was multiplied by the weight and obtained the value specified in each lower right corner of every cell of the matrix.

Table2. COMBINEX matrix

Conditions weights	Powerful technical knowledge	Flexible thinking	Cost employment	Relative results
	0,5	0,2	0,3	
Choices				
Modify curricula	9 4,5	7 1,4	7 2,1	8
Decrease dropout	7 3,5	5 1	9 2,7	7,2
Improve the efficiency of the staff	9 4,5	8 1,6	9 2,7	8,8

Another important aspect in the COMBINEX matrix is the importance of the factors or conditions. The total importance can be established at 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.

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 suggest or establish (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 be expensive also. 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, 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 seems like the last choice to be the answer to the required problem.

The model is only a simple simulation to make an options hierarchy. It is very important to understand also if the choices bring a plus value for university also (like increasing the prestige). Is important to split the question of fund: who is supplying the employers and who is supplying the university? Transilvania university is a state university but important industrial companies for the related area supply 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 fulfilled 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” must have a higher value for the society than the employer can pay. Otherwise, the employers will never be interested to make the exchange: money versus workforce.

My personal contribution in 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. Of course, the selling price of the workforce will remain the ultimate measurement but how can be established the equitable value for utility? How can we define the function? Can we increase the abstracting degree of the model and ask: why must the product “student” to answer to a specific demand? Or we can decrease the degree by asking: How can the product “student” must 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 on formulas but puts important concepts like value, function and method into another context.

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