European Proceedings of
Educational Sciences
EpES
www.europeanproceedings.com
e-ISSN: 2672-815X

DOI: 10.15405/epes.22032.71

ERD 2021
9th International Conference Education, Reflection, Development

TECHNOLOGICAL AND ENGINEERING EDUCATION. TEACHERS' AND STUDENTS' VIEWS

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Abstract

Today, technology and engineering, along with science, are the engine that ensures the development of society. Thus, this development should also be reflected in the school curriculum. Taking that into account, the contact of pre-schoolers and young school children with the study of these subjects should become compulsory /mandatory. These must be included in the curriculum and the education priorities for a future career would be appropriate to be the students' acquisition of concepts, skills and reasoning specific to the scientist, engineer and technologist. That is why, the integrated approaches, inquiry learning, problem based learning, practical and out of school activities are the most appropriate way to include these subjects/ topics in the curriculum. Along with the development of knowledge, skills and reasoning, the merit of these integrations is the contribution to the foundation of a scientific and general culture / knowledge. This study is a descriptive research study using a survey method. It aims to identify the opinions of a sample of 193 subjects with reference to the characteristics of the fields of technology and engineering, the relationship between them, and the occupations of an engineer and technologist.

Keywords: Engineering, future teachers, preschool, teachers, primary school, technology

https://doi.org/10.15405/epes.22032.71
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eISSN: 2672-815X

1. Introduction

Scientific and technical (technological and engineering) education are nowadays areas that need to be studied in schools due to the characteristics of today's society, where science, technology and engineering are undergoing accelerated development.

The study of science gives the learner the opportunity to acquire knowledge of scientific concepts and phenomena, to develop skills, to experiment and to use instruments and devices in order to respond to his or her curiosity, and thus to develop scientific and critical thinking.

The practice of scientific thinking is exercised at the stages of the scientific process and involves knowledge of scientific processes and possession of skills: formulating clear, precise and relevant problems and questions; collecting and analyzing scientific data in order to establish regularities; using scientific laws, theories and ideas to interpret data effectively; formulating hypotheses and predictions, conclusions and scientific solutions based on facts and evidence and responding to predetermined criteria; sharing knowledge and communicating/collaborating with others at each stage of a scientific endeavor (Paul & Elder, 2019).

Technology is a fuzzy concept (Albion et al., 2018), defined either in terms of human process-activity or in terms of product-artifact. For example, in a 1999 study, some Finnish teachers defined technology in terms of (i) the use of technical devices and machines (artifacts) and (ii) the application of knowledge, skills, and means for accomplishing different tasks; (iii) as a process (production process) respectively (iv) as a knowledge system of how technical devices and machines work (Alamäki, 1999). Cunningham (2018) integrates the two perspectives and defines technology as "a body of knowledge, artifacts, processes, and systems" obtained through engineering with the aim of solving practical problems and needs of society or individuals.

The relationship between science and technology has been characterized by Gardner (1994) as follows: science precedes technology because technological development is based on scientific knowledge (Technology as Applied Science-TAS); science and technology are independent, with different goals, methods, and outcomes; technology precedes science, meaning that historically and ontologically it is situated before science to which it provides the instrumentation and artifacts necessary for its conceptual development; technology and science interact bidirectionally, the scientists and the technologists are learning from each other (Collier et al., 2011).

The public often confuses engineering with technology, as they are strongly interdependent, as both of them are problem-solving. From the perspective of the aim, technology is the process of practicing the plans of engineers, architects, designers, etc. using tools, materials, and process skills (Dietz, 2014). Unlike technology, engineering is frequently associated with a design process, which combines knowledge of material properties and leads to the development of models that predict how designed solutions behave and respond to human needs.

The differences between technology and engineering can be discussed in terms of action, materials, products, innovation or invention. For example, technology is more action-based, centred on making practical/real products (artifacts) and innovation. Engineering, on the other hand, relies more on thinking, scientific and technological knowledge, design and modelling, and often involves not only

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innovation but also invention. Technologists use knowledge and raw materials to create something innovative for society. The engineer studies scientific applications to know how to make new inventions to meet society's needs.

Adey and Shayer (2002) and Adey et al. (2003) identify a set of important thinking skills in science and technology: classification (grouping things), causality (identifying causal relationships), combinatorial thinking (systematic identification of combinations), serialization (ordering things), concrete/practical modelling (building models and prototypes), exploring the relationship between variables and conservation (Cunningham, 2018). It is also added the ability to design, an important acquisition for the engineer's thinking. Some characteristics of the engineer's activity are: curiosity and ability to ask good questions and to document (study and research) deeply, imagination and ability to preview what they intend to design, accuracy in the use of tools and measurements, confidence in their own ideas and ability to put them into practice, the ability to work efficiently in teams, problem solving, the desire for performance and the ability to optimize the created products (Hunt, 2018). McCue (2016) identifies some differences between the cycle of the engineer's activity of making products or the cycle of making a process. Both cycles involve four stages. In the case of making products, these stages are: the product design, the product construction (preliminary realization of a prototype), the testing of the prototype and of the product, and the product optimization (McCue, 2016). The stage of achieving a process involves the following steps: planning, implementation, evaluation and optimization (McCue, 2016).

Engineering and Technology Education (ETE) implies, according to Schunn and Silk (2011), taking into account the contribution of Science and Mathematics in the fields of engineering and technology. As a result, ETE involves STEM knowledge. The cited source highlights three theories of learning that could be useful in ETE: Information Processing, Distributed Cognition, and Cognitive Apprenticeship. However, the authors appreciate that the problematic complexity of ETE involves a wider range of learning theories (Schunn & Silk, 2011).

As early as preschool, children come into contact with scientific and technical (technological and engineering) knowledge. They acquire scientific, technological, and engineering knowledge from kindergarten, family, friends, and the media. But this knowledge is fragmented and marked by naive ideas. Their scientific thinking begins to take shape when they learn to classify and recognize categories, observe and identify causal relationships, and formulate predictions or conclusions. Pierce and Karwatka (2010) appreciate that students must become not only scientifically literate, but also technologically and engineering literate).

2. Problem Statement

In Romanian education/instruction, engineering is only studied at the university while technology has recently been introduced into the secondary school curriculum. However, the trend is the migration towards information technology. In preschool and primary education, only practical activities (practical skills) are studied, aiming / highlighting children's creation products (handcrafts) as decorative objects. To understand to what extent to which it is possible to study technology and engineering processes and

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products at the primary school level, it is important to know what teachers think about these areas of interest.

3. Research Questions

Given the convergence of technology and engineering concerns and the confusion about their subject matter and the relationship between them, the question is: How do the teachers and the prospective primary and pre-school teachers perceive the two subjects? Is there an obvious difference, statistically speaking, in the selection of questionnaire items relating to the subject of engineering and technology and the occupation of an engineer respectively a technologist?

4. Purpose of the Study

Its purpose is to identify the opinions of a sample of 193 subjects with reference to (i) the characteristics of the fields of technology and engineering; (ii) the relationship between them; (iii) the occupations of engineer and technologist.

5. Research Methods

The investigation carried out consisted of a survey based on a questionnaire developed by the researchers. The sample was a convenience sample.

5.1. Demographics

94.3% of the respondents are female; 28% of the respondents are aged 19-24, 20.2% are aged 25-29, 18.1% are aged 35-39, 13% are aged 34-39 and 11.9% are aged 30-34. 40.4% of respondents are student- teachers/prospective teachers having no teaching experience at all, 29% have less than 5 years of teaching experience, and 11.4% between 5 and 9 years. 40.9% have a Bachelor's degree, 31.1% have a Bachelor's degree and 27.5% have a Master's degree. 25.4% of the respondents teach in pre-schools and 21.2% in primary schools.

5.2. The instrument

The instrument used in the survey included 53 items of which 20 items are referred to in this study. The questionnaire was completed online. Responses to the questionnaire were voluntary. The questionnaire was divided into two main sections. A 5-point Likert-type scale was used as a data collection instrument to obtain students' opinions about different characteristics of technology and engineering and 4-point Likert-type scale was used to find out students' opinions about engineering and technology occupations.

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5.3. Data collection process

The researchers specified how the results were to be used. Participants were invited to take part in the survey and were told that it would take about 15 minutes to complete the questionnaire. It was stressed that their participation was voluntary and that those responses were confidential.

6. Findings

IBM SPSS Statistics version 23 was used to perform analyzes to answer research questions. Data analyzes included descriptive statistics (measures of frequencies, percentages, averages, and standard deviations).

6.1. Respondents' views on the subject of engineering and technology

Respondents were asked to indicate their degree of agreement with reference to the items specified in Table 1 on a 5-step Likert-type scale. For the presentation of the results, the percentages corresponding to Strongly Disagree and Disagree respectively Strongly Agree and Agree to find labelled Disagree and Agree.

More than a third of respondents rate with "Neither agree nor disagree" the following item: "Technology is more related to engineering products than to its processes" (33.7% of respondents) and, surprisingly, one-fifth appreciate the item: "Engineering uses the products of technology".

Table 1. Respondents' agreement with statements on the subject matter of technology and engineering

Item	N	Disagree (%)	Neither agree nor disagree (%)	Agree (%)
The technology involves the practical application of knowledge in a field.	193	6.2	14	79.8
Engineering involves applying scientific methods and using technology products to solve practical/real problems.	193	5.7	11.9	82.4
Technology is more related to engineering products than to its processes.	193	18.1	33.7	48.2
Engineering involves the use of technology products.	193	12.4	20.7	66.8
The technological process also	193	4.6	10.9	84.4

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involves manual/hand activities.				
Various tools and devices are used in technology.	193	3.1	11.9	84.9
Engineering uses devices, instruments and various other technological products.	193	5.2	11.4	83.4
Engineering design is about the components of a product.	193	9.8	18.7	71.5
Engineering design covers the whole product (device, machine, construction, circuits, etc.)	193	2.6	14.0	83.4
Engineering design concerns the functioning of a product/device.	193	8.8	10.9	80.3

The calculation of the average highlights other opinions of the respondents (Table 2):

- Technology involves the practical application of knowledge (m=4.13; StDev=.946), manual/hand activities (m=4.36; StDev=.892) but also the use of various tools and devices (m=4.42; StDev =.857).
- The engineering design concerns both the product to be manufactured as a whole (m=4.36; StDev =.818) and its components (m=3.97; StDev =1.073) and its operation (m=4.19; StDev =.982).

Regarding the interactions between engineering and technology:

- Engineering involves the use of products of technology (m=3.81; StDev =1.132) or of devices, tools, and various technological products (m=4.28; StDev =.932). In addition, engineering involves the application of scientific methods and the use of technological products to solve practical problems/matters (m=4.23; StDev =.926).
- Opinions differ as to whether technology is more related to engineering products than to engineering processes (m=3.40; StDev =1.105).

Table 2 shows, with reference to the characteristics of the technological and engineering fields, the average of the respondents' ratings, the standard deviation, and the difference of the average of some teachers' and students' ratings (100 teachers and 73 students).

Table 2. Respondents' views on the subject of technology and engineering

Item	N	m	St. Dev.	$m_{teachers}$ (101) – $m_{students}$(73)
The technology involves the	193	4.13	.946	

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practical application of knowledge in a field.				0.17
Engineering involves applying scientific methods and using technology products to solve practical problems/matters/issues.	193	4.23	.926	-0.07
Technology is more related to engineering products than to its processes.	193	3.40	1.105	0.01
Engineering uses the products of technology.	193	3.81	1.132	-0.04
The technological process also involves manual/hand activities.	193	4.36	.892	-0.09
Various tools and devices are used in technology.	193	4.42	.857	0.09
Engineering uses devices, instruments, and various other technological products.	193	4.28	.932	0
Engineering design refers to the components of a product.	193	3.94	1.073	-0.06
Engineering design covers the whole product (device, machine, construction, circuits, etc.)	193	4.36	.818	0.18
Engineering design concerns the functioning of a product/device.	193	4.19	.982	0.02

* The data from Table 2 did not include the calculation of the difference in the average of the 14 respondents who indicated "other status" with respect to their occupation (student or teacher).

The t test shows that the teachers' and students' opinions do not differ significantly in terms of the object of study of technology and engineering.

6.2. Respondents' assessments of engineer and technologist occupations

To identify opinions on the occupations of a technologist and engineer, respondents were asked to rate on a four-level Likert type scale (1- Not important at all and 4 - Very important) a set of statements indicated in Table 3. The analysis of the data shows that the lowest percentages of respondents who consider a specific technologist / engineer's skill very important concern items "A technologist / engineer must troubleshoot faults" and "A technologist / engineer must use the expert language/the specialized language". On the other hand, the most important skill of the technologist/engineer is that "A technologist/an engineer must know the specifics of technology/engineering design and ought to be able to carry out projects".

Table 3. Respondents' opinions on the occupations of engineer and technologist (%)

Item	N	1 (%)	2 (%)	3 (%)	4 (%)
A technologist/an	193	0	1	9.3	89.6

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engineer must know the specifics of technology/engineering design and ought to be able to carry out projects.					
A technologist/an engineer must identify malfunctioning devices.	193	0	0	16.1	83.9
A technologist/an engineer must troubleshoot.	193	.5	6.2	30.6	62.7
A technologist/an engineer must optimize the operation of a device.	193	0	2.6	21.2	76.2
A technologist/an engineer must make models or prototypes.	193	.5	3.1	24.9	71.5
A technologist/an engineer must use a specialist language.	193	1.0	2.6	37.3	59.1
A technologist/an engineer must think logically.	193	.5	1.0	19.7	78.8
A technologist/an engineer must think mathematically and use computational methods.	193	.5	3.6	24.4	71.5
A technologist/an engineer must implement the designed products.	193	.5	1.0	21.8	76.7
A technologist/an engineer must investigate/research technical problems.	193	.5	1.0	21.8	76.7

Table 4 shows the average of the respondents' ratings of technical occupations, the standard deviation, and the difference of the average ratings of the 100 teachers and 73 students.

Table 4. Respondents' ratings with reference to engineer and technologist occupations (mean and StDev)

Item	N	m	St. Dev.	$M_{teachers}$ (101) – $m_{students}$ (73)
A technologist/an engineer must know the specifics of design in technology/engineering and be able to carry out projects.	193	3.89	.350	0
A technologist/an	193	3.84	.368	

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engineer must identify malfunctioning devices.				-0.04
A technologist/an engineer must troubleshoot.	193	3.55	.636	-0.21
A technologist/an engineer must optimize the operation of a device.	193	3.74	.498	0
A technologist/an engineer must make models or prototypes.	193	3.67	.561	-0.14
A technologist/an engineer must use a specialist language.	193	3.54	.603	-0.17
A technologist/an engineer must think logically.	193	3.77	.481	0.03
A technologist/an engineer must think mathematically and use computational methods.	193	3.67	.572	0.03
A technologist/an engineer must implement the designed products.	193	3.71	.548	-0.07
A technologist/an engineer must investigate/research technical problems.	193	3.75	.492	-0.12

*The data in Table 2 did not include the calculation of the difference of the averages of the 14 respondents, which indicated "another situation" with respect to their occupation (student or teacher).

The t test shows that the teachers' and the students' opinions do not differ at all regarding the professions of engineer or technologist.

7. Conclusion

The obtained results confirm that the differences between the fields of technology and engineering are difficult to be noticed by the teachers and the students who participated at this study. Thus, the teachers' and students' opinions and assessments do not differ significantly either with regard to the characteristics of the two technical fields under consideration or with regard to the skills required for the occupations (professions) of an engineer respectively a technologist. The explanation can probably be found in the fact that neither the population nor the respondents are familiar with the technological processes nor the work of an engineer nor the subfields of engineering (electronic engineer, mechanical engineer, etc.). In fact, they come into contact with artifacts, i.e., the results of the engineer's and the technologist's work. We deduce from this the importance of familiarising students-prospective teachers with production activities by visiting different enterprises, watching news reports, talking to engineers and technologists, studying materials and appliances in the family household, studying handmade products, etc.

Teachers must understand that we live in a technological society and that the education of students must include knowledge of mathematics, science, technology, and engineering. Binding together the mentioned fields with arts and reading we can develop STREAM approaches and the 'general culture' of students.

As a result, the first to benefit from education in this sense are themselves.

Acknowledgments

This work was possible with the financial support of the Babeş Bolyai University, from the budget allocated for doctoral students.

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