# Understanding better young people's views on technology in Finland

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## Introduction

Several studies have reported that there are groups among young people that view technology differently from each other and thus have different motives for studying or opting out of engineering. The contemporary youth are not only a diverse group in themselves, but they are also quite different in certain respects from previous generations. Therefore, understanding the perceptions and motives of young people is crucial in order to engage them in engineering studies. To advance the development of technology in the future, it is important not only to attract a sufficient number of young people, but also to achieve a diverse pool of applicants to ensure that multiple viewpoints and different talents contribute to the work in the field.

Career choices in postmodern society

In postmodern society, the rapid technological change, evolving new technologies, digitalization, and automatization are fundamentally changing the labor market [1, 2]. In the digital era, the importance of lifelong learning, upskilling, reskilling, and acquisition of new competences is emphasized [2]. Postmodern society emphasizes the role of an individual: for adolescents, self-exploration, self-actualization, finding an interesting field of study, developing a satisfying career, and establishing a meaningful life are among the key factors steering the decisions about education and occupation [3, 4, 5, 6].

In the modern world, where technology is ubiquitous and encompasses all our daily activities, it is highly important to raise awareness of significant career opportunities in technology. It is also worthy of note that technology is nowadays present also in many traditionally nontechnical professions. Thus, when informing young people about career options, open-minded and innovative approaches are required, providing examples of inspiring role models and various career paths in technology. This is especially important when addressing well-performing postmodern young women [5], for whom self-expression, finding intrinsically fulfilling jobs, establishing a meaningful career, and ultimately, finding sense of purpose in life are particularly important but who consider engineering and technology a second option only or no option at all. A potential approach to attract more girls and young women into engineering is to show by practical cases how jobs in technology can serve for the greater good and contribute to individual human beings and society. A viable strategy to attract practice-oriented boys and young men, in turn, may be to emphasize the opportunities provided by technology for self-expression through practical problem-solving and technological innovation.

In Finland, as a result of changes in the labor market and the educational system, especially in application to further studies, young people feel uncertain about their future, and they are confused about different study paths and alternatives available [4]. The general uncertainty among young people is manifested by the postponement of studies leading to a qualification or degree. In 2018, only 27% of women and 35% of men continued their studies immediately in the year of matriculation examination, even though 82% of the passers of the matriculation examination applied for further studies [7]. This is despite the fact that in general upper secondary school (grades 10-12), most Finnish students find that they have received plenty of information about the study alternatives from their guidance counselor [4]. Those performing well in school are of the opinion that they have received more than an average amount of

information from their counselors and media, yet they may still find it difficult to decide upon their field of study. On the other hand, young boys and men who remain outside further studies consider that they have received only little career counseling and information about study alternatives [4]. Therefore, to avoid postponement and discontinuation of studies, special attention has to be paid to both well-performing and underachieving adolescents.

In order to reach various kinds of young people and encourage them into engineering, information about studies and career opportunities in the field has to be produced in a suitable, attractive form. To successfully communicate such information to different types of young people, knowledge of their specific characteristics is required. These characteristics can be expressed in the form of youth profiles, which will be discussed with examples below.

## Different views on technology and engineering

There have been many attempts to understand the diversity and nature of young people's viewpoints on engineering and technology. The Dutch BètaMentality [8] project discovered four profiles related to adolescents and technology: High Techs, Career Techs, Socially Minded Generalists, and Non Techs. High Techs enjoy both science and technology. They are hands-on people who like practical examples and laboratory work. High Techs like to understand how things work and often have technology-related hobbies. Slightly less than forty percent of the boys and a quarter of the girls fall into this category. Career Techs enjoy technology as long as it works, but are not particularly interested in *how* it works. They have a more theoretical than practical mindset and enjoy learning, and may find school science easy but boring. The high status and career opportunities in science and technology appeal to Career Techs. About thirty percent of the boys and slightly more than a quarter of the girls are found to have this profile. Socially Minded Generalists appreciate the usefulness of science and technology subjects but do not have a clear perception of technology. They enjoy school science and want to contribute to society, but cannot necessarily see how these two can be linked. Slightly less than thirty percent of the girls and a quarter of the boys share this profile. Non Techs do not care about technology and find school STEM subjects difficult, boring, and uninteresting. They do not feel confident of science and technology and actively ignore them in favor of other subjects. Over three quarters of the Non Techs are girls. Seven percent of all the boys and twenty percent of all the girls fit this profile.

A Swedish project [9] identified three different types of technology-interested groups among upper secondary school students: Ingenjörsivrarna (Engineering Enthusiasts), Ambitiösa Naturare (Ambitious Scientists), and Teknikkreativa (Technical Creators). Ten percent of all the upper secondary school students are enthusiasts, who are very likely to enter engineering education. They are interested in technology and want to work with it in the future. Three quarters of the engineering enthusiasts are boys. Eight percent of the upper secondary school students are Ambitious Scientists, who are interested in technology but also in natural sciences. They are most likely to be attracted to the engineering education with close connections to societal issues or natural sciences. They often want to contribute to society or the environment. Gender distribution within this group is fifty-fifty. Six percent of the upper secondary school students are characterized as Technical Creators. They are usually in the forefront of using new technologies but are often more interested in applications and design than keen on understanding how they actually work. For them technology is a means to be creative. Three-fifths of the Technical Creators are boys and two-fifths are girls.

Engstöm [10] studied the gender differences and similarities among successful students in higher technical education in Sweden. Two interesting differences stand out among the many similarities. For one group of male students, science and mathematics had not necessarily been easy. They had been drawn to engineering because of a very practical interest in technology developed often through their upbringing "in the garage." This kind of tinkering orientation towards technology could not be found among the female students. On the other hand, within the female students, there emerged a profile which primarily wanted to do good for society. There was, however, no equivalent profile present among the male students.

## Methods

In order to better understand what kinds of young people are attracted to engineering in Finland, we conducted a survey on different aspects of young people's relationship to technology. The aim of the survey was to find out what kind of technology profiles are present among Finnish adolescents, and how the different profiles correlate with the interest in engineering. We also wanted to see what kinds of gender differences existed in relation to different profiles and interests in engineering and technology.

The objectives were pursued by seeking answers to three research questions:

1. What kinds of technology profiles can be identified among Finnish adolescents?
2. How do different profiles relate to the interest in technology and engineering?
3. What kinds of gender differences exist with respect to the technology profiles and the interest in technology and engineering?

### Data collection

Despite the existence of previous profiling studies, we could not find a ready-made and tested instrument for measuring the phenomenon of interest. Therefore, we built a questionnaire based on our findings in the literature. The questionnaire consisted of two questions with sets of statements: one asking the respondents to rate how well different statements described them or their relationship to technology and the other asking the respondents to evaluate their possible future study options. These two questions were placed as part of different, larger questionnaires to gather data from three different groups. The first question and the statements were exactly the same for all of the groups, whereas the latter question was modified according to the context and was not posed at all to one of the groups. The questions were in Finnish; a translation of the questions into English can be found in Appendix 1.

The questions were administered to three different groups of relatively similar ages and other demographics. The first group of respondents consisted of students that had just started their studies towards a B.Sc. in Mechanical, Electrical, Environmental, or Energy engineering at LUT University (Group A, N=133). This group was only presented with the first question as they had already made a study career decision by entering the technical university. The statements about their relationship to technology were a part of an electronic questionnaire about the beginning of the engineering studies, presented to the group at the end of the first semester in autumn 2017. The second group comprised upper secondary school students who attended a university course in Basic Electronics in three consecutive years from 2017 to 2019 (Group B, N=101). These students were motivated to study this technology-related topic but did not necessarily intend to pursue a career in engineering. The course was voluntary, and the participants were awarded both university and upper secondary school

credits for the completion of the course. The questions were a part of the feedback questionnaire of the course. In the first of the three years the questionnaire was electronic, whereas in the two latter years it was collected on paper. The formulation of the two questions remained unchanged throughout the three years. The respondents in the last group (Group C, N=211) were upper and lower secondary school students who participated in different class visits to the LUT University campus (not necessarily out of their own free will) and thus did not share a particular interest in technology or engineering. For them the questions were presented in a web-based form, which contained only these two questions and a question about the respondent's gender (male, female, does not want to answer). The data were collected between October 2017 and January 2019.

Most of the responses were valid, although some respondents left some statements unevaluated. Altogether, four respondents left all the statements blank or answered "I don't know." These responses were left out of the analysis. The gender distribution of the respondents was different in different groups with the fewest females (18%) in Group A. In group B, the proportion of female respondents was 31%, and in Group C 51%. The details of the valid responses and the gender of the respondents by group is presented in Table 1.

Table 1. Gender distribution of the respondents in different groups

| | **Group A** | **Group B** | **Group C** | **Total** |
|---|---|---|---|---|
| female | 24 | 31 | 107 | 162 |
| male | 109 | 65 | 90 | 264 |
| does not want to tell | 0 | 4 | 11 | 15 |
| **Total number of valid responses** | **133** | **100** | **208** | **441** |
| Total number of respondents | 133 | 101 | 211 | 445 |

Data analysis

The whole set of data was factorized using principal component factor analysis and rotated with Kaiser's rotation. The fit of the created solution was checked against the three groups. The distribution of the variables was mainly noted not to be normal by using the Shapiro-Wilk test for normality, and thus, the comparisons between groups were performed using the Wilcoxon rank-sum test (also known as the Mann-Whitney test). An alpha level of 0.05 was used for all the statistical tests. The analysis was conducted using the statistical software Stata 16.0.

The relationship between the created factors and the respondents' interest in technology was examined with linear regression analysis. A logistic regression analysis was used to study the effect of the factors on the willingness to study engineering and the gender differences in the interests in technology. The quality of the models was tested with Ramsay's RESET test (linear regression) and the Hosmer–Lemeshow goodness-of-fit test (logistic regression).

**Results**

A factor analysis was conducted using the statements of the question "How well do the following statements describe you and your relation to technology (1=very poorly, 4=very well)?". The first attempt contained the statements 2–20 as factorized items. The first

statement of the first question “I am interested in technology” was left out of the factorization as it was later used as a dependable variable in the linear regression analysis. In the second attempt, the items 3, 16, and 18, which loaded on several factors, were left out. The factorization produced five factors with eigenvalues greater than one and explained 66% of the total variation. The overall Keiser-Meyer-Olkin (KMO) measure for the sampling adequacy was above 0.8, and the KMO for each item was greater than 0.64 and for all but one greater than 0.7.

The factors created for the analysis are presented in Table 2. The reliability of the factors can be considered sufficient for all the other factors except for the Familiarity with engineering. The Cronbach’s alphas for all the rest of the factors were nearly 0.7 or over, both for the whole data and for different groups. The four reliable factors were used to create new variables, which were then used in the linear and logistic regression analysis. The pairwise correlation between the four summary variables ranged from 0.208 (between Idealist and Creator) to 0.377 (between Functionalist and Scientist).

Table 2. Factors, their reliability, and the constituents

| **Factors and the respective items** | **Cronbach’s alpha** | | | |
|---|---|---|---|---|
| | Total | Gr A | Gr B | Gr C |
| **Functionalist**<br>2. I am interested in how technology functions<br>6. I am interested in how technology can boost commercial profits<br>7. I have technology-related hobbies<br>8. I have been encouraged and guided to act with technology at home<br>9. I have been encouraged and guided to act with technology at school<br>10. I like constructing things and trying things out in practice | 0.782 | 0.752 | 0.736 | 0.802 |
| **Scientist**<br>11. I like mathematics<br>12. I like natural science<br>13. I am talented in science and mathematics<br>15. I want to apply my mathematic-scientific skills to something practical | 0.818 | 0.743 | 0.725 | 0.845 |
| **Idealist**<br>4. I am interested in how technology can promote the well-being of humans<br>5. I am interested in how technology impacts environment | 0.756 | 0.696 | 0.796 | 0.751 |
| **Creator**<br>14. I think creatively<br>17. I want a job where I can be creative | 0.761 | 0.760 | 0.705 | 0.780 |
| **Familiarity with engineering**<br>19. I know many people with a degree in engineering<br>20. I have at least one close relative who has a degree in engineering or studies towards it | 0.268 | 0.049 | 0.325 | 0.330 |

Four factors with a sufficient reliability were used to create summary variables, which were named similarly to the factors. The means and standard deviations of the summary variables for the whole data as well as the three groups are presented in Table 3. For the whole group the mean values and standard deviations of the variables Scientist, Idealist, and Creator are similar, but the mean of Functionalist is seemingly lower than the mean of the other summary variables. The difference is statistically significant.

Table 3. Mean and standard deviation of the summary statistics obtained by a factor analysis

| | Total | | Group A | | Group B | | Group C | | Female | | Male | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | mean | std | mean | std | mean | std | mean | std | mean | std | mean | std |
| Functionalist | 2.637 | 0.674 | 2.728 | 0.600 | 2.886 | 0.583 | 2.459 | 0.712 | 2.188 | 0.582 | 2.922 | 0.551 |
| Scientist | 3.040 | 0.725 | 3.086 | 0.565 | 3.368 | 0.526 | 2.851 | 0.834 | 2.951 | 0.843 | 3.104 | 0.624 |
| Idealist | 3.000 | 0.775 | 3.199 | 0.699 | 2.985 | 0.809 | 2.879 | 0.782 | 2.994 | 0.806 | 3.019 | 0.745 |
| Creator | 3.005 | 0.723 | 2.985 | 0.696 | 3.132 | 0.641 | 2.946 | 0.770 | 2.988 | 0.769 | 3.021 | 0.687 |

There were also some differences between the means of the four variables among the different groups and the female and male respondents. The p-values of the statistical difference tests for a comparison of the means can be seen in Table 4 with the statistically significant (confidence level 0.95) bolded.

Table 4. Statistical significance of the differences in the variable means between different respondent groups

| | Group A vs Group B | Group A vs Group C | Group B vs Group C | female vs male |
|---|---|---|---|---|
| Functionalist | **0.0195** | **0.0008** | **0.0000** | **0.0000** |
| Scientist | **0.0001** | **0.0425** | **0.0000** | 0.2881 |
| Idealist | 0.0638 | **0.0002** | 0.1686 | 0.9599 |
| Creator | 0.0836 | 0.7871 | **0.0431** | 0.8958 |

First, a linear regression analysis was conducted to find out how the variables created through the factor analysis explain the respondents' interest in technology measured by the responses to the statement "I am interested in technology." Before gender was introduced as a variable to the analysis, all the four summary variables had a statistically significant effect and the model explained 52.5% of the variation (R-squared). When gender was added to the analysis, the statistical significance of the variable Creator disappeared, and the explanation rate rose to 56.3%. The difference between the males' interest in technology was significantly greater than the females' interest (Mann-Whitney, $z = 10.689$, $p=0.0000$). The final analysis was carried out with Functionalist, Scientist, Idealist, and Gender as independent variables. With only 15/441 respondents not wanting to state their gender, the gender was treated as a binary variable, and the respective 15 answers were omitted from the analysis. The results are collected in Table 5. Ramsay's RESET test suggests that there is still room for improvement in the model (H0: model has no omitted variables, $F(3, 411) = 12.31$, $p = 0.0000$).

Table 5. Results of the linear regression examining the interest in technology

| **Dependent Variable** | Interest in technology | | |
|---|---|---|---|
| **Independent Variable** | **Parameter Estimate** | **t-value** | **p-value** |
| Intercept | 0.302 | 1.93 | 0.055 |
| Functionalist | 0.568 | 10.16 | 0.000 |
| Scientist | 0.205 | 4.68 | 0.000 |
| Idealist | 0.153 | 3.78 | 0.000 |
| Gender (base female) | | | |
| male | 0.514 | 7.33 | 0.000 |
| **Model fit** | | | |
| **F-value (d.f. 4, 414)** | 133.49 | **R-Square** | 0.563 |

To study the relationship between the respondents' interest in engineering studies, a logistic regression analysis was conducted. Group A was left out of the analysis as they had already made the choice to study engineering. The variable Interested in engineering studies was composed differently for Groups B and C. For group C, the variable got a value 1 if the respondents evaluated their willingness to study engineering or technology (Question 2b, option 1) as 3 or 4, and a value 0 if their answer to the statement was 1 or 2. For Group B, the value of the variable was defined as 1 if the respondents evaluated either their willingness to study electrical engineering (Question 2a, option1) or their willingness to study some other field of engineering or technology (Question 2a, option 2) or both by giving 3 or 4 as an answer to the statement. Otherwise, the value was defined as 0.

First, the logistic regression analysis was made with all the factors as independent variables. The whole model exhibited a statistical significance (p=0.0000), but the summary variable Idealist did not. The explanatory power of the model as measured through Pseudo R2 was 0.4439. Once the gender as a binary variable was included in the analysis, the summary variable Creator no longer showed a statistical significance (p=0.122). The model explained more than the previous model (Pseudo R2= 0.4935) and remained statistically significant (p=0.0000). In the final model, the dependent variable Interest in engineering studies was explained with the dependent variables Functionalist, Scientist, and Gender (binary). The results are presented in Table 6. The Hosmer–Lemeshow goodness-of-fit test suggests that the model can be improved (H0: Model has good fit with the data, Pearson chi2(172) = 292.62, Prob > chi2 = 0.0000)

The second logistic regression analysis was conducted to study which of the summary variables would predict the respondents' gender. The 15 respondents who did not want to tell their gender were omitted from the analysis. Again, the first trial was made with the created factors as independent variables. The model was statistically significant (p=0.0000), with Pseudo R2=0.2940. However, the variable Scientist did not show a statistical significance (p=0.322). When the variable Group was added to the model, the model as a whole, and all the rest of the independent variables remained significant. Furthermore, the explanatory power of the model improved. The results of this final model are collected in Table 7. The Hosmer–Lemeshow goodness-of-fit test showed a good fit between the model and the data (H0: Model has a good fit with the data, Pearson chi2(338) = 325.41, Prob > chi2 = 0.6789).

Table 6. Results of the logistic regression analysis predicting the interest in engineering studies

| **Dependent Variable** | | | Interest in engineering studies | | |
|---|---|---|---|---|---|
| **Independent Variable** | | | **Odds Ratio** | **z-value** | **p-value** |
| Intercept | | | 0.000 | -7.10 | 0.000 |
| Functionalist | | | 12.789 | 5.67 | 0.000 |
| Scientist | | | 2.258 | 3.07 | 0.002 |
| Gender (base female) | | | | | |
| male | | | 5.823 | 4.45 | 0.000 |
| **Model fit** | | | | | |
| **LR chi2(3)** | 183.90 | **Prob > chi2** | 0.0000 | **Pseudo R-Square** | 0.4877 |

Table 7. Results of the logistic regression analysis predicting the gender of the respondent

| **Dependent Variable** | | | Gender (male/female) | | |
|---|---|---|---|---|---|
| **Independent Variable** | | | **Odds Ratio** | **z-value** | **p-value** |
| Intercept | | | 22.363 | 3.45 | 0.001 |
| Functionalist | | | 0.055 | -9.58 | 0.000 |
| Idealist | | | 2.186 | 3.91 | 0.000 |
| Creator | | | 1.781 | 2.87 | 0.000 |
| Group (base Group B) | | | | | |
| Group A | | | 0.203 | -3.99 | 0.000 |
| Group C | | | 1.417 | 1.03 | 0.304 |
| **Model fit** | | | | | |
| **LR chi2(5)** | 202.05 | **Prob > chi2** | 0.0000 | **Pseudo R-Square** | 0.3626 |

**Discussion**

A factor analysis of the survey data yielded four distinct summary variables, and the linear regression analysis suggests that three of these are connected to the adolescents' interest in technology. The Functionalist orientation or profile appears to be rather similar to the High Tech profile [8] and the Engineering Enthusiast profile [9] and predicts the interest in technology the strongest. The Scientist and the Idealist profiles also had a positive connection to the interest in technology, whereas the Creator profile had no statistically significant impact. The Scientist orientation resembles the Ambitious Scientist profile [9]. It also has similarities with the Career Tech profile [8], but there are also differences, such as a missing connection to career prospects and a good salary. The Idealist profile matches the Socially Minded Generalist [8], which has no counterpart in the Swedish profiles. Further, the Swedish Technical Creator profile [9] has no equivalent in the Dutch classification, and although Creator is present in our factors, it does not seem to be connected to the interest in technology.

Even though the Functionalist, Scientist, and Idealist orientations all promote the interest in technology, only the Functionalist and Scientist profiles are connected to the willingness to study engineering. Hence, the Idealist's interest in technology does not seem to translate into

an interest in engineering education. This is interesting, especially when Group A, the young people already studying engineering, score higher in the Idealistic variable than the other groups, and the difference compared with Group C, university visitors, is statistically significant. The higher score is likely due to the environmental engineering students, many of whom are female and are expected to want to do good for society [10]. However, it does not explain why the environmentally and socially minded secondary school students are not drawn into engineering.

Being a male predicts interest in technology more than being a Scientist or an Idealist. It also predicts an interest in engineering studies more than the Scientist orientation. This strong gender-related divide has been found to be typical especially for the economically developed countries with high levels of gender equality. It has been suggested to relate to the gender-essentialist ideology and self-expressive value systems [11] and to girls' intraindividual strengths in reading as opposed to science [12]. Our data do not allow us to speculate on the reasons behind this divide, which would definitely be worthy of further study.

Expectedly, males' interest in technology was greater than females' interest. Although the Functionalist profile was the only one with a statistically significant difference between the male and female respondents, the logistic regression analysis suggests that having an Idealist or Creator profile is positively linked to being a female, whereas the Functionalist orientation predicts the opposite. This is in line with the previous discoveries of the technical orientation being more linked to boys, the socially minded orientation to girls, and the scientist orientation equally to both. However, in the Swedish study, Technical creators were more often male than female, which slightly contradicts our findings.

## Conclusions and Implications

The results give insights into what kinds of technology-related views and experiences may draw people to engineering and what, on the other hand, may push them out. A practical interest in how technology functions is the traditional strength of engineering students and draws primarily male students to the discipline also in Finland. An interest in natural sciences and mathematics also promotes engineering studies. However, an idealistic interest in technology as a means to help society or a creative personality do not seem to generate an interest in engineering studies. Communicating the message of opportunities to change the world through engineering more effectively and emphasizing the creative aspects of engineering could help in attracting proportionally more women to engineering. Although our data showed no statistically significant gender differences between the Scientist, Idealist, and Creator orientations, replacing some of the predominantly male Functionalists would shift the now male dominant gender balance in the discipline.

The data and results of the survey are of use when promoting the role of engineering and shaping young people's views on technology. In this work, the course in Basic Electronics and other similar educational actions that give a glimpse into engineering studies can be used as a promotional material and to create positive experiences through technology-related activities. For this purpose, the survey provides useful data when developing the course and targeting potential students in the future. The survey also has wider implications for raising awareness and increasing understanding of the forces and factors driving young people in today's world.

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**APPENDIX 1**

**Question 1** (administered to all groups)

How well do the following statements describe you and your relation to technology (1=very poorly, 4=very well)?

1. I am interested in technology
2. I am interested in how technology functions
3. I am interested in what can be done with technology
4. I am interested in how technology can promote the well-being of humans
5. I am interested in how technology impacts environment
6. I am interested in how technology can boost commercial profits
7. I have technology-related hobbies
8. I have been encouraged and guided to act with technology at home
9. I have been encouraged and guided to act with technology at school
10. I like constructing things and trying things out in practice
11. I like mathematics
12. I like natural science
13. I am talented in science and mathematics
14. I think creatively
15. I want to apply my mathematic-scientific skills to something practical
16. I want a job with good career prospects and a good salary
17. I want a job where I can be creative
18. I want to have an effect on the future
19. I know many people with a degree in engineering
20. I have at least one close relative who has a degree in engineering or studies towards it

**Question 2a** (administered to Group B, upper secondary school students in Basic Electronics course in 2017-19)

After upper secondary school, could you think of studying (1=surely not, 4=definitely yes, I don't know)?

1. Electrical engineering
2. Some other field of engineering or technology
3. Mathematics
4. Natural sciences
5. Medicine, health sciences, or nursing
6. Business administration
7. Education
8. At [anonymised] University
9. At another technical university or faculty
10. At another university
11. At polytechnic/university of applied sciences
12. In upper secondary-level education

**Question 2b** (administered to Group C, lower secondary school students in University visits)

After upper secondary school, could you think of studying (1=surely not, 4=definitely yes, I don't know)?

1. Engineering or technology
2. Mathematics
3. Natural sciences
4. Medicine, health sciences, or nursing
5. Business administration
6. Social sciences or law
7. Languages or humanities
8. Education
9. Art