INTELLECTUAL OUTPUT 2 (IO2): SELF-ASSESSMENT TOOL: HOW MUCH OF AN ENGINEER ARE YOU?

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Written by:	Reviewed by:
Riitta Lehtinen, Metropolia UAS, Finland Katriina Schrey-Niemenmaa, TEK, Finland	Darren Paisley, ENSTA Bretagne, France Darren Carthy, TU Dublin Una Beagon, TU Dublin Klara Kövesi, ENSTA Bretagne, France Claus Monrad Spliid, AAU, Denmark

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1.0 Executive Summary

This Intellectual Output (IO2) document reports on the outcomes of Activity 2 as part of the A-STEP 2030 (Attracting diverSe Talent to the Engineering Professions of 2030) project. This project is an EU Erasmus + project funded under call number 2018-1-FR01-KA203-047854. The document begins by explaining the purpose and aims of the overall research project and more specifically, the research questions associated with Activity 2. Two tasks were completed in order to contribute to this report, the first being EU mapping of future engineering profession connection with the values of engineering students' of today (report 3 of A-STEP2030 project) and the second an on-line survey: Self-assessment tool: How much of an engineer are you? (Piloted in Finland 2020). In addition, outcomes from BEST's (Board of Engineering Students of Technology) two symposia (2019) about Diversity in STEM education are included in this document. All reports are available on the project website https://www.astep2030.eu/en.

The purpose of this Activity 2 was to find out, how to attract young people from diverse backgrounds to study engineering. Hypothesis for this has been that sustainable development is so important for young people, that if they can see engineering education to be a solution to solve big global SDG problems, they would like to choose to become engineers or at least include some parts of the engineering studies in their curricula. Even though any of these three surveys done in this Activity 2 didn't straight answer to the question, can some recommendations for the Activity 3 (new and innovative teaching and learning practices to attract students with diverse backgrounds) be done by combining Activity 2 findings with the findings from Activity 1(IO1: Model of skills and attributes needed for engineers to achieve the SDGs).

The report summarises the outcomes of these studies and highlights skills related to, and attitudes towards – the UN Sustainable Development Goals (SDGs) for 2030 among engineering and humanities students and pupils of the age of 16. These studies reveal the needs of students for a better understanding of the SDGs - whether they are engineering or humanities students, or pupils of the age of 16 – as well as showing the extent of their willingness to promote sustainable development. Generally, it can be said that there is a tendency among students in all of the countries studied to give more prominence to environmental and social responsibility compared to economic issues, issues which had hitherto certainly been considered more important. Especially humanities, but also female engineering students placed these environmental and social responsibility issues high on their lists of career goals and attractive employer attributes. For all humanities students for example, the career goal "To be dedicated to a cause or to feel that I am serving a greater good" was the most important one.

Still, among engineering students in all studied countries, the two attractive employer attributes which were of least concern were "Commitment to diversity and inclusion" and "Corporate social responsibility" - issues which were highlighted as important ones in BEST recommendations. For engineering students, the three most important work attributes were - in this order - "Innovation", "A creative and dynamic work environment" and "Professional training and development".

For all students, "Work/life balance" was very important while at the same time they claimed to lack "Time management" skills. Engineering students' strongest soft skills were "Problem-solving", "Responsibility" and "Team work", while humanities students' strongest soft skills were "Responsibility", "Positive attitude" and "Adaptability". "Responsibility" was considered somewhat more important by the younger generation Z than by the older Generation Y. All these skills are also highlighted as important for STEM graduates and as skills needed in STEM professions.

The results of the on-line-survey for 16-year-old students' correlates to the findings of the Universum study (EU mapping of future engineering profession connection with the values of engineering students'

of today). The pupils demonstrate a high degree of awareness of SDGs and are very much willing to promote sustainable development. The most important SDG for them was "Good Health and Well-Being". Also, more than 60% of pupils had selected "Quality Education", "Zero Hunger" and "Climate Action" among the three most important SDGs. According to their answers, most of the pupils were willing to work in groups, ready to apply technology, and prepared to solve challenging problems in multicultural environments.

2.0 Summary of Overall Research Project

The main objective of the A-STEP 2030 project is to develop new and innovative teaching approaches which are relevant to learners' values, but which are nonetheless appropriate for teaching the new sets of skills and competencies needed for the future. Our goal is to create an attractive and fascinating learning environment, thereby encouraging young people and adult learners with diverse backgrounds to engage in engineering studies and in the engineering profession. The project comprises the following three activities:

Activity 1: Determine future roles and skills requirements of engineers to enhance the sustainable development of society.

Activity 2: Investigate the values and motivations of young people, students and adult learners to determine how this influences their future career choices and use this knowledge to make a career in engineering more attractive to all young people.

Activity 3: Develop new and innovative teaching and learning practices to respond to these findings.

The project consortium has seven members from six EU countries (France, Denmark, Finland, Ireland, Sweden and Belgium) and 10 associated partners. The team includes four different European HEIs all involved in Engineering Education Research. (ENSTA Bretagne, France, TU Dublin, Ireland, Aalborg University, Denmark and Metropolia University of Applied Sciences, Finland.) The team is also complemented by representatives from SEFI and BEST (Board of European Students of Technology) which represents HEI students in STEM, and Universum - experts in research relating to student motivations and career choices.

Figure 1 shows the main activities associated with the project. This report focuses on the result of Activity 2: Attracting young people from diverse backgrounds to study engineering.

The outcomes of this Activity are the focus of this report (IO2).

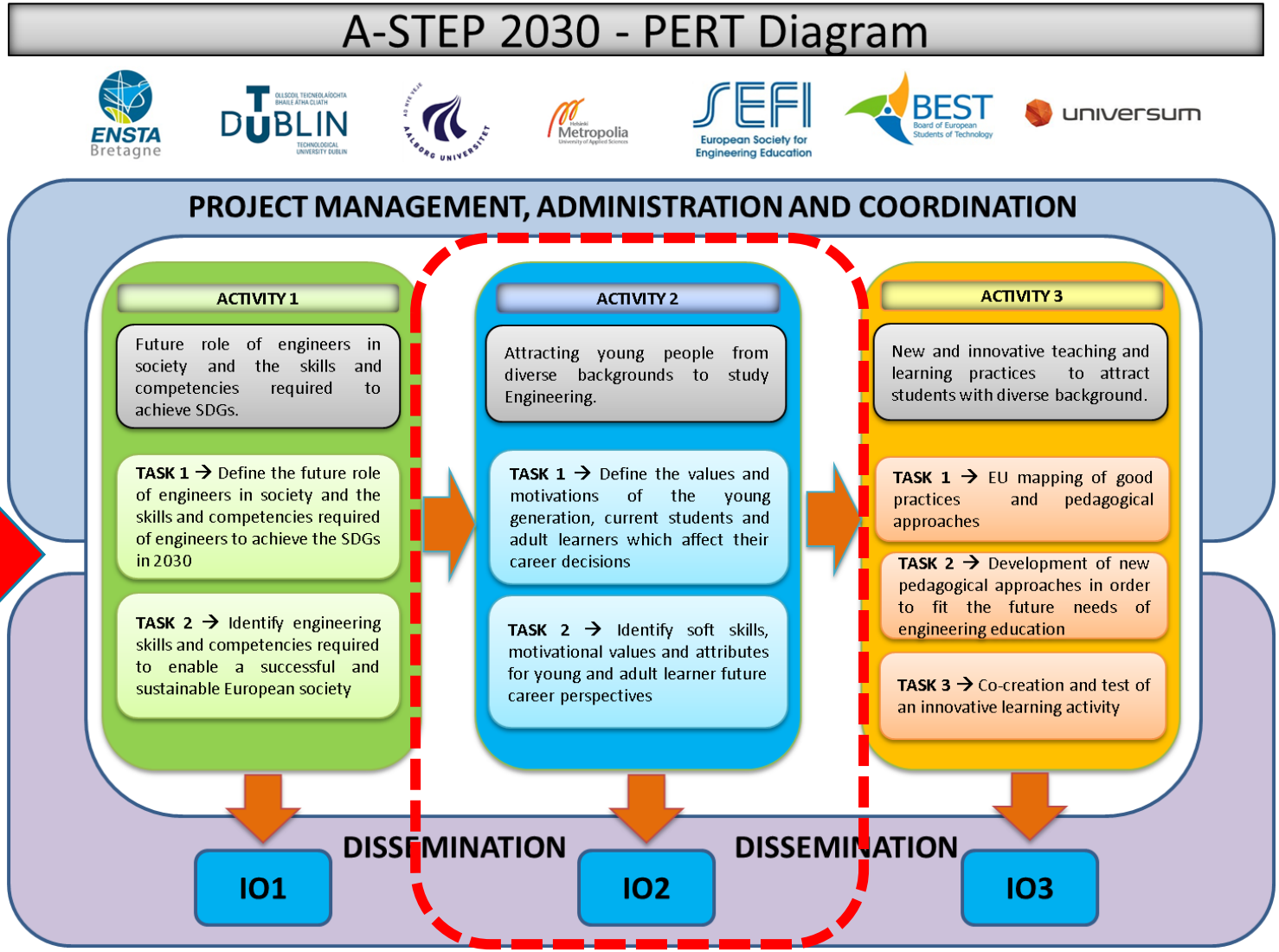

Figure 1: Overall Project details showing the aims of each activity.

3.0. Research Questions

The purpose of this Activity 2: Task 2 was to identify the overlap between future skills and motivational values in order to give policy recommendations for skill and competency development in engineering education.

The overall research questions associated with this activity were:

1. How do the values and career goals of diverse students reflect the future needs of working life?
2. How could engineering education respond to these and thus become more attractive to the diverse students?
3. What attributes could attract teenagers to study STEM and encourage them to continue to higher engineering education?

The analysis of these research questions will be summarized as the Journal Article will be published.

4.0. EU mapping of future engineering profession connection with the values of engineering students' of today (Universum study)

EU mapping of future engineering profession connection with the values of engineering students of today was undertaken by a Universum study. The questions relating to this mapping were selected by all the project participants in a Transnational Project Meeting in Dublin in April 2019. They were:

1. Which of these career goals are most important to you?
2. How would you rate yourself in the following skills?
3. Which of these employer attributes are most important to you?

For each question, the differences between male and female engineering students, engineering and humanities students and students from generations Y and Z were investigated in six target countries – namely: Belgium, Denmark, Finland, France, Ireland and Sweden. Deeper analysis was carried out using Danish, Finnish, French and Irish data and is presented in Report 4.

4.1. Findings regarding students' career goals

The most important career goal for all students in every country in the study was "To have work/life balance". The career goal "To be dedicated to a cause or to feel that I am serving a greater good" was important to all students, but we can see a difference between humanities students and engineering students in that 2/3 of humanities and 1/3 of engineering students had rated this goal among the three most important ones. This goal was also more important to female than to male engineering students in all studied countries. The least important career goal for all humanities students in all studied countries was "To be a technical or functional expert". Also, the goal "To be a leader or manager of people" was less important to humanities than to engineering students.

4.2. Findings regarding students' soft skills

The engineering students' perceptions of their strongest soft skills varied by country, but generally it can be said that "Problem-solving", "Responsibility" and "Team-work" were their three strongest soft skills. Nearly half of the engineering students of both Gen Z and Gen Y think that "Problem-solving" is their strongest soft skill. "Time management" and "Integrity" were the two weakest soft skills among all engineering students and "Communication" was the third weakest soft skill among engineering students.

Humanities students' perceptions of their strongest soft skills also varied by country, but in general their three strongest soft skills were in the following order: "Responsibility", "Positive attitude" and "Adaptability". Engineering students' strongest soft skill - "Problem-solving" - was the 3rd weakest soft skill for humanities students. Just as for engineering students, among humanities students' the weakest soft skill was "Time management". This latter group's second-weakest soft skill was "Communication". Nevertheless, on average, humanities students think that their "Communication" skills are better than engineering students' "Communication" skills.

4.3. Findings regarding attractive employer attributes

The most attractive employer attributes for engineering students were not similar in all studied countries, but the employer attribute least valued from the given list was in all studied countries "Commitment to diversity and inclusion" and the last but one employer attribute least valued was "Corporate social responsibility". On average, the most important work attribute for engineering students in studied countries was "Innovation", the second most important being "A creative and dynamic work environment" and the third most important "Professional training and development".

Just as for engineering students, among humanities students the most attractive employer attribute varied between countries. Nonetheless, "Inspiring purpose" was - on average - the most highly rated. The least attractive work attribute among humanities students was the same in all countries, namely: "Embracing new technologies". The second least attractive was "Interaction with international clients and colleagues". "The sponsorship of future education" was the third least attractive work attribute.

The biggest difference between male and female engineering students' attractive employer attributes is in "Support for gender equality". On average about 44 % of female engineering students in studied countries had rated this issue among the three most attractive work attributes, while among male engineering students the percentage was only 14 %.

5.0. On-line survey: Self-assessment tool: How much of an engineer are you?

This on-line-survey was carried out by questionnaire in the e-form-system in one Finnish high school. The aim was to gather information on 16-year-old pupils' values, interests, and expectations related to the Sustainable Development Goals (SDGs) and to their future. To begin with, the questionnaire form was created. It consists of information about Sustainable Development Goals and a total of 10 questions. Five questions were about pupils' expectations regarding their skills - similar to those in the Universum study - while the remaining five were questions about pupils' wishes concerning their future work environment, also similar to the Universum study. At first, the pupils were asked to select the three most important SDGs.

In the second part, students were asked to rate on a scale "not at all (1)/ somewhat (2)/much (3)/very much (4)" if they want to a) promote sustainable development, b) solve challenging problems, c) work in a group, d) apply technology, and d) work in a multicultural environment.

In the third part of the survey, students were asked to rate the skills and knowledge they would like to acquire on the same scale: "not at all (1)/ somewhat (2)/much (3)/very much (4)". They answered if they wanted to know: a) skills needed for sustainable development, b) problem solving skills, c) interpersonal skills, d) skills to work responsibly, d) time management skills.

195 entries were received in this survey.

5.1 Findings of the On-line-survey: Self-assessment tool: How much of an engineer are you?

The most important SDG for these pupils was "Good Health and Well-Being". More than 60% of pupils selected "Quality Education", "Zero Hunger" and "Climate Action" among the three most important Sustainable Development Goals. The least votes were received by: "Sustainable Cities and Communities", "Industry, Innovation and Infrastructure", "Decent Work and Economic Growth", and "Affordable and Clean Energy".

Only a few pupils answered that they were not interested in promoting sustainable development, while about 75% wanted to promote it. The second claim - "I want to solve challenging problems" - divided the pupils into roughly equal groups of either "not at all (1)/somewhat (2)" and "much (3)/very much (4). The ratings for the claims - "I want to work in group" and "I want to apply technology" - are concentrated on the "somewhat (2)/much (3)" end of the scale, indicating that the pupils are mentally prepared to work in groups and ready to apply technology. The last claim - "I want to work in a multicultural environment" - indicated that most of the pupils are at least willing to work in a multicultural environment since only a marginal number of pupils were opposed to this. So, these pupils want to promote sustainable development, want to work in groups in multicultural environments and are at least somewhat willing to apply technology and solve challenging problems.

Pupils were also asked about their willingness to learn a) skills needed for sustainable development, b) problem solving skills, c) interpersonal skills, d) skills to work responsibly and d) time management skills. The survey indicated that the pupils are willing to learn all the skills mentioned, while only a very small number thought those of no importance at all.

This questionnaire was created to test are the pupils interested in the area of studies and work which can be achieved though engineering education. These results are indicating very much willingness and interest to the area of engineering education although the pupils might not have recognised the path to the knowledge.

6.0. Symposia of BEST

BEST, Board of European Students of Technology organized two symposia 2019 about Diversity in STEM (Science, Technology, Engineering and Mathematics) Education. The more detailed analysis of these are reported in a A-STEP 2030 Report 4, where "Recommendations on what universities and other higher education stakeholders can do in order to improve diversity", "Recommendations on what companies, employers and other bodies in charge of youth employment can do to improve diversity" and "General recommendations and ideas" are presented.

6.1. Findings of BEST symposia

The various ideas and recommendations from BEST's 2 symposia about Diversity in STEM education is presented in Chapter 7 in A-STEP2030 report 4. Diversity can be seen to play a key role in the Sustainable Development Goals (SDGs) and that is why it is important to consider it in developing engineering education. According to BEST, the ten most important skills for STEM graduates are Critical Thinking, Analytical Skills, Problem Solving, Innovation, Collaboration, Communication, Customer Orientation, Adaptability, Social Responsibility and Balance. The skills needed in STEM professions according to BEST are the following: Teamwork (23,5 %), Ability to learn (17,6%),

Adaptability (17,6%), Communication (11,8%), Motivation (11,8%), Leadership (5,9%), HR skills (5,9%) and Versatility (5,9%).

7.0. Conclusions

All of the studies above reveal the requirements of both students - whether in engineering or humanities – and pupils at the age of 16, to gain a better understanding of SDGs. They also show their willingness to learn more knowledge and skills to promote sustainable development.

According to the Universum study, there are differences between countries among engineers, among humanities students and among generations Z (now 17-22 years) and Y (now 23-38 years). So, the students' career goals, their perceptions regarding the relative strength of their soft skills, and those employer attributes considered to be attractive are all quite country specific.

It can nonetheless be said that there is a general tendency among students in all countries now to accord more importance to issues surrounding environmental and social responsibility when compared to economic issues, which was certainly not the case in the past. Both humanities students and female engineering students place a particularly elevated value on these environmental and social responsibility issues, rating them highly regarding both their career goals and employer expectations. For example, all humanities students considered the career goal "To be dedicated to a cause or to feel that I am serving a greater good" to be the most important.

Still, among engineering students in all studied countries, the two employer attributes of least valued were universally considered to be: "Commitment to diversity and inclusion" and "Corporate social responsibility" (Report 4). These are the issues which BEST symposia last year valued high in their recommendations. For engineering students, the three most important work attributes were - in this order: "Innovation", "A creative and dynamic work environment" and "Professional training and development".

For all students "Work/life balance" was very important and at the same time, all of them said that their weakest soft skill was "Time management". The other weak soft skill for all students was "Integrity". In "Communication" skills there still seems to be room for development with all students, even though humanities students trust themselves more regarding this skill than do engineering students. Engineering students think that their strongest soft skills are: "Problem-solving", "Responsibility" and "Teamwork", while humanities student consider their strongest soft skills to be: "Responsibility", "Positive attitude" and "Adaptability". In "Responsibility", the younger generation Z appears to make a somewhat better showing than the older Generation Y. All these skills are also highlighted in the BEST report as important for STEM graduates and as skills required in STEM professions.

The on-line-survey of the Finnish 16-year-old pupils shows a high degree of sensitivity to the Sustainable Development Goals as well as their willingness to promote sustainable development. Notably, "Good Health and Well-Being" were considered the most important SDGs by this group. Also more than 60% of pupils had selected "Quality Education", "Zero Hunger" and "Climate Action" among the three most important Sustainable Development Goals.

When pupils were asked about their willingness to learn different skills identified as important in sustainable development work, they did not raise any special skill to a greater prominence than the others, but instead they recognized the need for all the skills mentioned. The skills were: a) skills needed for sustainable development, b) problem solving skills, c) interpersonal skills, d) skills to work responsibly and d) time management skills.

According to the answers, most of the pupils were willing to work in groups, ready to apply technology, and prepared to solve challenging problems in multicultural environments. The results of this on-line-

survey correlate with the findings of the EU mapping of future engineering profession connection with the values of engineering students' of today.

The purpose of this Activity 2 was to find out, how to attract young people from diverse backgrounds to study engineering. Hypothesis for this has been that sustainable development is so important for young people, that if they can see engineering education to be a solution to solve big global SDG problems, they would like to choose to become engineers or at least include some parts of the engineering studies in their curricula. Even though any of these three surveys done in this Activity 2 didn't straight answer to the question, can some recommendations for the Activity 3 (new and innovative teaching and learning practices to attract students with diverse backgrounds) be done by combining Activity 2 findings with the findings from Activity 1(IO1: Model of skills and attributes needed for engineers to achieve the SDGs).

The broad worldview, which raised as an important character of the future engineer in IO1, could attract humanities students to engineering education according to their answers about their career goals, strong and weak soft skills and attractive employer attributes. For them it seems to be important to take social effects into account in decision-making. According to the on-line-survey of the Finnish 16-year-old pupils, as 60 % of them raised "Climate Change" and "Zero Hunger" as an important SDG, can be seen, that for them also environmental effects of people's behaviour are important. Compared to traditional engineering education, where always economic consequences of technical innovations have been taken into account in decision-making, the future engineer has to be able to understand and take into consideration also social and environmental consequences of his/her/company's decisions. To be able to do that as a professional engineer, engineering education has to contain both knowledge of SDGs and pedagogical solutions to deepen the understanding of these.

As said in Report IO1 engineers still need to be toughed the technical and application skills required to achieve engineering projects, but non-technical skills will be equally important in their education. Besides the technical and non-technical skills in the model of engineering skills and attributes required to meet SDGs (Report IO1) there are listed attitudes of world view (e.g. global awareness, social responsibility, environmental awareness, challenging the status quo) and attitudes of character and ethical orientation (e.g. respect for others, open mindedness, agility, adaptability, flexibility, curiosity, empathy) to be important in meeting SDGs.

The non-technical skills in the model (Report IO1) are divided into two categories; Outward Facing - People oriented and Inward Facing - Ways of Thinking. Many of the people oriented non-technical skills (e.g. inter cultural skills, collaboration, leadership, negotiation, conflict management, communication, teamwork, respecting diversity) have already been included into engineering education and for example according to engineering students' answers about their soft skills teamwork is one of their three strongest soft skills. Engineering students' strongest soft skill in the study was problem solving, which for a long time has been a natural part of engineering education. In the model it belongs to the application skills in technical skills. In the inward facing non-technical skills' list in the model there is time management, which all students raised as their weakest soft skill. So there seems to be a great demand for training time management skills in engineering education. From the sustainable development goals' perspective new ways of thinking like life cycle thinking, holistic thinking and system thinking are essential in addition to more traditional critical and analytical thinking. So the question for the Activity 3 of this A-STEP 2030 project is: "What kind of pedagogical solutions and content modernisations could be added to traditional engineering education to achieve this kind of changes in future engineers' thinking?"

8.0. Acknowledgements

We would like to acknowledge the EU Erasmus+ funding body and all partners and associated partners in the A-STEP 2030 project for their help in Activity 2. Many thanks also to all the students who completed the Universum CareerTest survey. Many thanks also to Vaskivuori senior high school and their pupils concerning their participation in the on-line-survey; Self-Assessment Tool: How much of an engineer am I?

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