Challenges of Integrating a Sustainability Interdisciplinary Profile in Computing Education: A Case Study

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Abstract. Sustainability in higher computing education is becoming an increasingly important direction adopted by educational institutions, IT industry, and researchers. However, the incorporation of sustainability at the curriculum level is challenging. Among the challenges are students' attitudes towards the integration of a sustainability profile (minor) within the core curriculum, as explored in this paper. This research evaluates students' attitudes to an existing undergraduate computing education model, in which a sustainability profile is included. The empirical focus is on the case of the integration of an elective sustainability profile within the informatics curriculum at a Norwegian university. The case study involves examining relevant documents and conducting interviews with students who did not choose the interdisciplinary profile or, particularly, the sustainability track, followed by a discussion with the sustainability profile leader to discuss students' responses. The findings provide the faculty with feedback that can be employed in effective planning to include a sustainability profile in computing curricula. The study emphasizes that the incorporation of a profile that combines technology and humanity subjects, such as sustainability, is challenging, mainly due to lack of computing students' interest in humanitarian topics. The findings indicate that higher educational institutions need to consider the time and provide sufficient information about the interdisciplinary subjects to students, especially that the choice of interdisciplinary courses affects, and is affected by, students' pre-professional identity. The most significant finding in the study is the necessity of collective collaboration across the concerned disciplines to engage students from different academic fields in sustainability.

Keywords: Sustainability, higher computing education, informatics, students' attitudes, students' self-motivation, interdisciplinary profile, computing education for sustainability, pre-professional identity.

1 Introduction

The ongoing digital revolution is employed to stand up to sophisticated challenges. And challenges are emerging, including those that threaten the society and the environment. Sustainability-related issues have become a major concern, where sustainability can be defined as meeting the "needs of the present without compromising the ability of future

generations to meet their own needs" [1]. Such concerns have formed a driving force to revolutionize the technological education to build up graduates armed with the required knowledge and skills to be change agents well-prepared and engaged in tackling sustainability issues.

Incorporating sustainability in computing education is difficult. Several challenges have been studied in the literature, supported by evidence from real cases [2]. One of these challenges is related to students' attitudes and motivations towards sustainability content in the core educational curriculum. Various research efforts have been made to study this topic within the engineering education field [3]. The existing efforts are targeted to the integration of sustainability at different levels, such as, course components, interdisciplinary courses, or study program level profiles such as a major or a minor (In this study, the term "interdisciplinary profile" will be used since it is the term used by the case under study). However, less focus has been targeted to incorporating sustainability at the profile curriculum level of computing education.

The research presented in this paper stems from a practical problem addressing computing students' attitudes and motivations towards incorporating sustainability as an interdisciplinary profile within a higher computing education curriculum. To achieve the sustainability global vision, the university put forth a plan to incorporate sustainability in study programs. A pilot study was initiated, where bachelor students in selected programs at selected faculties, e.g. in Informatics, were given the opportunity to select an interdisciplinary profile, of 30 credits, among three tracks: digital innovation, digital transformation, and sustainability. The students who select the interdisciplinary profile additionally take 30 credits from the curriculum of their study program to get a total of 60 credits in the year in which they take the profile. To evaluate and learn from this initiative, a follow-up study of these profiles was conducted. Results from the study are presented in this paper. Based on the belief that the students' selection of profile must be self-determined, the study's focus is on investigating the problem based on students' self-motivations and perceptions.

In accordance with the self-determination theory [4], a significant aspect of a decision is the degree to which it is self-determined. Based on this, the primary objective of this research is to identify ways to improve the engagement of computing students in sustainability through an academic profile.

The study poses the following research questions:

RQ1: What are the factors that play a role in computing students' (non)-selection of a sustainability interdisciplinary profile in a higher computing education curriculum?

RQ2: What are the motivational factors that could contribute to IT students' selection of a sustainability interdisciplinary profile in the curriculum?

RQ3: What could be done at the university level to address the challenges of the incorporation of sustainability-related academic offerings within existing computing education programs?

The major contribution of this research is an insight into computing students' perceptions of, and interest in, an undergraduate computing education model, in which sustainability is incorporated as an elective interdisciplinary profile. The findings provide the faculty with feedback that can be employed in effective strategic inclusion of sustainability in a higher computing curriculum.

The second section of the paper will provide some related literature, followed by section III presenting the adopted research methodology. The results are presented in section IV and discussed in section V. Section VI concludes the paper and addresses future work.

2 Background

As pointed out in the previous section, this research stems from a practical problem. Interdisciplinary profiles were developed as part of a university's development plan for future studies and lifelong learning. The plan was based on strategic elements, one of which is to contribute actively and constructively to achieving the sustainability goals. The profiles are integrated within a major technology study profile that is also aimed to be aligned with technological advances, societal challenges, and business needs. Based on this, a pilot project concerned with future technology studies had, among its recommendations, the development of interdisciplinary profiles as powerful instruments to implement the university's ambitions for interdisciplinary diversity in technology education. Regarding the sustainability profile, a practical driver for the sustainability track is the strong connection between digitization and sustainability, which resulted in the increasing need among Norway's IT companies for graduates with expertise in sustainability in addition to IT and technology. This called for more interdisciplinary study programs that are based on collaboration across the main profile and other subject areas in relation to sustainability. The sustainability profile was established after dialogues with all stakeholders, surveys, and analyses to consider the educational sector as the main supplier of the required proficiency to participate in creating a sustainable future. The sustainability profile consists of a compulsory sustainability profile course and three elective courses, among which at least one needs to be from a technology field and at least one from the humanities.

There is some research literature addressing students' attitudes and motivations towards integrating sustainability in higher computing education curricula. For example, students' attitude towards integrating sustainability in engineering majors was evaluated in [5]. The study found that students' participation in experiential and active learning experiences (e.g., internships and sustainability-focused projects and activities) correlated to higher levels of their understanding of sustainability. Hence, providing such opportunities for students can increase their motivation to engage in sustainable engineering courses. These findings have been confirmed by [3], where the authors explored the impact of students' participation in a sustainability-focused project and an international field learning course on their attitudes towards including sustainability in engineering majors. The participation in the project-based experience increased the positive attitude of students towards sustainability. It allowed them for more hands-on experiences, which deepen their understanding of the value of sustainability in the engineering context. Various studies have emphasized the significance of the implementation of active learning methods in engineering education to prepare graduates for both; their future profession and to participate in tackling global issues, one of which is sustainability [6], [7]. The authors in [8] identified the factors that contribute to the success of

integrating sustainability into their curricula and its associated challenges. The authors asserted that the need for interdisciplinary collaboration and joint efforts between departments introduces some difficulties for both faculty staff and students, which need to be carefully studied and planned when designing sustainability courses.

The existing research literature indicates a research gap in students' perceptions and attitudes, which is significant to understand students' lack of interest in an interdisciplinary sustainability educational offering.

3 Methods

This research followed the interpretivist paradigm. An explanatory case study was adopted as a research strategy since the objective of the research is to gain a deep detailed insight into the studied case within a real-life context. The case under study required a triangulation of data, which included interviews and documents analysis.

3.1 Participants

The study targeted informatics undergraduate students, aiming to understand students' attitudes and motivations towards the integration of sustainability interdisciplinary profile within the informatics curriculum, especially that none of the inforamtics students selected the sustainability track. The first interviews targeted students who selected the digital innovation profile. Invitations were sent by email to the students registered in the Digital Innovation profile course. Two respondents were individually interviewed. Another invitation for interviews was sent, through the students' counsellor, to all informatics students (N=276) to interview the students who didn't select any interdisciplinary profile. Personal individual interviews were conducted with the first seven respondents. A meeting with the sustainability profile leader, a professor, was conducted at the final stage to discuss students' responses.

3.2 Documents

The documents provided necessary information about the interdisciplinary profiles, and included the report provided by the university's future technology studies project, and the course plan, description, teaching and learning materials for the mandatory sustainability profile course.

3.3 Interviews

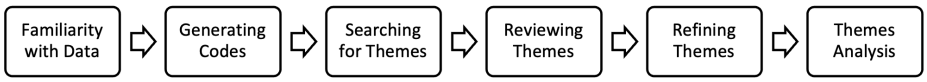
Semi-structured interviews, 20 minutes each, were conducted to obtain detailed information, allowing for elaboration by the interviewer and interviewee when needed. An interview guide (see Appendix) was designed to address four main subjects. First, students were asked about their motivation to select their academic program, which is informatics, in this case, and their future career objectives. The second part of the inter-

view was dedicated to identifying students' motivations towards (not) selecting the offered interdisciplinary profiles. The aim of the questions in the third part was to get a deep insight into students' knowledge about the concepts of interdisciplinarity and sustainability-related concepts and some knowledge about the offered profiles, with a focus on sustainability, which is the core of the study. This part of interviews is of great significance since the level of knowledge the students have might give an indication of the reason behind not selecting a sustainability track. Maybe if they were aware enough of some concepts, they might value how their informatics studies can be of high relevance and instrumental to sustainability issues. Finally, students were asked about how much some factors motivated them to select the interdisciplinary profile or the courses of the core informatics curriculum. The objective of this last part was to get an idea about students' self-motivational factors, and a five-point scale answer format was used.

3.4 Data Analysis

The interviews were recorded, fully transcribed and qualitatively analyzed by the first author in an inductive approach to abstract the substantial themes for the research questions [9]. The software tool, NVivo, was used for organizing data, coding, searching, and writing notes. The analysis followed axial coding [10]. After performing the first coding phase, a relationship between some codes was noticed, leading to incorporating some codes under broader headings, as presented in the Results section. Moreover, some codes were identified as more significant than others in relation to the study's research questions as it will be discussed later in the paper. The data analysis process is illustrated in **Fig. 1**.

Fig. 1. Thematic Analysis Phases



4 Results

4.1 Non-selection of an interdisciplinary profile

The students' responses to the questions on not selecting any of the offered profiles were coded and categorized into four major themes that captured the reasons as to why the students took the decision not to select an interdisciplinary profile. These reasons are summarized in **Table 1**.

Table 1. Factors affecting students' non-selection of an interdisciplinary profile.

Factors	Students %
Unfamiliarity	
a) Brand-new	43%
b) Not enough time	57%
c) Not enough information	43%
Significance of Informatics courses	
a) Personal interest in informatics	56%
b) Effect on future career	33%
c) Taking profiles courses as electives	22%
Social reasons	
a) Not taken by friends	43%
Academic reasons	
a) Most of curriculum courses are taken	43%

Examination of the interviewees' responses reveal that the major reasons for students' non-selection of the profiles was their unfamiliarity with the profiles. The unfamiliarity was either due to lack of information about the profiles and insufficient time to get such information, or because it is a brand-new offer. Comments included: '*It felt like scary to suddenly choose something I was not very well informed about, and I didn't have enough time to read through properly. I decided I will not choose something I am not familiar with*'.

At the same level of effect, the second reason pertained to the significance of the informatics courses from the points of views of students. Approximately half of the interviewed students expressed their personal interest in informatics and their desire to have the opportunity to learn as much as possible from informatics courses. One of the students indicated a desire for taking more informatics courses: *'If I choose the interdisciplinary profile, I will lose the opportunity to select from a wide variety of informatics electives'.* Some respondents pointed to the effect that it might have on their future career if informatics courses are excluded from the curriculum. One of the students commented *'the (sustainability profile) courses will not be useful for me in the work I will be doing in the future'.* Two respondents pointed out (mistakenly) that they can take the courses as electives from the traditional informatics curriculum without having to change the structure of their curriculum.

The least important among the identified reasons for not selecting an interdisciplinary profile was related to social aspects: some of the students didn't choose to select a profile since their preference is to take courses with friends. One of the reflections was '*I wanted to do it but none of my friends wanted to*'.

A final reason for not selecting an interdisciplinary profile is linked to special cases of students who already took most of the courses in the curriculum because this is their second bachelor. So, they had fewer number of remaining credits in their plan, thus, there was no room in their curriculum to include more.

4.2 Non-selection of the sustainability interdisciplinary profile

The major motivation for the study is to understand students' attitude towards sustainability. The first part of the results indicated that a major reason for not choosing an interdisciplinary profile is students' preference for a more clear-cut Informatics curriculum. Some questions were additionally asked about the sustainability profile in particular. In addition to the reasons in **Table 1**, the students' points of view here concentrated on the interest in informatics and technology in general compared to sustainability. Regarding sustainability, the students tend to consider it a humanitarian subject that is not close to their field of study and that they don't have enough knowledge about. These views were grouped into two themes: personal interest and level of knowledge, as shown in **Table 2**.

Table 2. Factors affecting students' non-selection of a sustainability profile.

Factors	Students %
Personal Interest	
a) Passion with technology	33%
b) Lack of interest in humanitarian subjects	33%
c) Lack of interest in reading and writing text	22%
Level of Knowledge	
a) Less knowledge about sustainability	22%

The students' interests demonstrated a preference of technology over humanitarian subjects. One student, who selected the digital innovation profile, conveyed this by saying: '*sustainability is like choosing more humanitarian courses. Digital innovation is more fun to work with'.* Another student's understanding of sustainability is: *'researching and writing text'.* The responses reveal the students' interest in performing programming projects rather than reading and writing reports. One of the standpoints was: *'Digital innovation goes with what I have done previously'*. Another student, who decided to stick to the original informatics program without selecting a profile, commented: '*I am artistic in programming. It is more fun*'. This reflects that students' preference goes with courses closer to technology fields.

4.3 Familiarity with interdisciplinarity and sustainability concepts

During the third part of the interview, the questions were targeted to the students' level of knowledge about concepts related to interdisciplinarity, sustainability and being change agents. Students' familiarity with such concepts might be significant to their attitudes towards the selection of an integrated interdisciplinary profile. The answers varied, but most of them indicated limited knowledge of the concepts in question.

The students' responses about the meaning of 'sustainability' varied from *'Ensuring the future generations have the same starting point as us'* through *'climate change'* to other concepts related to their field of study, such as *'using less power for data storage'* or '*sustainable programming languages*'. The concept of 'change agent' was unclear

to around half of the students, while the others tried to express it in different ways. For instance, *'a person who facilitates innovation, open to new perspectives'*. Only a few students were able to explain the concept of 'digital innovation' (seeing it e.g. as '*inventing new ways*') and '*entrepreneurship'*, while 'digital transformation' was a new concept to most of the students.

4.4 Motivations for courses or profile selection

At the end of the interview, the students were asked to evaluate, on the scale 1 to 5, the extent to which some factors affected their decision to select an interdisciplinary profile or to choose the courses of the pure Informatics curriculum. Although the major reasons were discussed during the interviews, the objective of this part was to get a glimpse of the major factors that motivate students when they select courses, and which factors are of the most- or least-significance. This might stimulate other studies to focus on what can motivate students to take interdisciplinary courses. As it is clear from **Table 3**, the students mostly consider the contents and the amount of work in courses. Taking the courses with friends and future career were also influential factors. The factor that was graded the lowest was the recommendation by others. This can be taken to imply that students' decisions tend to be relatively self-determined.

Table 3. Factors affecting students' selection of interdisciplinary profile and/or informatics courses.

Factors	Average Answer
Future Career	3.4
Contents and learning activities of courses	3.8
Recommendation by others	2.7
Taken with friends	3.4
Amount of work in the courses	3.7

In general, the dialogue with the students uncovered that most of them were intrinsically motivated, either to major in pure Informatics or to (not)-select an interdisciplinary minor profile. Most of the students enjoy programming and technology, in general, looking forward to applying their knowledge and skills in developing useful applications or providing valued services. Some of the interviewed students mentioned the influence of their school teachers on their appreciation of programming. One of the respondents, for instance, expressed this by saying: "*I really liked programming in high school. The teachers at school were motivating*". Other students explicitly indicated their interest in serving society. One of the students selected to major in Informatics in addition to his first major since, through Informatics, he can be able to provide a wider service. He declared: "*I felt that I cannot contribute enough to the society (talking about his first major). So, I wanted to contribute more to society by reaching more people"*. An extrinsic motivational factor to study informatics was salary, but this was mentioned

by only one interviewee as an addition to his passion with technology, where he said: *"…. Also, the salary attracts*".

One analytical point of view can demonstrate the students' non-selection of sustainability based on their answer to the question in the first part of the interview about the future job they see themselves in. The desired future jobs are shown in **Table 4**. As it is clear from the answers, most of the jobs are strongly related to the informatics field. The students' picture of future jobs thus seems to be based on the information they have about the study program they are already enrolled in, where they might be provided with information regarding future jobs perspectives. This point can assert and be asserted by the concept of employability, which has been defined as Pre-Professional Identity (PPI) [11]. PPI is not only about possessing the right skills and knowledge, but also concerns awareness of the desired profession and what counts as competence in this job [12]. One of three modes of identification in the identity component is imagination [13], which was apparent in this case study through students' imagination of their future work. Some students used the word "imagine" or other semantically related words. One of the interviewed students, for instance, answered: "*I imagine myself as either a product owner or a manager*".

Table 4. Students' future imagined jobs.

Imagined future job	Students #
Software Developer	2
Consultant	2
Having a startup	2
Product Owner	1
Manager	1
Haven't decided yet (Planning to pursue master studies)	2

4.5 Discussion with the sustainability profile leader

The discussion with the sustainability profile leader focused on the feedback given by the students in the study.

The profile leader pointed to some misunderstandings on part of the students. An example was the students' viewpoint that they can take the courses as electives without having to change the structure of the curriculum. However, according to the sustainability profile leader, this is a misunderstanding: The major profile course is only available to students who are enrolled. Another important clarification was in response to students' misconception about considering that the sustainability courses are limited to reading and writing text. The profile leader affirmed that the students could select the project's method according to their interests and academic majors.

Most of the insights gained from the interviews with the students will be forwarded, by the profile leader, to the management of the profiles for further discussions. The input will aid the work to find ways to improve the collaboration with the informatics

teaching staff and conduct any necessary changes to the structure or contents of the offered courses to make them more engaging for students.

5 Discussion

This study is conducted about informatics and gives insights about the motivation of informatics students. Its results might also apply to other students in other disciplines. For instance, students' lack of interest in humanitarian subjects might be a barrier to choices of courses and profiles that deviate from the traditional structure, e.g. in the direction of sustainability. Many students may fail to see how sustainability can be an integral part of a professional identity in their main field, e.g. informatics. Raising students' awareness of the relevance of their main field of study for sustainability can be done by incorporating sustainability at various levels of study and the digital gateways of the university.

Also, the students in our study didn't have enough time or information to take the selection decision. According to the documents, the information about the option of selecting an interdisciplinary profile was sent by email to informatics students in Spring 2022 whereas the profiles started in Autumn 2022. For the students to get more information, the email contained an invitation to a digital meeting for those who are interested to be enrolled in one of the offered interdisciplinary profiles to get more detailed information.

Given the experiences from the process of introducing a set of interdisciplinary profiles to students in selected bachelor programs, as presented in this paper, we have some recommendations for the university in the study, with relevance for other higher education institutions launching similar initiatives. Our focus is on the sustainability profile. The recommendations mainly address the need for properly informing the students about the contents of the profile and its relevance for work-life and being a professional.

First, the profiles could be announced, with relevant information, on the university's website, YouTube channel, and the other official social media accounts. In general, students need to be given examples through the description of the profiles to correct misconceptions about the courses in the profile. For example, in our study it was clear from the documents and the discussion with the profile leader that the courses' project method is in fact up to the students based on their academic background, and not limited to reading and writing text.

Second, orientation lectures may be provided through cooperation between the academia and the industry about the relevance of having a sustainability profile for future jobs. This may be a key step since it has been confirmed in the literature that the educational choice is affected by early career awareness and clarification of career options [14]. An understanding of the work-relevance of sustainability knowledge and competence is expected to direct students' imagination, as discussed in the previous section, to such interdisciplinary sustainability-related career options, thus fostering students' pre-professional identities towards sustainability.

Third, to consolidate the foundational knowledge part, an introductory computing

course or course module within the mandatory part of the curriculum of the first year is required to introduce students to the concept of sustainability and how their field of study can contribute to sustainability. This will introduce the students to key concepts, which might presently be unclear to students as evident in the interviews. It might also clarify the students' anticipated role in society and encourage them if they are interested to select interdisciplinary studies as part of their study program.

A fourth recommendation is to recruit some students to be sustainability ambassadors at the campus through several activities. Having role models and peers who can present options from a student perspective might add credibility to the message, encouraging students and providing them with an opportunity to learn from each other. Such initiatives might be run by, or in collaboration with, established students' clubs and associations and be followed up by the university.

Fifth, another encouraging step is to organize competitions to motivate students to think about and provide sustainability solutions and participate in national and global championships on the intersection between computing and sustainability. In the informatics area, some form of hackathon might be appropriate.

Our sixth recommendation is to offer sustainability-focused internships and active learning projects. Such opportunities have proved their efficiency in improving the positive attitudes towards sustainability learning as shown by real cases [3].

Additionally, there may be challenges on the organizational level of the higher education institution that need to be addressed in order to succeed with interdisciplinary educational offerings in the area of sustainability. Collaboration between the concerned university departments is essential to succeed with interdisciplinary teaching offerings. This appeared to be a challenge in our case and in general needs to be acknowledged and tackled as it is evident also in related real cases [6].

In higher education research there have been studies on how role models can affect students' engagement in computing education, especially the engagement beyond technical or theoretical computing [15]. Drawing on these results we suggest that the success stories of people who have had influential effects on sustainability through computing be presented to students. This can be done in several ways, the simplest of which is through universities' websites and official accounts.

Finally, universities have a role in exploring and selecting promising concepts of education, needed in such uneasy times to enable people to participate in creating a viable future. An example of such conceptualizations of education is Emergentist Education [16], which was developed based on several fields, one of which is Education for Sustainable Development (ESD), exploring the "reorientation of education into something radically different from current mainstream education at universities [16]".

6 Conclusions

In response to the research questions, this study emphasizes the significance of joint efforts between the concerned departments to engage students from different academic fields. This includes helping the students see how sustainability is a relevant part of their pre-professional identity also within a more technical field such as informatics.

Information about the option of choosing an interdisciplinary profile should be given in time, with sufficient information about work-life possibilities and curriculum constraints. The paper contributes by focusing on the factors that attract students to sustainability engagement and the role of the higher educational institution in motivating students. The institutional roles can take several directions, including, for instance, developing innovative learning methods and internships in collaboration with the industry, offering orientation to clarify future career options in relation to sustainability, and incorporating sustainability concepts and issues at various levels of the study program to raise students' awareness and give them the opportunity to practice how to employ informatics for tackling sustainability issues.

One limitation of this case is that it is restricted to a particular study program, i.e. a bachelor in Informatics. The study does not address whether the same problem was faced by other eligible programs. Another limitation is the number of participants, which is nine students; two of them selected the digital innovation profile, while the rest stuck to the pure informatics curriculum. Furthermore, insufficient information about the profiles can be considered as a limitation, as it prevented further insight about the choices the students would have made if they had known more about the different profiles. Still, lack of information was among the reasons why the students did not select the sustainability track. We stress this point in this study to highlight the significance of giving students enough information to assist in making their choices of academic offerings. As it is clear from the results, however, the interviews give insights about the major reasons behind the lack of interest in selecting a sustainability interdisciplinary profile to be integrated within the informatics major curriculum. Thus, the findings can be used to give directions towards the challenges to be addressed.

This work will be followed up by more research on the applicability of the sustainability interdisciplinary profile and students' attitudes towards it in the next years. Moreover, the researched problem calls for future research in the field of computing education on employability in relation to the incorporation of sustainability within the computing curriculum.

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Appendix

Interview Guide (Students)	
Study	Integration of Sustainability Interdisciplinary Profile in Computing Education Curriculum
Foreword	(The interviewer begins the interview once the information letter has been signed, which is sent by email to the interviewees) As of Autumn 2022, a new study offer has been offered for Bachelor students, which provides students with the opportunity to combine technological, humanistic, and social science subjects, so that they gain an interdisciplinary competence that is valuable for the future. Today, we will be discussing your perspective on the provided interdisciplinary profiles, which you are eligible to take as part of your curriculum. We are highly interested in hearing your opinion.
Part 1 – Educational Objectives	1) What is your study program? 2) Why have you decided to study this field? Are there any other factors? 3) What is the job you see yourself having after you have graduated?
Part 2 – Selecting the interdisciplinary profile	4) Have you selected to take an interdisciplinary profile as part of your curriculum? a. If yes: i. How did you receive information about the offered interdisciplinary profiles? ii. Which profile have you selected? iii. What reasons motivated you to select this profile? Are there any other factors? iv. Are there any reasons which affected your decision regarding not choosing the two other interdisciplinary profiles? b. If no, could you please explain the reasons behind not selecting the interdisciplinary profile track?
Part 3 – General knowledge about the interdisciplinary profiles	5) What comes to your mind when you think of an interdisciplinary profile? 6) What comes to your mind when we talk about: a. Digital Innovation? b. Sustainability? c. Digital Transformation? d. Change Agent?