Finding a Common Ground Vision to Develop and Execute an Education Ecosystem for Future-Proof Engineering Professionals
Testing our common ground vision in two 3D printing minor programs

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1. INTRODUCTION

The pressure on engineering education and universities to better prepare and deliver excellent professionals for the industry is ever increasing. The main driving force here is a predicted shortage of technical professionals [1]. The industry is demanding professionals with a broad range of competences (knowledge, skills and attitude) [2]. Learners want better, attractive, personalized, state of the art and up to date educational programs. Lecturers and researchers want a powerful learning environment with access to the latest emerging technologies [3]. According to a recent report by KPMG Dutch universities feel the sense of urgency but are not acting upon it [4].

In line with these developments in 2013 Fontys set up an experimental educational playground called Objexlab [5]. The main task of Objexlab [6] is to develop and execute programs and projects to achieve the following goals: Excellent, state of the art and up to date education, applied research on emerging technologies and retraining/post-training, tailored to the High Tech Systems & Materials industry in the Brainport region of Eindhoven [1]. The long term and overall goal is to deliver more top graduates to the industry from the Engineering and Science institutes by increasing the inflow or improving the flow.

Objexlab developed a vision and model to build the solid ground to reach the above mentioned goals. The "Connecting Engineering Technology and Science" model (C.E.T.S.) acted as a blueprint to build a solid ground based on three main factors: human resources, facilities and environment [7]. The C.E.T.S. model made it possible to build a playground for students, researchers, lecturers and the industry to stimulate collaboration and co-create and participate in education and applied research.

In "How to create an ecosystem for engineering education to prepare future professionals to sustain in a fast changing and dynamic environment?" [8], the 3C model and the Circle of Five (5) were introduced to provide starting points for developing and executing new education. These models for developing (3C model) and executing (Circle of Five) education, are elaborations of the C.E.T.S. model, particularly focusing on learning in education and applied research. Research focused on the extent students recognized the 3C model and Circle of Five (5) model in their minor program (T1 measurement in February 2016 at 25% completion). Students recognized aspects as 'Collaboration' and 'Take Full Advantage of Opportunities' best in the 3D minor programs. Although students predominantly recognize the vision of the education ecosystem, a great amount of students remained neutral in their answers.

The present paper describes a second measurement in May 2016 (T2 at 75% completion of the program) on recognizing a common vision (3C model and Circle of Five (5)) by students, lecturers and companies in our education. This research focusses on newly developed Additive Manufacturing (3D printing) minor programs which were designed, developed and executed in close collaboration with students, researchers, lecturers and the industry (conform the C.E.T.S. model). The aim of this research is to find a common ground vision to develop and execute an education ecosystem for future-proof engineering professionals?

1 VISION ON EDUCATION

The educational playground Objexlab aims to design and develop programs, in which learners are triggered to develop a pro-active attitude, develop a healthy research mentality, manage their own time, to strive for excellence, to be meaningfully and actively engaged, take full advantage of opportunities, to focus on quality and relevance of the subjects they are studying or researching. To create common ground with a variety in multidisciplinary educational designers, the 3C model was introduced.

1.1 Starting point for developing education: 3C model

Embedding the 3C model into new education programs should include more *collaboration* in multidisciplinary student teams with the industry. An open invitation for industry and other institutes to *co-create* educational programs and design the programs in a way that the learners can take full *control* over their own learning needs and learning path (personalized learning, talent development) [9].

1.2 Starting point for execution of education: Circle of Five

The Circle of Five focusses on changing the mindsets and seeing the bigger picture. Other than that the learner should experience and be purposeful and meaningful engaged to change their mindset (from fixed to growth) to prepare themselves for the future [10].

Focus on the positive - With focus on positivity, we want to support talent development and self-directedness of every learner.

Trust gives ownership - We believe that a motivated learner who takes responsibility of his own learning path, is able to assess himself on his competences for work, life and society.

Providing challenge for every learner – By providing a variety of active learning opportunities learners can discover their unique talents and their personal ambitions (specialist versus generalist, T-shape profile) [11].

Cohesion in development of education - Cohesion in modules, subjects and study activities increases the learning potential for learners [9].

Lean education – Every activity in development or executing education should add value. Eliminating waste and focussing on every day small improvements will be beneficial for the overall quality [12].

We believe that these models will help universities to adapt to fast changing technologies and the increasing demand for more, distinctive and broader qualified engineering professionals who are able to adapt and persist in the evolving digital economy [13].

2 METHOD

2.1 Data collection

This research was carried out to obtain insight in the extent of recognition of the proposed vision of the education ecosystem by students, lecturers and the industry who are currently participating in one of the 3D printing minor programs. The stability of recognizing the vision will be analyzed by comparing the data obtained in May 2016 (T2) with data obtained in February 2016 (T1). The value of the 3C model and Circle of Five (5) was measured under participating companies.

2.2 Respondents

All students, lecturers and companies involved in the 3D printing minors were included in this study.

The criterion for students is to follow one of the three 3D printing minors: From Idea to Product with 3D Printing, Smart Product Development with Additive Manufacturing or The Engineering Minor with 3D printing module and project. The criterion for lecturers is to participate in development of study material and/or giving lectures and/or guiding a project team as a tutor in one or more of the three 3D printing minors. The criterion

for companies is to participate in development of study material and/or giving guest lectures and/or guiding a project team as a problem owner/tutor in one or more of the three 3D printing minors.

2.3 Measurement instruments

Google Forms was used to design a questionnaire about the vision of the education ecosystem. The questionnaire for students and lecturers consists of 32 items, formulated as statements, with answers from 'totally disagree' to 'totally agree' on a 5-point Likert scale. The questionnaire for companies is shortened to 18 items, formulated as statements, with answers from 'totally disagree' to 'totally agree' on a 5-point Likert scale. At the end of every questionnaire, an open question for feedback enables respondents to express their opinion in their own words.

The questionnaire consists of several categories to distinguish the 3C model, Circle of Five (5) and the Desired Outcomes. The 3C model is divided into three categories: Collaboration (score range from 4 to 20), Co-Creation (score range from 1 to 5) and Control (score range from 2 to 10). The Circle of Five is divided into five categories: Focus on the Positive (score range from 5 to 25), Providing Challenge for Every Student (score range from 7 to 35), Trust Gives Ownership (score range from 7 to 35), Cohesion in Development (score range from 4 to 20) and Lean Education (score range from 2 to 10).

2.4 Analysis

To find an answer to the first research question "To what extent do our current minor students recognize the vision of the education ecosystem in their minor program?" percentages and mean scores were calculated of every category and feedback was analyzed. To find an answer to the second research question "Is recognition of the vision of the education ecosystem in the minor program stable over time?" we compared data of T1 with T2. To analyse what companies think of our models and what they recognize, a closer look was taken to their feedback.

3 RESULTS

3.1 Response rate

Out of 95 distributed questionnaires in May 2016 (70 to students, 16 lecturers and 9 companies), a total of n = 24 respondents (14 students, 6 lecturers and 4 companies) filled out the questionnaire (response rate 25%).

A total of 19 respondents (6 lecturers and 13 students) filled out the questionnaire in May 2016 for the second time (T2) at 75% completion of the minor program.

3.2 Recognition of 3C model and Circle of Five (5) at 75% completion of the program.

To obtain insight in the extent of recognition of the proposed vision of the education ecosystem of the respondents at 75% completion of the program, we counted the answers in every answer category and calculated the percentages. Figure 1 shows the percentages found for every category of the Likert Scale of the questionnaire (1 = "I disagree totally" to 5 = "I agree totally"). The results are based on 20 respondents (6 lecturers and 14 students).
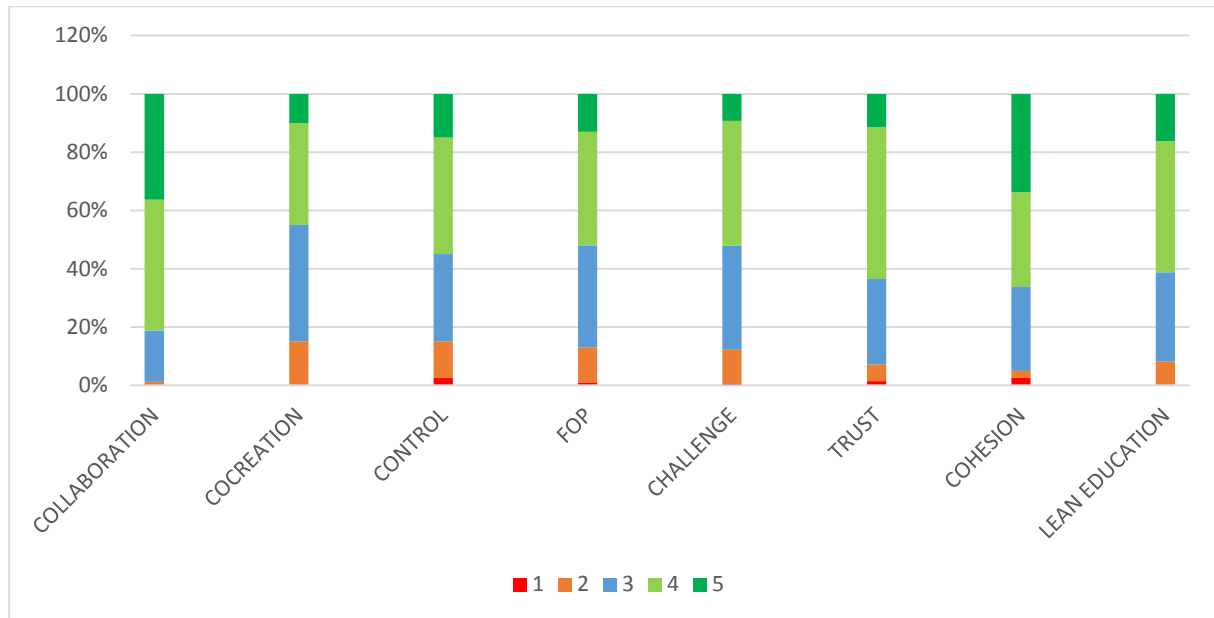

Figure 1. Recognition of 3C model and Circle of Five in May 2016 (T2; n = 20)

The green parts of the bars represent the amount of positive answers, the orange and red parts of the bars represent the amount of negative answers, and the blue part of the bars represent neutral answers.

3.3 Stability of recognition of 3C model and Circle of Five.

Comparison 1
To obtain insight in the stability of recognition of the proposed vision of the education ecosystem, we compared the mean scores of the respondents who filled out the questionnaire on both T1 and T2 (n = 19; 6 lecturers and 13 students). Have they changed in opinion and is it more positive or negative on T2 with regard to T1? Figure 2 shows the result of this comparison.
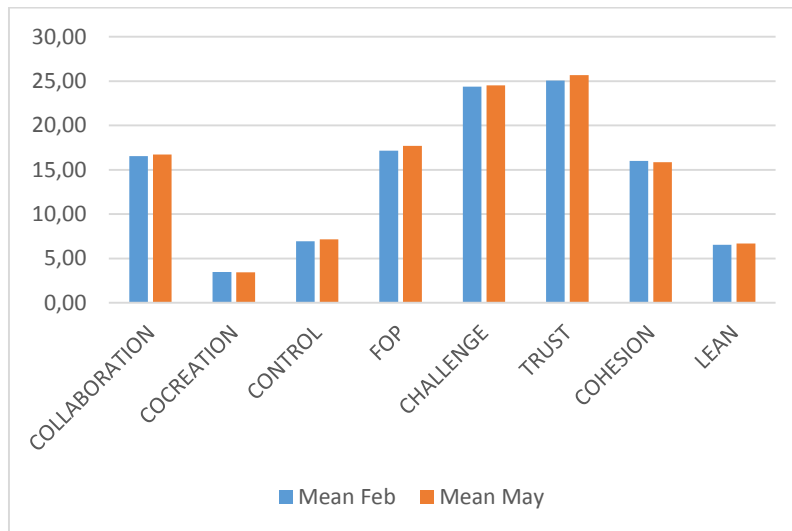
Figure 2. Comparison 1: mean scores of respondents participating in T1 and T2 (n = 19)

Comparison 2
For the second comparison, the mean scores of all respondents on T1 and T2 were compared (February: n = 59; May: n = 20). Figure 3 shows the result of this comparison.
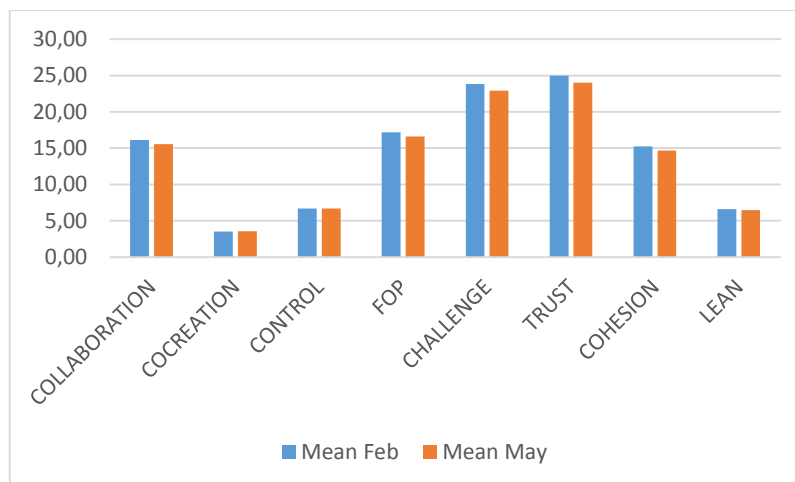

Figure 3. Comparison 2: mean scores of respondents participating in T1 and T2
(Feb: n = 59; May: n = 20)

In both comparisons no great differences occur. The two comparisons show that respondents remained stable over time, in recognizing the 3C model and Circle of Five in education.

On a closer look, the difference between the two comparisons is that respondents in comparison 1 had a slighter higher score in May than in February on Trust gives Ownership, but in comparison 2 the score was lower in May than in February.

3.4 Companies

A total of 4 companies gave their opinion through a shortened version of the questionnaire (14 items). This questionnaire focuses on the value of the aspects of the

3C model and the Circle of Five for development and execution of education and on recognition of the elements by companies.

Value

In Figure 4 it is shown that all companies indicated that the proposed elements for developing and executing education are valuable. Most seen as valuable is Collaboration and least seen as valuable is Cohesion.
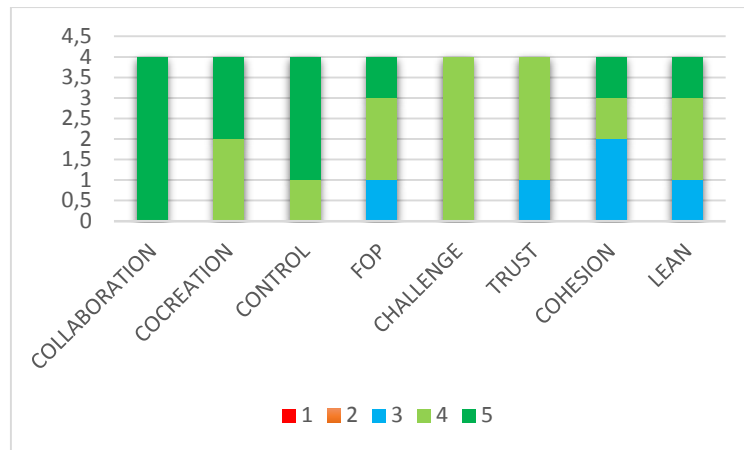

Figure 4. Value as seen by companies (n = 4)

Recognition

The most prominent result in recognition of the elements are shown in Figure 5. Apparently, Collaboration and Co-creation are recognized but Control and Cohesion are less recognized. Overall, we see that however all elements were found valuable, the minor program has not succeed yet to display all these elements properly.
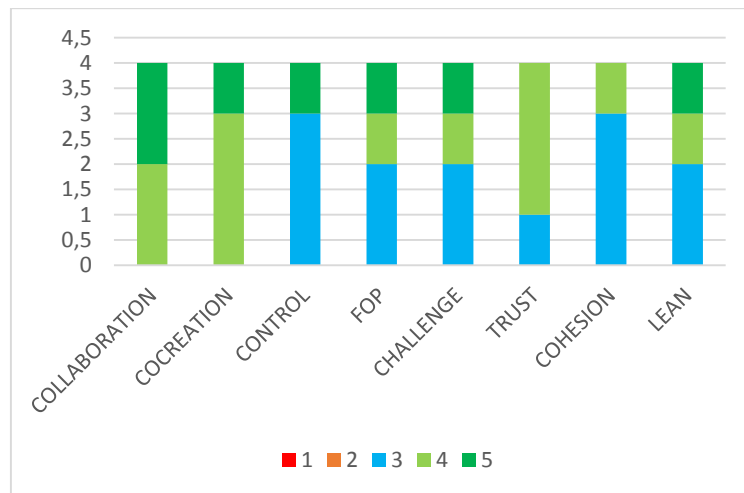

Figure 5. Recognition of the elements by companies (n = 4)

3.5 Open feedback

A total of 21 respondents filled out the open question at the end of the questionnaire to express their opinion in their own words. The feedback was counted, clustered and categorized. Three main feedback categories were found: organizational aspects, student's motivation and freedom.

Regarding organisational aspects, mainly students indicate that the timing of the information about schedule, deadlines, and assignments can be approved. We acknowledge this is an important factor to facilitate students. Although we acclaim 'just in time' learning (and therefore the organisation around it to achieve this), we experience challenges to manage this ambition in practice, because of current traditional organizational restrictions and, in some cases, mind-sets. We strive for an educational program which provides the freedom of educational institutes and companies to collaborate, regardless of time and planning restrictions. For the future, not only students, but lecturers have indicated to be clearer about the assessment part of the minor.

One respondent remarked that "*There is a difference among students in motivation and activity. This is standard in group dynamics (I assume). Some students have to put in more energy to keep everyone motivated and keep work flowing.*" In the questionnaire, we received a lot of valuable feedback varying from negative to positive. To serve every individual is a challenge and we use tools and activities to alternate between different kinds of student's interest. One of the lecturers *stated "I experience that students have to get used to this way of education, teaching and learning. They have been conditioned to learn in a very linear and standard way in which self-control and motivation especially creativity is not particularly stimulated. Therefore coping with change and a dynamic environment is experienced as stressful by some students. We have to manage the expectations for every individual student but at the same time prepare them for the dynamic environment of the future (…)".* The variation in competence to learn from every situation, or intrinsic motivation, is an implication of working with every group, but certainly one to keep in mind when designing new education.

The last main category showed that opinions are divided when it comes to freedom to take control over one's own learning path. Some students remarked that they would like to have more freedom of choice in choosing not only their project, but also their (international) team members. Others indicate that being put in a group, helps students to get out of their comfort zone. A lecturer suggested to decrease the amount of lectures and concentrate on coaching and co-creation with the students, but student's feedback did not imply too much class but too less freedom of choosing of optional modules, or workshops, was suggested to accommodate challenge for every student.

The companies suggest to stimulate open peer feedback and self-refection in the process. In general the companies' feedback *"I very much like the model and idea, though the real challenge is to keep traction on a practical level and I see a lot of opportunity still."* And *"Very satisfied with the process and students at the moments"* suggest we are on the right track towards a common ground vision for an education ecosystem.

4 CONCLUSION

Finding a common ground vision to develop and execute an education ecosystem for future-proof Engineering professionals is a challenge we cannot deny facing anymore [13] [4] [14].

Concerning recognition of the 3C model and the Circle of Five at 75% completion of the program, it can be stated that in general, respondents are quite positive about recognizing the 3C model and Circle of Five in our education. However, still a considerable amount of students remain conservative. Collaboration is best recognized. Surprisingly, respondents see Co-creation as the least obvious aspect in our education while we explicitly facilitate and stimulate the parties to co-create.

When it comes to stability of recognition of the 3C model and Circle of Five, no great differences were found over time. Meaning that the model remained stable over time and time and progression did not have a major influence on recognition of the elements of the model. However, the reason why a considerable amount of respondents remained neutral in recognizing the model, needs to be researched more thoroughly.

Although all companies indicated that the proposed elements for developing and executing education are valuable, the minor program has not succeed yet to display all these elements properly. Important finding is that Collaboration and Co-creation are the most valued aspects of companies, meaning that currently they are more than ever willing to reach out to education.

Finally, the open feedback of all respondents were found in three main categories: organizational aspects, student's motivation and freedom.

As a footnote, the low response rate of T2 must be taken into consideration. Students and lecturers stated that they had a busy schedule during the week the questionnaire was distributed. There is no explanation for the low response rate of companies. We are aware that the results may not be representative. Therefore we shifted our focus to the qualitative data of the questionnaire. Both quantative and qualitative results will be taken into account for follow up research.

Since the 3D printing minors are yet in a pilot phase, a lot of qualitative improvements are on the list for the next run. The feedback given by the students and companies confirmed our own suggestions for improvements to realize an education system that provides the optimal playground for our current and future professionals.

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