

Evaluation report

Nanotechnology pilot course

Experts in Nanotechnology Exploitation project

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Contents

Introduction	2
Curriculum contents	2
Feedback.....	3
Pre-pilot questionnaire	3
Post-pilot questionnaire	5
Methodology.....	10
Organization	11
Appendix A. Full program.....	13
Appendix B. Pre-pilot questionnaire	15
Appendix C. Post-pilot questionnaire	16

Introduction

From the 25th till the 27th of January 2016 the pilot course of the nanotechnology part of the Experts in Nanotechnology Exploitation (ENEX, www.enex-nano.com) project took place. This pilot is used as a check whether the chosen curriculum fits the demands of the target group.

The target group of the ENEX project are the professionals from small and medium-sized enterprises (SMEs). The goal in the ENEX project is to develop an e-learning module which can be used for vocational education of these professionals. It can be used as a first introduction into nanotechnology and to explore the possibilities of nanotechnology for one's company.

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Curriculum contents

The already existing concept of the workshop "Fundamentals of Nanotechnology", which is yearly organized by the University of Twente (Enschede, NL), was used as a starting point. This concept is worked out as a three-day workshop during which a mixture of lectures on fundamentals and on applications is given, hence the new name "Fundamentals of Nanotechnology and its Applications". The first two days were focussed on the fundamentals and direct translation of these fundamentals into applications. These days were divided in the following key themes:

- Basics of nanotechnology
 - o Top-down processing philosophy and techniques
 - o Bottom-up fabrication methods
 - o Nano-characterization techniques
 - o Guided lab tours in the MESA⁺ NanoLab, BioNanoLab, and Scanning Electron Microscopy characterization lab
- Unconventional electronics
 - o Fundamentals
 - o Applications
- Storage of renewable energy
 - o Fundamentals
 - o Applications

- Early diagnostics of diseases
 - o Fundamentals
 - o Applications

The bridge to applications is made by two workshops, which were incorporated on the first two days:

- Technology venturing
 - o Fuzzy Front End and technology roadmapping
 - o Triangulation of value creation
- Societal aspects of nanotechnology

The third day was completely focussed on the applications of nanotechnology. This day consisted of:

- Valorisation
- Company presentations
- Case study

In the last two weeks before the pilot started, the two speakers of the “storage of renewable energy” theme cancelled their participation. It was impossible to find two new speakers in this theme or a complete new theme on such short notice. Themes like nanosensing, nanomedicine, membranes, nanobiophysics, and inorganic thin films/semiconductors were good possibilities to fill in the gap, if there were speakers available to do it.

The full program can be found in appendix A.

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Feedback

The workshop registration form did not only consisted out of the standard questions (name, address, affiliation) but it also contained questions about the participants background, how they did hear about the workshop, and if they have heard of the ENEX project (a pre-pilot questionnaire). This information is used to characterize the group of participants. During the pilot, participants were asked to fill in the post-pilot questionnaire. This form contained questions about how they experienced the workshop and if they missed some elements. Both the pre-pilot and the post-pilot questionnaire are made by the partner CNR-IFAC from Italy and can be found in the appendices B and C, respectively.

Pre-pilot questionnaire

In order to determine the characteristics of the group of participants, a pre-pilot questionnaire is carried out. This was part of the registration form, and care is taken that all the participants filled in the questions. As can be expected, the major group consisted out of males. Most of the people are in the age group of 25 to 30 years. These results are shown in figure 1.

The background of the group was rather multidisciplinary, ranging from physics to bio sciences to human sciences. The level of the participants range from master’s student to post-doc and director of a company. These pie-charts are shown in figure 2.

The major group (slightly over $\frac{3}{4}$) did not hear of the ENEX project before. This can be explained by the fact that Master and PhD students joined the pilot. They are slightly out of the target group of the ENEX project. However, 52% considers attending the ENEX course, once it is finished. These results are shown in figure 3.

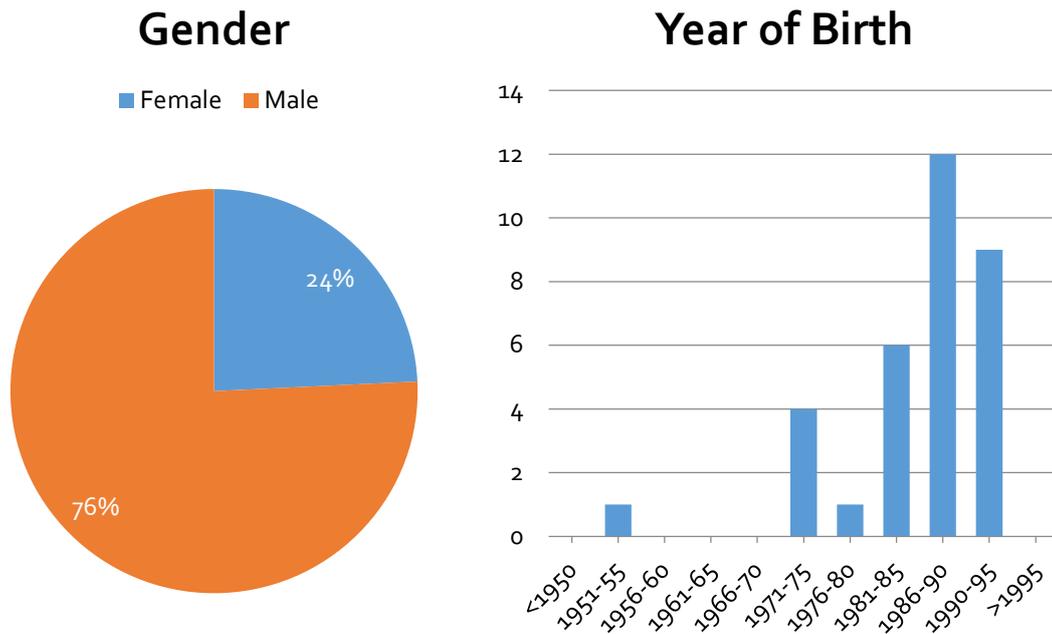


Figure 1. Division of males and females (left) and the age distributions (right).

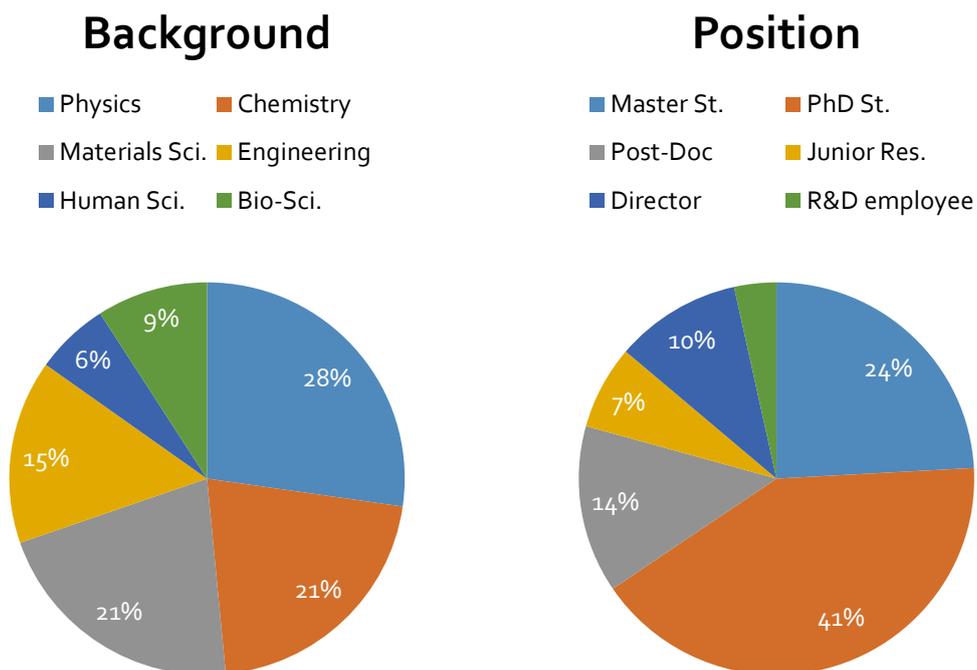
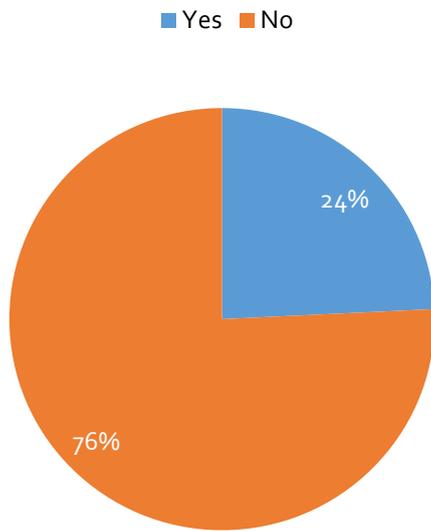


Figure 2. Background (left) and level (right) of the participants.

Have you heard of the ENEX project?



Would you consider to attend the ENEX course?

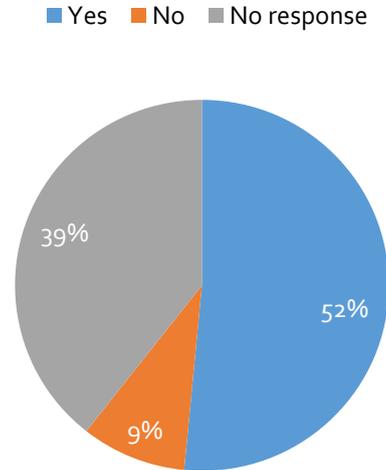


Figure 3. Awareness of the ENEX project amongst participants.

Post-pilot questionnaire

In order to check the satisfactory level of the pilot, a post-pilot questionnaire was carried out. The participants were asked during the pilot to fill this in and care was taken that a large group of participants filled it in by making it "mandatory" for the certificate of attendance. The principal scope of this questionnaire was to gain feedback on the selection of topics for the training course and to correlate the background of the trainees with their probability to profit from the training course in terms of improvement of their prior knowledge.

Of the group of participants, 72% declared to have some professional experience in fields that relate to Nanotechnology and 17% in fields are related to Economy or Finance, as can be seen in figure 4. Again, the level of academic degree of the participants was asked. In particular, 44% of the participants started from some formal education in Chemistry or Chemical Engineering, 22% in Physics or High Technology, 22% in Materials Science or Nanotechnology, 5.6% in Economy or Finance, 17% in Social Sciences and 11% in Life Sciences and Pharmaceutical Sciences. These results are shown in figure 5.

Professional experience

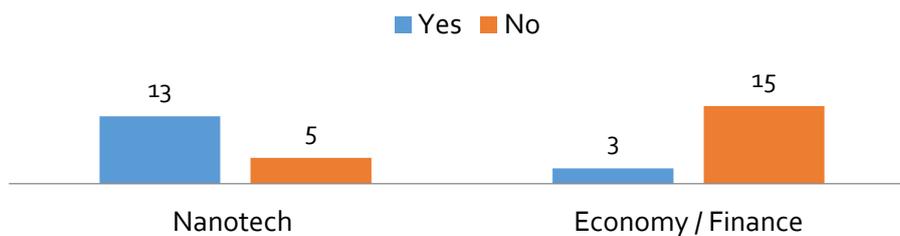


Figure 4. Professional experience of the participants.

Academic degrees

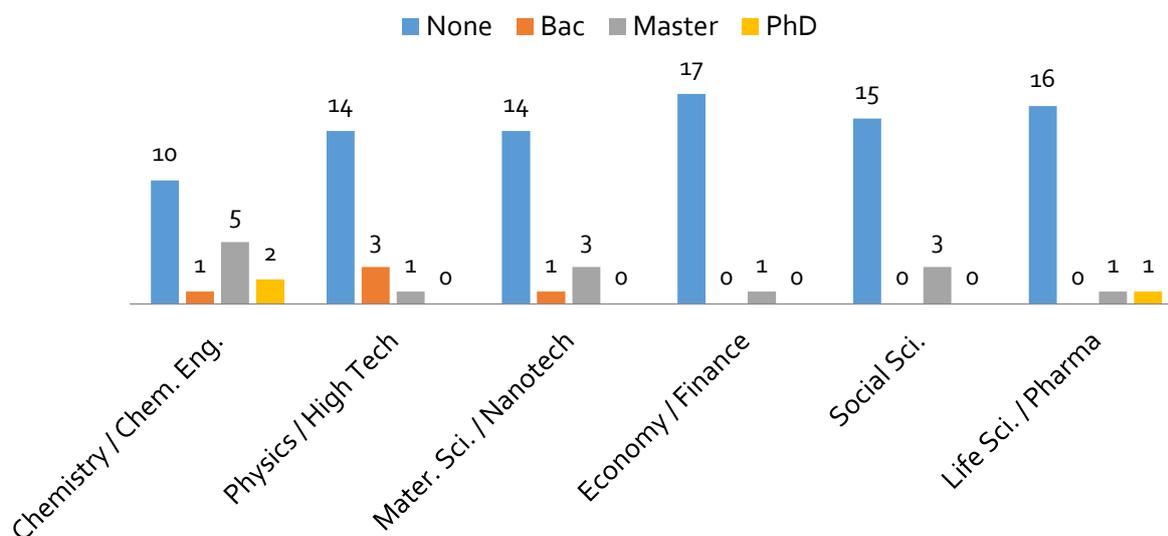


Figure 5. Academic degrees of the participants.

The discussed topics of the pilot are:

- Topic 1: Basics (top-down fabrication, bottom-up fabrication, nano-characterization)
- Topic 2: Unconventional electronics (fundamentals and applications)
- Topic 3: Technology venturing/innovation
- Topic 4: Lab tours (NanoLab, BioNanoLab, SEM characterization lab)
- Topic 5: Storage of renewable energy (fundamentals and applications)
- Topic 6: Early diagnostics of diseases (fundamentals and applications)
- Topic 7: Societal embedding of nanotechnology
- Topic 8: In practice (applied nanotechnology, valorization)
- Topic 9: Company presentations

The relevance level of these topics are shown in figure 6. All topics received a high level of satisfaction. Those that were regarded to be most relevant are, in that order, topics 1, 6 and 2. Conversely, those that received less satisfaction are topics 7, 4 and 3.

Participants also indicated that some components were missing. These are depicted in figure 7. In particular, 17% of the participants expected to receive more training in the macro areas that relate to Medicine or Biotechnology. This can be explained by the fact that 9% of the participants are working in these fields.

Figure 8 displays the satisfaction of the participants with respect to the relative weight of the contents that were covered in the pilot. The relative weight of all topics was considered to be adequate by the majority of the trainees. Those that were perceived to be most oversized are, in that order, topics 7, 8 and 9. Those undersized are topics 5 and 1.

Relevance of topics

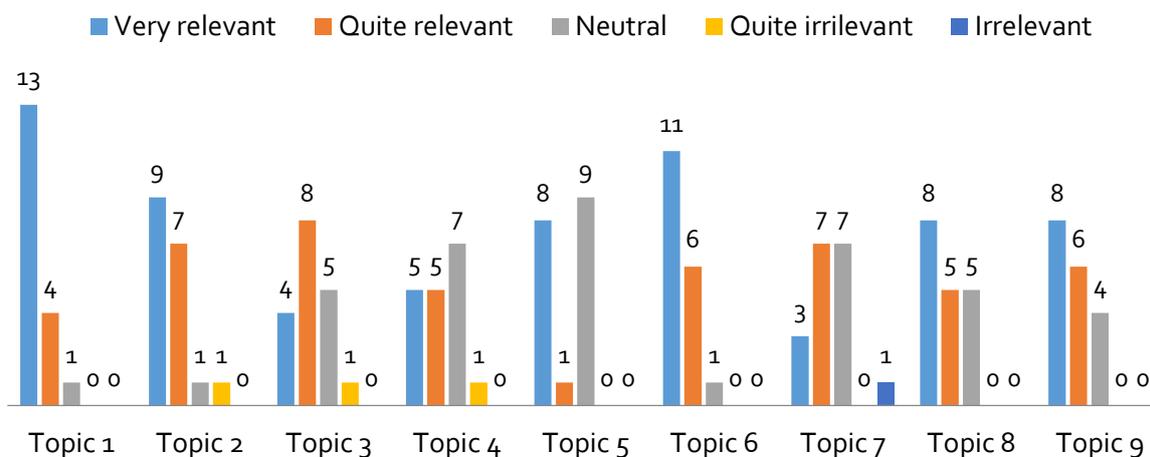


Figure 6. Relevance level of the topics.

Demand for more content

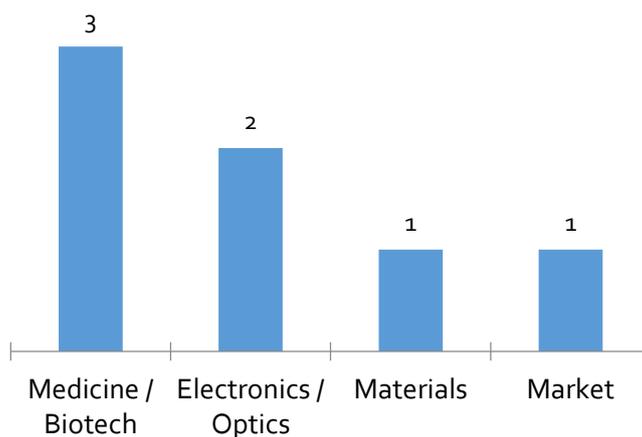


Figure 7. Missing components.

Weight of topics

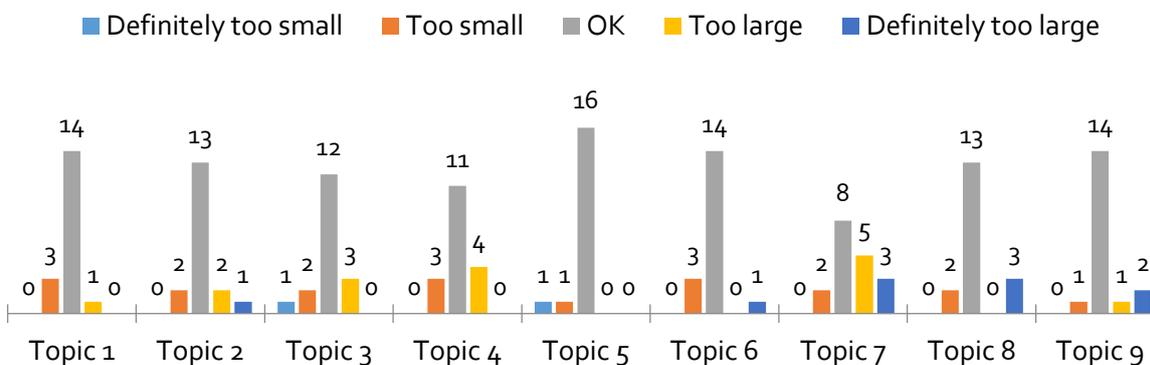


Figure 8. Satisfaction with the relative weight of the topics.

Figure 9 provides an overview on the satisfaction of the participants with respect to their ability to take advantage of the course and improve their knowledge and skills.

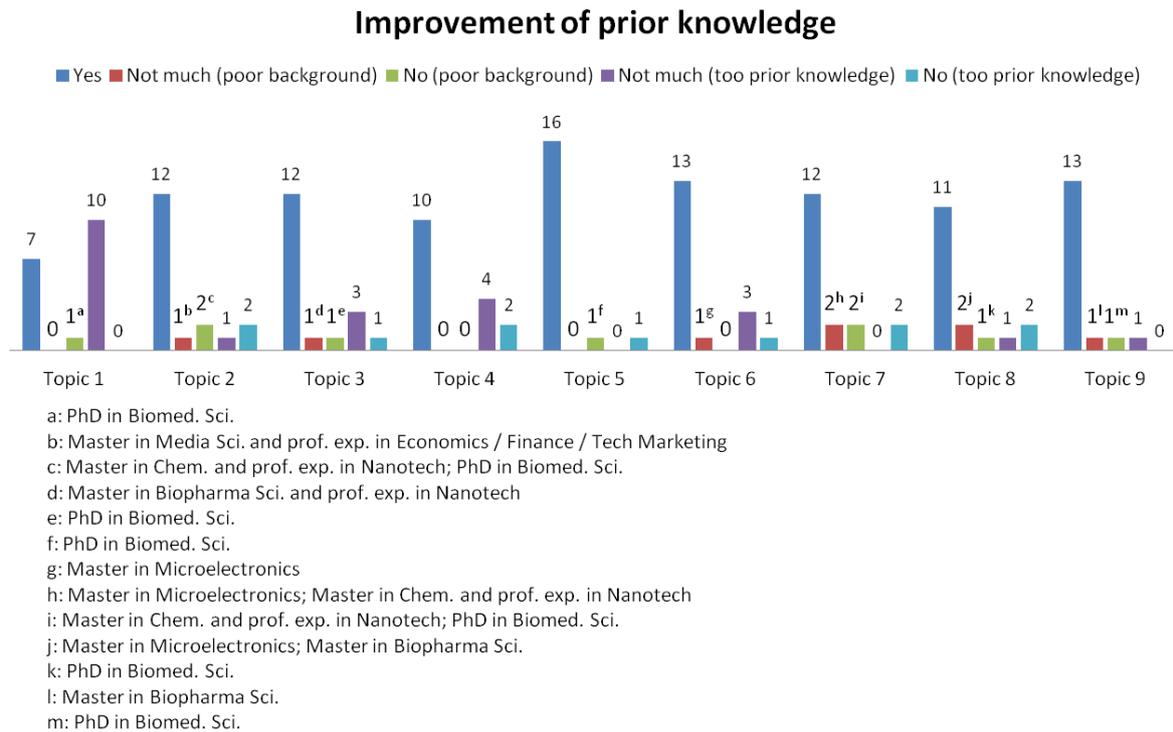


Figure 9. Knowledge improvement of participants.

With the exception of topic 1, the majority of the participants improved their prior knowledge in all topics to a good level of satisfaction. As of topic 1, 56% of the respondents did not take much advantage of the training, because their prior knowledge already was extensive enough. However, in the framework of a VET programme that is intended to integrate and to detect the prior knowledge of entrants, this discomfort is deemed to be uncritical. Instead, we decided to focus more on those who suffered from a lack of background, because this may affect their admission. Details on these cases are given in the notes to figure 9, which describe the profiles of the trainees who did not improve their prior knowledge to their satisfaction due to gaps in their background. Participants were regrouped with respect to their principal background and their percent of discomfort due to a lack of prior knowledge is represented in figure 10.

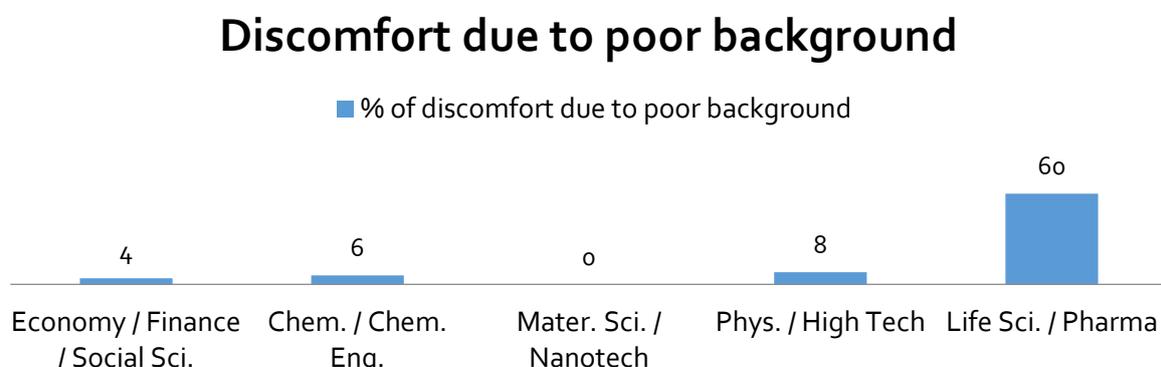


Figure 10. Discomfort due to poor background due to gaps in the prior knowledge vs. the principal background of participants.

As it was expected, participants with a background in Materials Science or Nanotechnology did not suffer from any lack of prior knowledge. Participants with a background in Economy, Finance, Social Sciences, Chemistry, Chemical Engineering, Physics or High Technology almost displayed the same level of hardship below 10%, which is deemed to be normal. Instead, those with a principal background in Life Sciences or Pharmaceutical Sciences perceived a high frequency of hardship, which should be taken into due account.

Figure 11 contains the answers of the participants to the question on their intention to attend a full e-learning format of the training course, in order to become an ENEX. Answers are also plotted for different groups of trainees with different principal background.

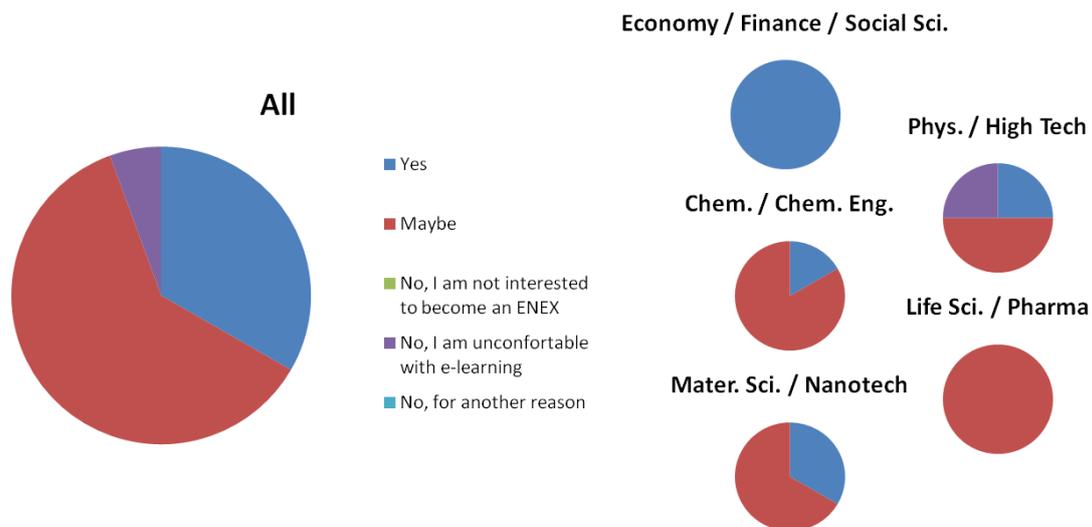


Figure 11. Willingness of the participants to attend a full e-learning course, in order to become an ENEX. The pie-charts at the right contain the answers from participants with different principal backgrounds.

Most of the participants displayed some interest in the final format of the training course. Only one respondent out of 18 was negative, due to a general discomfort with e-learning platforms. The greatest interest was received from participants with a background in Economy, Finance or Social Sciences. Conversely, more doubt was expressed by those with a background in Life Sciences or Pharmaceutical Sciences, which correlates well with their difficulty to understand the pilot, as it is seen in figure 10.

Figure 12 contains the answers of the trainees on their intention to recommend the pilot to others. The majority of the participants would recommend the pilot to others. Only one attendant out of 18 would not. In this context, the greatest satisfaction came from the participants with a principal background in Economy, Finance, Social Sciences, Materials Sciences or Nanotechnology. Less satisfaction was found among those with a principal background in Life Sciences or Pharmaceutical Sciences, with a pattern to the results in figure 10.

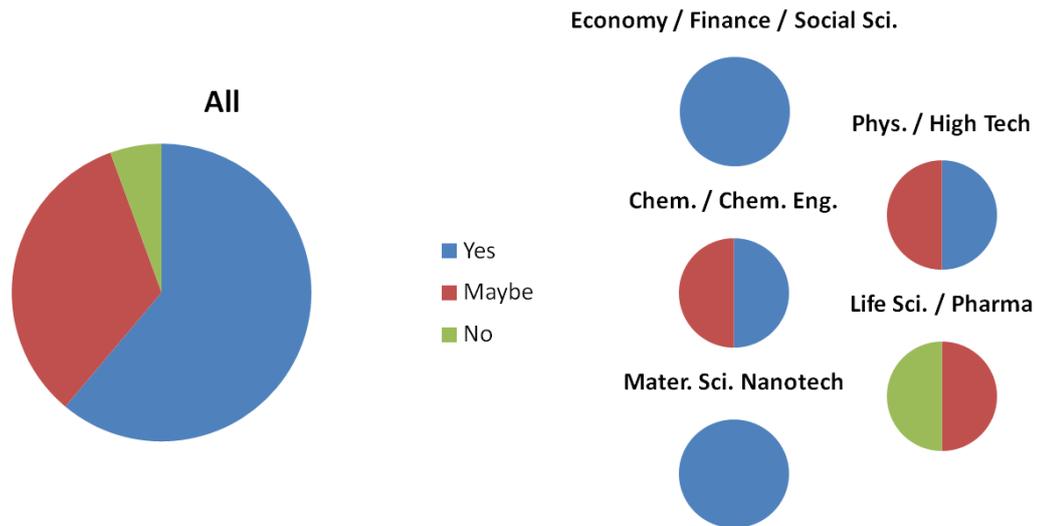


Figure 12. Willingness of the participants to recommend the same course to others. The pie-charts at the right contain the answers from participants with different principal backgrounds.

Most of the comments were positive. Explicit recommendations were expressed along different directions, as it is summarized in figure 13.

Recommendations

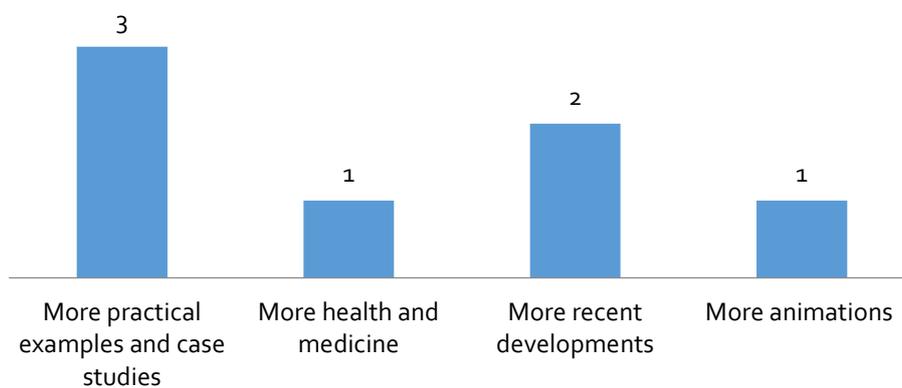


Figure 13. Explicit recommendations from the participants.

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Methodology

As can be seen in the post-pilot questionnaire, the chosen methodology was a success. The variety in the program was well appreciated. Some commented that they missed components like nano-optics, nanomedicine, and organ-on-chip systems (medicine). This small amount of missing components indicate a representative mix of the nanotechnology curriculum.

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Organization

By looking at the questionnaires we can conclude that we had a variety in the group of participants. However, the amount of technical academics was still rather high. The main target group were industrialists from SMEs and people lacking an in-depth background in nanotechnology. This kind of participants was also present during the pilot. Therefore we can conclude that we reached our target groups. These groups of participants evaluated the pilot different. Mainly the questions whether the background knowledge was sufficient scored low, but this was as expected. The overall organization of the pilot scored pretty well, as can be seen on previous pages.

~oOo~

Missing components and translation to an e-learning module

In the post-pilot questionnaire, the participants were also asked which components they missed and if they had recommendation. The participants replied with the results of figure 7 and 13, which are summarized as:

- Medicine and biotechnology
- Electronics and optics
- Materials
- Market
- More practical examples and case studies
- More health and medicine
- More recent developments
- More animations

The whole nanotechnology world is too big to fully cover in an e-learning module, which is also focused on innovation. A large part is still fundamental research and therefore not of interest for the ENEX e-learning module. This was the same for the pilot workshop. Decisions of which topics we wanted to cover had to be made. We decided to incorporate a basics theme, technology venturing/societal aspects theme, and for the rest we followed the research themes of MESA+:

- Early diagnostics of diseases
- Unconventional electronics
- Storage of renewable energy
- Physics for security

From this set of research themes, it directly became clear that Physics for security is not suited as part of the pilot and e-learning module. This theme is still too fundamental and it was hard to find speakers for it. The same counts for the Storage of renewable energy theme. After cancellation by the two speakers, it was hard to find speakers with a connection to applications (and also speakers on the fundamentals). The two research themes that were discussed in the pilot workshop were Early diagnostics of diseases and Unconventional electronics. Both discussed the fundamentals and applications, but the latter was more fundamental orientated than the first one. Therefore it is understandable that the participants pointed out that more practical examples and recent development need to be discussed.

Based on the comments of the participants and my personal experience of the content I can conclude the following points on the nanotechnology part of the e-learning module:

- Both the early diagnostics as the electronics themes are very suitable for using in the e-learning module. They both contain enough examples that can be used in the content. These examples need to contain:
 - Fundamental background knowledge
 - The use of fabrication processes in the device development
 - The use of characterization methods during and after the device fabrication
 - Examples that can be used as cases for innovation management and research-to-market studies
- In my personal opinion, the Early diagnostics theme is more suitable because there are quite some examples on the market or ready to go on the market, the fabrication of such devices involve a wider range of fabrication methods, the used materials and the applications are more diverse, and there are more ethics involved (which are also important in the research-to-market process).
- The Early diagnostics theme can be extended by incorporating more health, medicine, and biotechnology. For example, the nanomedicine part is also quite evolving. However, this is more soft nanotechnology and more dedicated to a certain group of companies/users.
- It will be good to use animations in the e-learning module. This is something you quite often see in other e-learning courses on FutureLearn, EdX, and Coursera. These animations clarify difficult concepts more easily. This is desired because the module will be a VET module and will also be given to people with a minimal technological knowledge. A downside is that the animations need to be made.
- With the Early diagnostics theme, it is also easier to take practical examples. The most famous examples are the pregnancy test and the blood glucose tester for diabetic patients.

Participants also noted that they would like to see more about the electronics and optics. This is understandable because there were quite some academics in the group of participants. However, by looking at the applications of electronics and optics part of nanotechnology, I would not recommend this as a part of the e-learning module.

Appendix A. Full program

25th of January		The basics, Unconventional electronics, and venturing
Morning		
08:55 – 09:00	Opening of the workshop <i>dr. Martin Bennink</i>	CR.2H
09:00 – 09:40	Basics <i>Top-down fabrication: Principles, Techniques and Examples – dr. Alexey Kovalgin (SC)</i>	CR.2H
09:45 – 10:25	Basics <i>Molecular Nanofabrication: functional nanostructures by integrated lithography-assembly processes – prof. Jurriaan Huskens (MnF)</i>	CR.2H
10:30 – 10:45	Coffee break	
10:45 – 11:25	Unconventional electronics <i>Fundamentals – prof. Wilfred van der Wiel (NE)</i>	CR.2H
11:30 – 12:10	Unconventional electronics <i>Applications of nanotechnology in integrated circuits – prof. Jurriaan Schmitz (SC)</i>	CR.2H
12:15 – 13:00	Lunch (at own costs)	
Afternoon		
13:00 – 13:40	Basics <i>Nano-characterization: Chemical identification and imaging at the molecular and atomic scale – dr. Peter Schön (MTP/Saxion)</i>	CR.2H
13:45 – 14:25	Workshop <i>Fuzzy front-end and Technology Roadmapping – Koos Slagter MSc (Saxion)</i>	CR.2H
14:30 – 14:40	Coffee break	
14:40 – 15:25	Workshop <i>Technology Venturing: triangulation of value creation – Matthijs Hammer MSc (TU Delft/Saxion)</i>	CR.2H
15:30 – 16:30	Lab-tours Group 1 Group 2 NanoLab BioNanoLab & SEM characterization lab	The labs

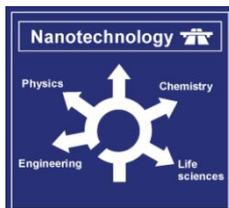
26th of January		Early diagnostics and societal aspects
Morning		
09:00 – 09:40	Cancelled due to cancellation by speaker	CR.2H
09:45 – 10:25	Cancelled due to cancellation by speaker	CR.2H
10:25 – 10:45	Coffee break	

10:45 – 11:25	Early diagnostics of diseases <i>Fundamentals – prof. Jan Eijkel (BIOS)</i>	CR.2H
11:30 – 12:10	Early diagnostics of diseases <i>Applications – dr. Loes Segerink (BIOS)</i>	CR.2H
12:15 – 13:00	Lunch (at own costs)	
Afternoon		
13:00 – 14:00	Workshop <i>Societal aspects of nanotechnology – dr. Haico te Kulve (STAPS)</i>	CR.2H
14:00 – 14:15	Coffee break	
14:15 – 15:15	Workshop <i>Societal aspects of nanotechnology – dr. Haico te Kulve (STAPS)</i>	CR.2H
15:30 – 16:30	Lab-tours Group 2 Group 1 NanoLab BioNanoLab & SEM characterization lab	The labs

27th of January	Nanotechnological innovations, applications, and valorization	
Morning		
09:00 – 09:40	In practice <i>Applied Nanotechnology – dr. Martin Bennink (NBP/Saxion)</i>	RA2.503
09:45 – 10:25	In practice <i>Translating scientific innovations into products: from ideas to business, risks and opportunities – dr. David Fernandez Rivas (MCS/BµBclean)</i>	RA2.503
10:25 – 10:45	Coffee break	
10:45 – 11:25	Company presentation 1 <i>Medspray – Jeroen Wissink</i>	RA2.503
11:30 – 12:10	Company presentation 2 <i>Solmates – Arjen Janssens</i>	RA2.503
12:15 – 13:00	Lunch (at own costs)	
Afternoon		
13:00 – 13:40	Company presentation 3 <i>Micronit Microfluidics – Monica Brivio</i>	RA2.503
13:45 – 14:30	Casus workshop part 1 <i>Discussing problems opposed by companies 1 to 3</i>	RA2.503
14:30 – 14:45	Coffee break	
14:45 – 16:00	Casus workshop part 2 <i>Discussing problems opposed by companies 1 to 3</i>	RA2.503
16:00 – 16:45	Drinks <i>Closing of the workshop</i>	

Appendix B. Pre-pilot questionnaire

Registration form



MESA+ workshop

**“Fundamentals of Nanotechnology
and its applications”**

January 25-27, 2016



Please fill out this registration form and return this as an email attachment
to h.veltkamp@utwente.nl.

Full name	
Year of birth	
Gender	<input type="checkbox"/> male <input type="checkbox"/> female
Main background	<input type="checkbox"/> physics <input type="checkbox"/> chemistry <input type="checkbox"/> materials science <input type="checkbox"/> economics <input type="checkbox"/> finance <input type="checkbox"/> other: ...
Position	
Company / Affiliation	
Field/topic of research (if applicable)	
How did you first hear about this course?	<input type="checkbox"/> search engine <input type="checkbox"/> email announcement <input type="checkbox"/> colleague <input type="checkbox"/> other: ...
Have you heard of the ENEX project? http://www.enex-nano.com/	<input type="checkbox"/> yes <input type="checkbox"/> no
If yes, would you consider the possibility to attend the ENEX course?	<input type="checkbox"/> yes <input type="checkbox"/> no
Address	
Phone number	
Email	
Participation in lab tours If you already have working experience in these labs, then it is of less interest for you.	<input type="checkbox"/> NanoLab <input type="checkbox"/> BioNanoLab <input type="checkbox"/> SEM characterization lab

A confirmation message will be sent to you by email as we have received your registration form.

Appendix C. Post-pilot questionnaire

Satisfaction Questionnaire

This questionnaire is intended to gather statistical information for the preparation of an e-learning course for Experts in Nanotechnology Exploitation (ENEX). We appreciate your collaboration.

As an alternative to this paper form, you may complete this survey online by using the QR code below.

*Vereist



1. **1.1 Do you have an academic degree in... ***

Markeer slechts één ovaal per rij.

	Yes, a bachelor degree	Yes, a master degree	Yes, a PhD degree	No
... chemistry?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
... physics?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
... materials science?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
... economy?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
... finance?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
... other disciplines?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

2. **1.2 If you answered other disciplines, please specify disciplines and degrees**

.....

3. **2.1 Do you have professional experience in... ***

Markeer slechts één ovaal per rij.

	Yes	No
... production, characterization or exploitation of nanotechnology-based materials?	<input type="radio"/>	<input type="radio"/>
... other fields that relate to nanotechnology?	<input type="radio"/>	<input type="radio"/>
... economics or finance?	<input type="radio"/>	<input type="radio"/>
... other fields that relate to economics or finance?	<input type="radio"/>	<input type="radio"/>

4. **2.2 If you answered other fields that relate to nanotechnology, please specify**

.....

5. **2.3 If you answered other fields that relate to economics or finance, please specify**

6. **3.1 How do you rate the relevance of... ***

Markeer slechts één ovaal per rij.

	Very Relevant	Quite relevant	Neutral	Quite irrelevant	Very Irrelevant
...basics (top-down fabrication, bottom-up fabrication, nano-characterization)?	<input type="radio"/>				
...unconventional electronics (fundamentals and applications)?	<input type="radio"/>				
...technology venturing/innovation?	<input type="radio"/>				
...lab tours (NanoLab, BioNanoLab, SEM characterization lab)?	<input type="radio"/>				
...storage of renewable energy (fundamentals and applications)?	<input type="radio"/>				
...early diagnostics of diseases (fundamentals and applications)?	<input type="radio"/>				
...societal embedding of nanotechnology?	<input type="radio"/>				
...in practice (applied nanotechnology, valorization)?	<input type="radio"/>				
...company presentations?	<input type="radio"/>				

7. **4.1 Please list other topics that you would have expected this course to cover**

8. 5.1 How do you rate the relative weight of... *

Markeer slechts één ovaal per rij.

	Definitely too large	Too large	OK	Too small	Definitely too small
...basics (top-down fabrication, bottom-up fabrication, nano-characterization)?	<input type="radio"/>				
...unconventional electronics (fundamentals and applications)?	<input type="radio"/>				
...technology venturing/innovation?	<input type="radio"/>				
...lab tours (NanoLab, BioNanoLab, SEM characterization lab)?	<input type="radio"/>				
...storage of renewable energy (fundamentals and applications)?	<input type="radio"/>				
...early diagnostics of diseases (fundamentals and applications)?	<input type="radio"/>				
...societal embedding of nanotechnology?	<input type="radio"/>				
...in practice (applied nanotechnology, valorization)?	<input type="radio"/>				
...company presentations?	<input type="radio"/>				

9. 6.1 Did the training course improve your knowledge in... *

Markeer slechts één ovaal per rij.

	Yes	Not much, because my prior knowledge was already quite thorough	No, because my prior knowledge was already very thorough	Not much, because my background was hardly sufficient	No, because my background was insufficient	No, for another reason
...basics (top-down fabrication, bottom-up fabrication, nano-characterization)?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
...unconventional electronics (fundamentals and applications)?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
...technology venturing/innovation?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
...lab tours (NanoLab, BioNanoLab, SEM characterization lab)?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
...storage of renewable energy (fundamentals and applications)?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
...early diagnostics of diseases (fundamentals and applications)?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
...societal embedding of nanotechnology?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
...in practice (applied nanotechnology, valorization)?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
...company presentations?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

10. 6.2 If you answered "No, for another reason" for any topic, please specify

.....

.....

.....

.....

.....

11. **7.1 Would you attend a complete open-license version of this course online, in order to become an Expert in Nanotechnology Exploitation (see <http://www.enex-nano.com>)? ***

Markeer slechts één ovaal.

- Yes
- Maybe
- No, because I am not interested to become an Expert in Nanotechnology Exploitation
- No, because I am uncomfortable with e-learning
- No, for another reason

12. **7.2 If you answered "No, for another reason", please specify**

13. **7.3 Would you recommend the same to friends, colleagues or business partners? ***

Markeer slechts één ovaal.

- Yes
- No
- Maybe

14. **8.1 Suggestions or comments**

Thank you for your time!
