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Report on Deliverable D4.4.4: update questionnaire

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CONTENT

1. ABSTRACT

This report of FlexNet project deliverable D4.4.4 provides an overview of the work done in work package four task force four: to update the PRODI questionnaire of 2008. The objective of this 2008 questionnaire was to determine whether there is a need for training/further training in the field of flexible, organic and large area electronics (FOLAE). The 2008 questionnaire did not include an investigation of professional as well as additional (soft) skills which are necessary in order to be employable in the field of FOLAE. Moreover, it did not investigate whether the existing educational situation is good enough to suit the needs of the industry or not. To compensate these lacks was the main objective of this questionnaire. Therefore, the 2008 PRODI questionnaire was evaluated and a new questionnaire was designed with the help of some experts in the field. TUC decided to use a web-based questionnaire which was easier to distribute. This was important since the questionnaire was supposed to be distributed in Europe or even in America and Asia. After the questionnaire was designed, a strategy for dissemination was made and carried out. The target group of the questionnaire was the industry, so TUC concentrated on distributing the questionnaire among Organic Electronics Association (OE-A) members because of the 152 (03.11.2010) members of OE-A 93 members are from the industry.

The questionnaire was then presented at two meetings of the OE-A and included into several OE-A newsletters. Finally, the new questionnaire has been evaluated so that the results could be presented in this report.

Summed up, it can be said that the results provide a good overview of the educational demands and the necessity to foster education in this field. It further gives information as to the question whether there is a need for offering further special trainings to other employees (skilled worker, certified technician, engineer, senior scientist). For the future, it is intended to make specific recommendations for universities in order to have a guideline when developing courses which meet the industrial needs. It is moreover planned to develop a concept for an international master course (or PhD program) in M30 of the FlexNet project.

2. BACKGROUND AND OBJECTIVES

The growing flexible, organic and large area electronics (FOLAE) industry is creating a high demand for new and well-educated employees with specialised knowledge and skills. Within this project, the aim is to develop a concept for education and training on the European level which meets the needs of this emerging industry. This training concept is also part of the FlexNet objective of European countries working together in order to support Europe in becoming a world leader in FOLAE. Not only Europe's FOLAE-expertise should be interlinked in the domains of science, technology development, components, devices and systems integration technologies but also in the domain of higher education.

Before developing this concept for education and training in the field of FOLAE, already existing training programs have to be listed and evaluated and the needs of the industry have to be analyzed. Therefore, in a first step, a public inventory ("mapping") of existing university courses or existing bachelor/master degree programmes in this field was started in 2010. At the same time, we started with updating the PRODI questionnaire of 2008 which tries to find out the needs of the industry. The results of this new questionnaire together with the findings of the mapping will help to finalise this work of task force 4.4 - to create a general concept for a European master degree programme in the field of FOLAE.

Until now, no specific information exists which gives a hint towards the educational needs of industry in the field of FOLAE. A survey was carried out within the EU FP7 project PRODI which found out that further education/ training in the field is necessary but not yet offered enough. This new questionnaire now also focuses on finding out the educational needs of the industry. Contrary to the version of 2008, the 2010 questionnaire asks in more detail about the necessary and already existing professional as well as additional (soft) skills of graduates which are important when working in the field of FOLAE. The results should provide a good overview about the educational demands and the necessity to foster education in this field. But some limitations are also clear from the beginning. The findings can only be interpreted as signalling a tendency and since FOLAE is a highly interdisciplinary field, results are a general recommendation rather than being specific guidelines for creating a direction in the course development.

Also included in the evaluation are some brief information about the necessity of internships and a ranking of the need of further training for certain employment levels (technician, scientist etc.) in FOLAE.

This report closes with a short conclusion and an outlook on the future work in FlexNet work package 4 task force 4 for which the present report will provide a basis..

3. METHOD

The objective of TF4.4 is to develop a concept for education and training on the European level which meets the needs of the flexible, organic and large area electronics (FOLAE) industry. Therefore, the educational needs of the FOLAE industry are to be analyzed with this FlexNet questionnaire. In order to do so, TUC needed to know the specific skills which are important for being employed in this field. A general definition of "employability" is given by the Bologna Follow-up Group (BUFG: 2005) which can be found on the official Bologna Process website. Employability is defined as

> *the ability to gain initial employment, to maintain employment, and to be able to move around within the labour market. [...] The role of higher education in this context is to equip students with skills and attributes (knowledge, attitudes and behaviours) that individuals need in the workplace and that employers require, and to ensure that people have the opportunities to maintain or renew those skills and attributes throughout their working lives. At the end of a course, students will thus have an in-depth knowledge of their subject as well as generic employability skills.*

This means that besides the professional knowledge, additional skills such as methodological skills, social/ interpersonal skills and personal attributes play a significant role in order to be employable after university graduation. These points also received support from several experts at the official Bologna seminars for example Dr. F. S. Becker from Siemens (comp. Becker: 2008), Dr. J. Metcalfe from the UK GRAD Programme (comp. Metcalfe: 2006) or Prof. A. Pearce from Rose Bruford College (comp. Pearce: 2006). In Germany, a survey was carried out in 2004 by the *Industrie und Handelskammern* together with the *Deutscher Industrie- und Handelskammertag* asking industry (in general) about the importance of certain skills (professional as well as additional skills). The results show that professional knowledge is important but that other additional skills such as initiative, sense of responsibility or self-management are of equal importance.

Moreover, the Bologna definition of employability highlighted that it is also necessary to "ensure that people have the opportunities to maintain or renew those skills and attributes throughout their working lives" (The Benelux Bologna Secretariat: 2007 - 2010). So further training is of utmost importance.

Keeping all this in mind, TUC decided tostructure the questionnaire in five main parts. Besides questions about professional knowledge, we also inquired about additional skills, about the links of graduates to the industry and about further training. From the five parts, the most important section was the one pertaining to professional skills followed by additional skills, internships and further training. Besides those questions, we needed to know some personal details and put emphasis onquestions concerning the market trend in order to know whether better educated students are necessary.

Fort he set of questions inquiring professional skills, TUC consulted internal experts in the field of FOLAE after retrieving the information from the OE-A brochure on "Organic and Printed Electronics" (comp. OE-A: 2009). The set of questions focussing on additional skills is mostly a selection of findings from literature research since in the course of the Bologna Reform this was an important topic and has been addressed rather extensively since then. The section *Internships and Further Training* is a result of the efforts of a small working group within our department.

The order of the question sections (1. General questions about experiences with university graduates; 2. Higher Education (professional and additional skills); 3. Internships; 4. Further training; 5. Personal data + market trend) is in accordance with Sudman and Bradburn who suggest some "easy, salient, nonthreatening, but necessary questions" (Sudman and Bradburn: 1982, p. 207) before moving to the important sets of questions. Sudman and Bradburn also

recommend posing demographic questions at the end and to always complete questions relating to one topic before moving on to the next (cf. Sudman and Bradburn 1982: 208). TUC decided on the following outline. The personal data are addressed in the final section since they are strongly connected with the most delicate t set of questions concerning the market trend.

OUTLINE of the FlexNet questionnaire: 21 questions and 5 different parts:

1. General questions about experiences with university graduates
2. Higher Education (professional and additional skills): Actual situation among graduates and importance for industry
3. Internships
4. Further training
5. Personal data + market trend (most delicate questions)

The questions are mostly closed questions meaning that TUC has offered alternative answers instead of letting the respondents answer in their own words. The advantage of such questions is according to Converse and Presser that, since *closed questions spell out the response options, they are more specific than open questions and therefore more apt to communicate the same frame of reference to all respondents* (Converse and Presser 1986: 33). Bühner stresses that a questionnaire with closed questions is easier to carry out and to analyse. One should adapt the differentiation of response options to the objective of the investigation. More options increase reliability and validity but too many options can decrease both of them. Bühner suggests a 5-level response option which has also been used in the present case (cf Bühner 2004: 51-52). He also mentioned the disadvantages of the closed questions: for one thing, the options can be interpreted subjectively; furthermore, the middle option when having a 5-level response option can be interpreted as thinking of the question as not adequate or even as rejecting the question. But when leaving out the middle option, respondents might feel forced to make a decision. (cf. Bühner 2004: 51)

During designing the new questionnaire, all endeavors were based on the experiences from the 2008 PRODI questionnaire (cf. Fig. 1) which started with the investigation of educational needs on the part of the industry. TUC changed the set of questions or rather extended them and modified the possible answers. Moreover, we decided to have the new questionnaire web-based (comp. Fig. 2) in order to increase its accessibility. Therefore, an internet host had to be found and a distinct layout had to be designed by TUC.

After a phase of several internal pretests during which the questions and the design of the questionnaire were changed multiple times, the questionnaire was than tested externally at Organic Electronics Saxony (oe-s). TUC announced the release in the August newsletter in 2010.

In a next step, TUC worked on a strategy of dissemination. Since the target group of the investigation was the industry, we decided to disseminate the questionnaire among the industrial members of the OE-A.

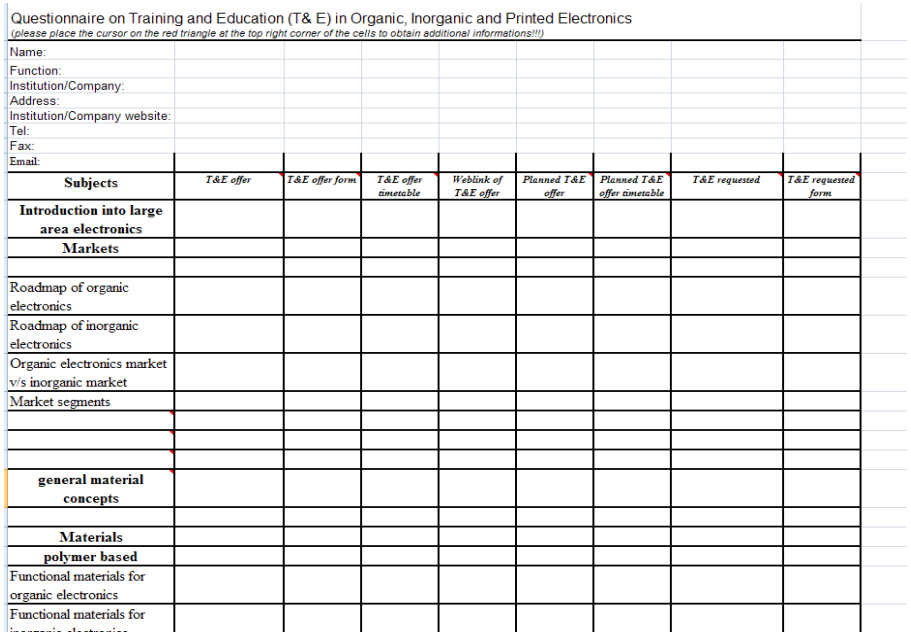
In September, 2010 TUC started with the dissemination by explaining the background and the objectives at the working group meeting of the OE-A in Dresden. This presentation was followed by two OE-A newsletter entries (October 22, 2010 and November 8, 2010) as well as another oral presentation at the OE-A working group meeting on November 17, 2010 in Munich. Since the response rate was still low, the submission date of the deliverable was postponed

from M12 to M16. This allowed to extend the dissemination strategy. TUC, thus, decided to select 57 **(of 93 on Oct.3, 2010)** industrial members of the OE-A and contacted them directly via personalised E-Mails (January 4/5, 2011 and February 22, 2011). The response rate increased considerably to 61%.

It also has to be mentioned that Dario della Sala (ENEA) introduced this questionnaire to some Italian companies and afterwards, we received 4 completed questionnaires from Italy.

The questionnaire is still online under: <https://bildungsportal.sachsen.de/survey/limesurvey/index.php?sid=62675&newtest=Y&lang=en>.

Figure 1: 2008 PRODI questionnaire



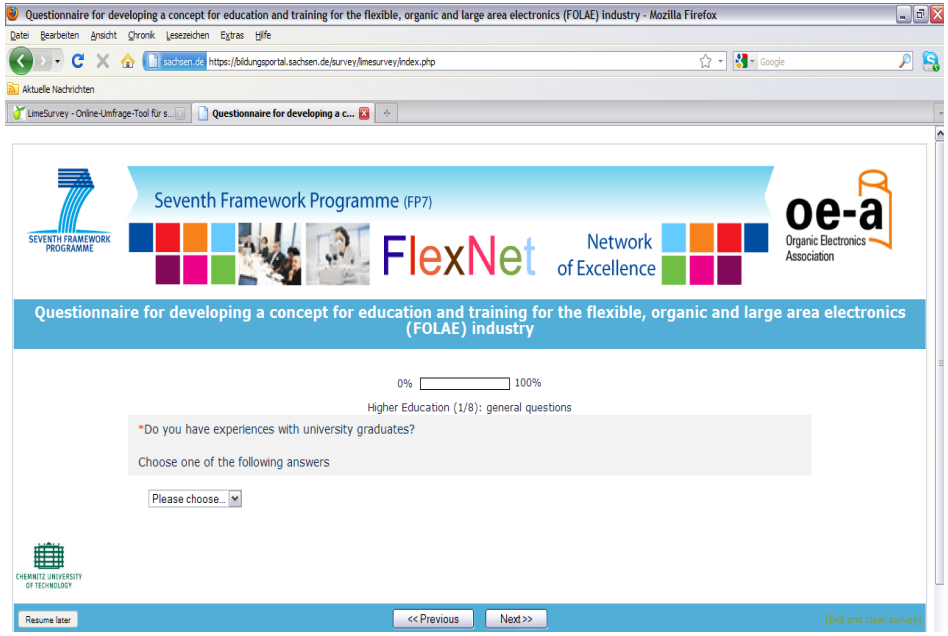
Questionnaire on Training and Education (T& E) in Organic, Inorganic and Printed Electronics

(please place the cursor on the red triangle at the top right corner of the cells to obtain additional informations!!!)

Name:
Function:
Institution/Company:
Address:
Institution/Company website:
Tel:
Fax:
Email:

Subjects	T&E offer	T&E offer form	T&E offer timetable	Weblink of T&E offer	Planned T&E offer	Planned T&E offer timetable	T&E requested	T&E requested form
Introduction into large area electronics								
Markets								
Roadmap of organic electronics								
Roadmap of inorganic electronics								
Organic electronics market v/s inorganic market								
Market segments								
general material concepts								
Materials								
polymer based								
Functional materials for organic electronics								
Functional materials for								

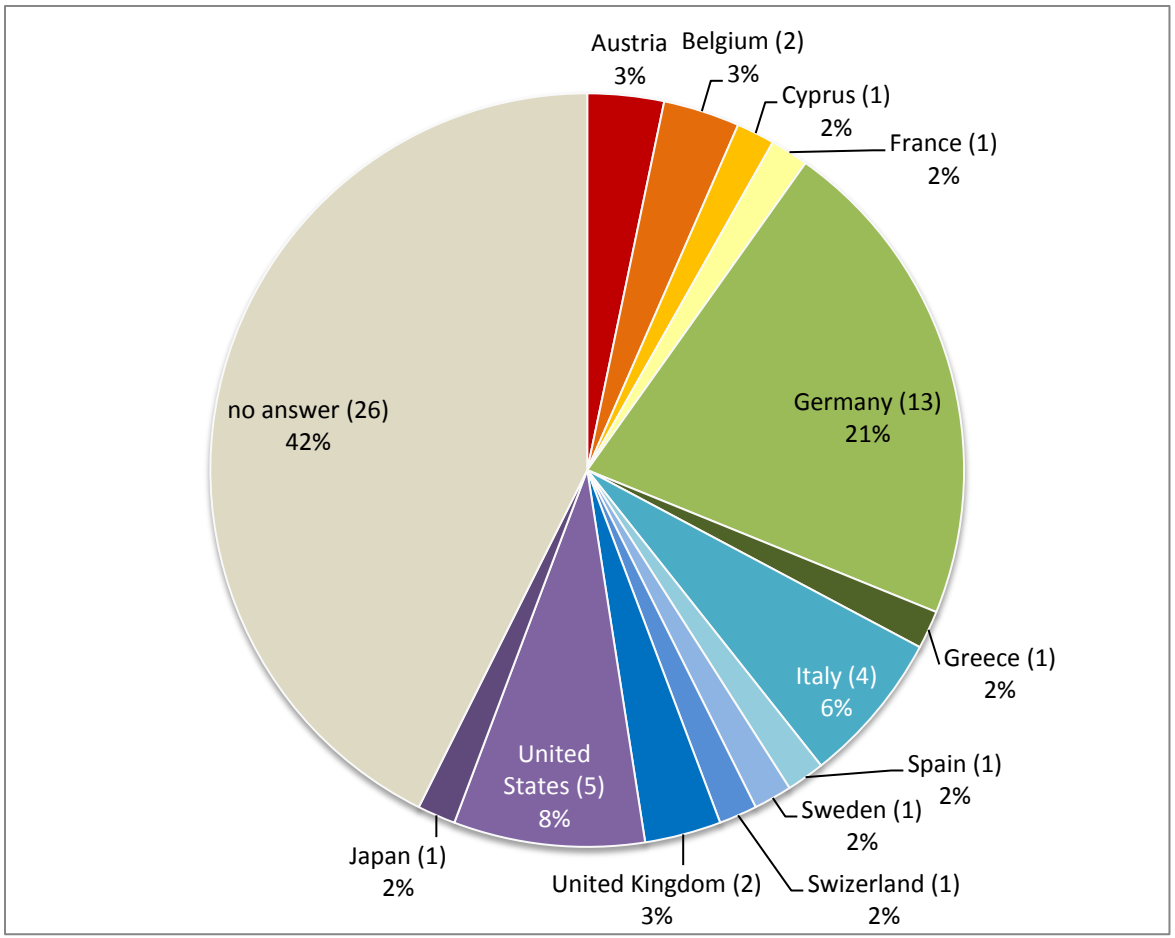
Figure 2: FlexNet questionnaire



4. RESULTS

4.1 PERSONAL DATA

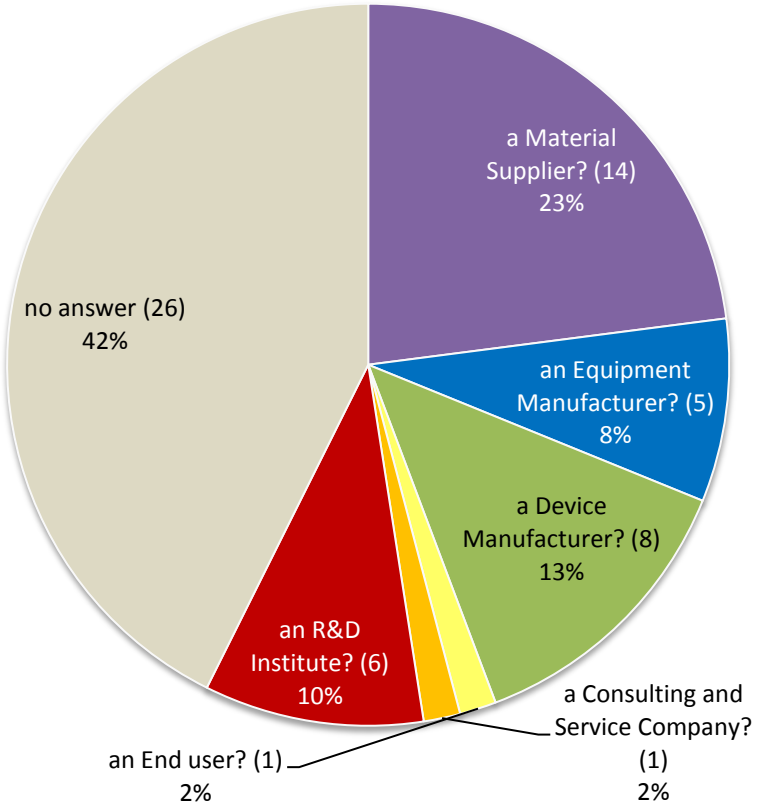
Figure 3: Country distribution of respondents



The questionnaire was answered by 61 respondents as shown in Figure 3. 34 of them completed the questionnaire. Since the section "Personal Data" was the last one of the questionnaire, 26 respondents never reached this question. Of the 34 respondents answering the whole questionnaire, the majority was from Germany (13 respondents) followed by the United States (5 respondents) and Italy (4 respondents). Response rates were low from Austria, Belgium and the United Kingdom (each: 2 respondents) whereas very low rates were observed in Cyprus, France, Greece, Spain, Sweden, Switzerland and Japan (1 respondent each).
The majority of answers were from Europe whereas we also had some feedback from America and even Asia.

Figure 4 shows the industrial core competences of the respondents. As seen in the table, most respondents were material suppliers (14 respondents), device manufacturers (8 respondents), R&D institutes (6 respondents) and equipment manufacturer (5 respondents). Moreover, we asked about specific competences in FOLAE. A selection of these is shown in Figure 4.

Figure 4: Industrial core competences of respondents in FOLAE with selected examples of specific competences in FOLAE



Selected examples of specific competences in FOLAE

→ OLED materials and devices, OPV materials, OE materials
→ applications
→ OLED technology, substrates
→ printing
→ engineering and manufacture of turnkey machinery for different applications e.g. PV, display, etc.
→ substrate supplier
→ specific test systems
→ printable conductors
→ digital printing of complex materials
→ prospective supplier for paper based substrates in organic electronics
→ organic photovoltaic
→ supplier of devices for manufacturers
→ OE materials for TFT & OPV
→ substrates, coating, printing, application development
→ semiconductor design
→ printed battery/display modules
→ conducting materials, supports V
→ mainly packaging materials and technologies
→ printing technologies - TQM

Figure 5: Company position of respondents

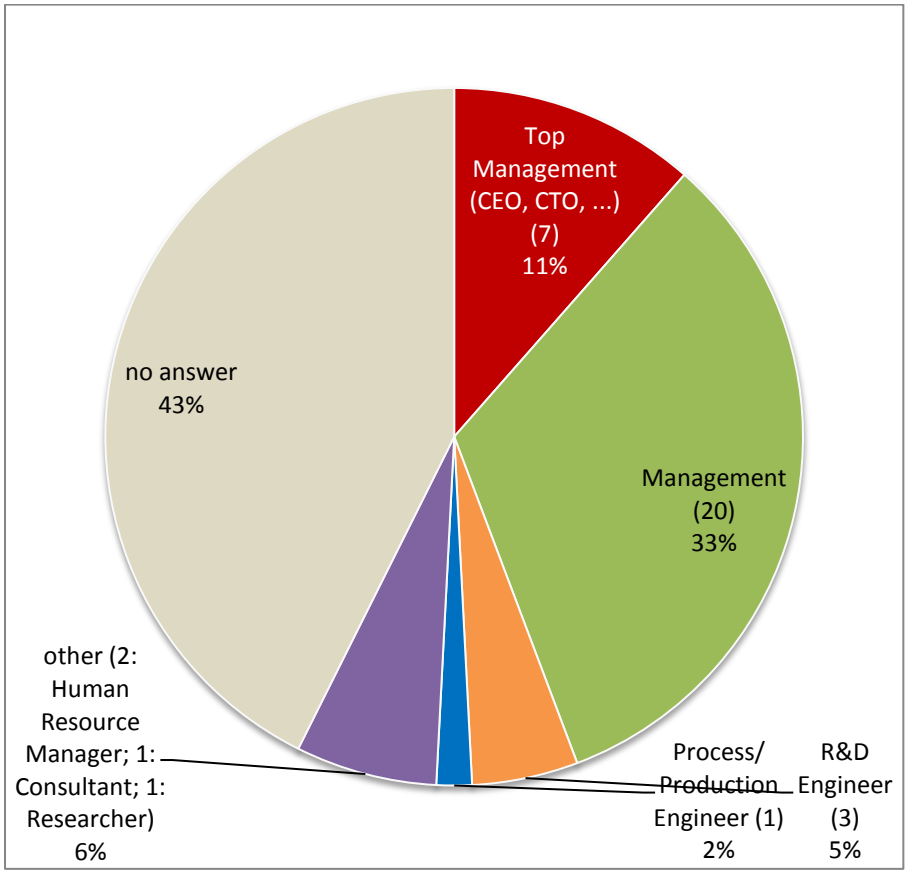
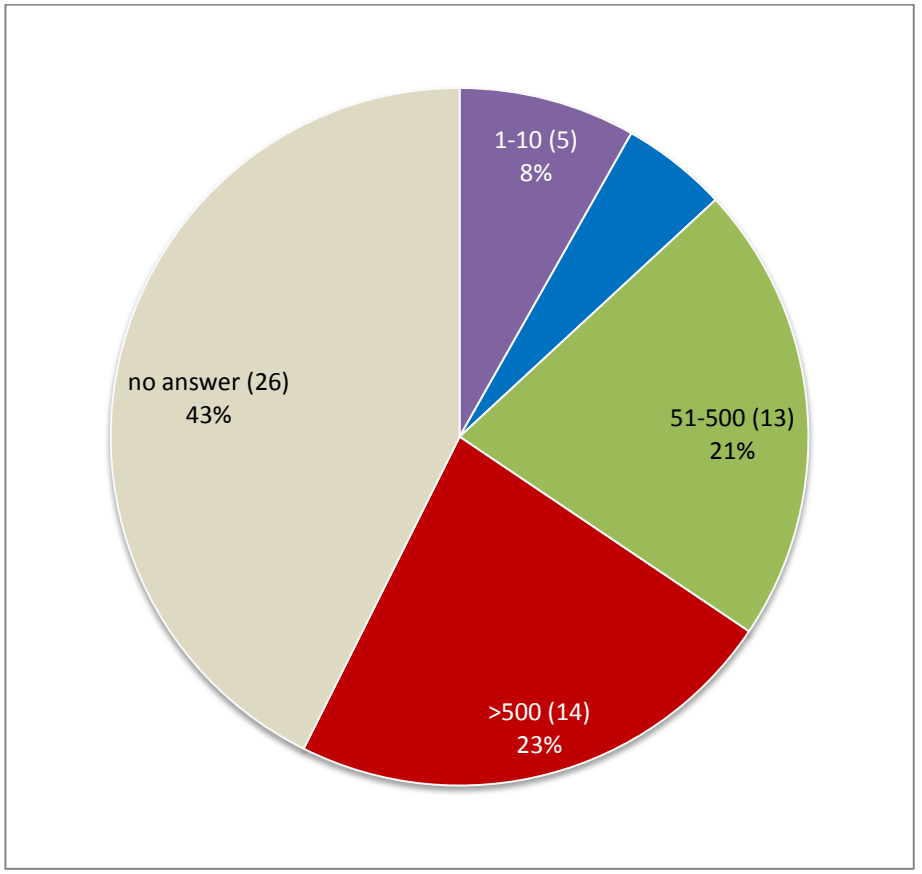


Figure 6: Company size of respondents



Figures 5 and 6 provide a more detailed analysis of the respondents. The questionnaire was mostly answered by the management (20 respondents) of bigger companies with the majority of companies having more than 500 employees or at least 51 to 500.

4.2 GENERAL DATA ABOUT EXPERIENCES WITH UNIVERSITY GRADUATES AND MARKET TREND

The reason for putting the personal data section at the end was the following two questions. These questions needed to be following the company size but could not be positioned at the beginning of the questionnaire since it would have reduced the number of respondents for the most important sections of professional and additional skills.

Figure 7: Employees who joined the company (Aug. 2009-Aug. 2010)

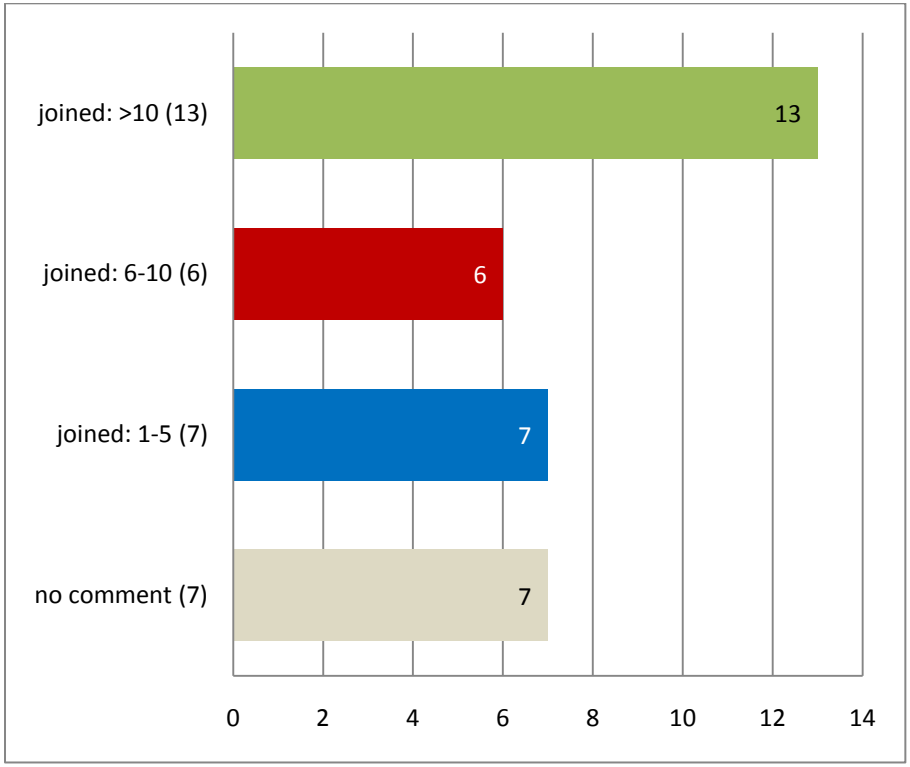


Figure 8: Reasons for the "growth" of the company (Aug. 2009-Aug. 2010)

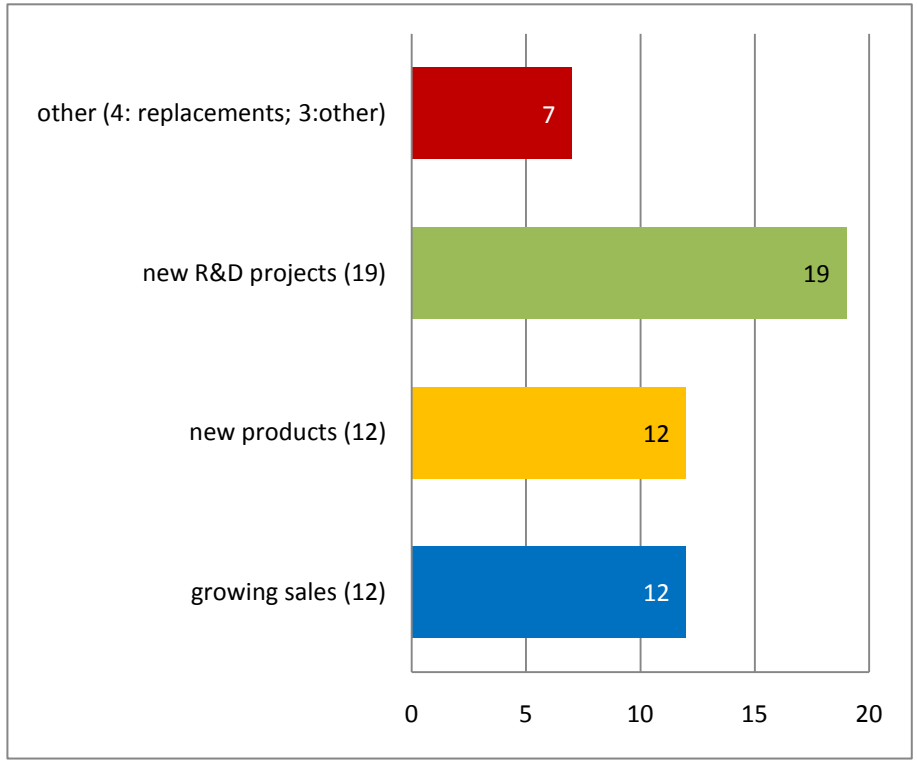


Figure 7 shows a tendency of the current market situation in FOLAE. Since 26 respondents stated that they were able to employ new people and most of them (13 respondents) even more than 10 in one year, one can be optimistic that this industrial field is still growing and the demand for well-trained people is given. Most respondents stated their reason for employing new people to be new R&D projects (cf. Figure 8). So, one could conclude that the field of FOLAE still has an excellent potential for further research. Furthermore, new products are on the way which are also sold much more than in the previous year.

The following two figures give an idea of the respondents' experience with university graduates. More than half of the asked industry representatives stated that they are experienced (56%, 35 of the respondents) with university graduates. In combination with 25% (15 respondents) of respondents who have "some

experience", one can say that almost all respondents qualified to answer the whole questionnaire. The second section of experiences with university graduates ("Higher Education: actual situation") was skipped for only 6% (4 respondents) who are not experienced with university graduates.

Figure 10 is the result of respondents voting which university degree they prefer when employing university graduates. This question gave respondents the possibility to select multiple answers. One can see that Material Science is the preferred M.Sc./ B.Sc. degree with 34 respondents voting for it, closely followed by Physics (34 votes), Chemistry (31 votes), Printing Technology (28 votes) and Electrical Engineering (27 votes). Two further degrees which we did not consider were mentioned: Mathematics and Biosciences.

Figure 9: Degree of respondents' experiences with university graduates

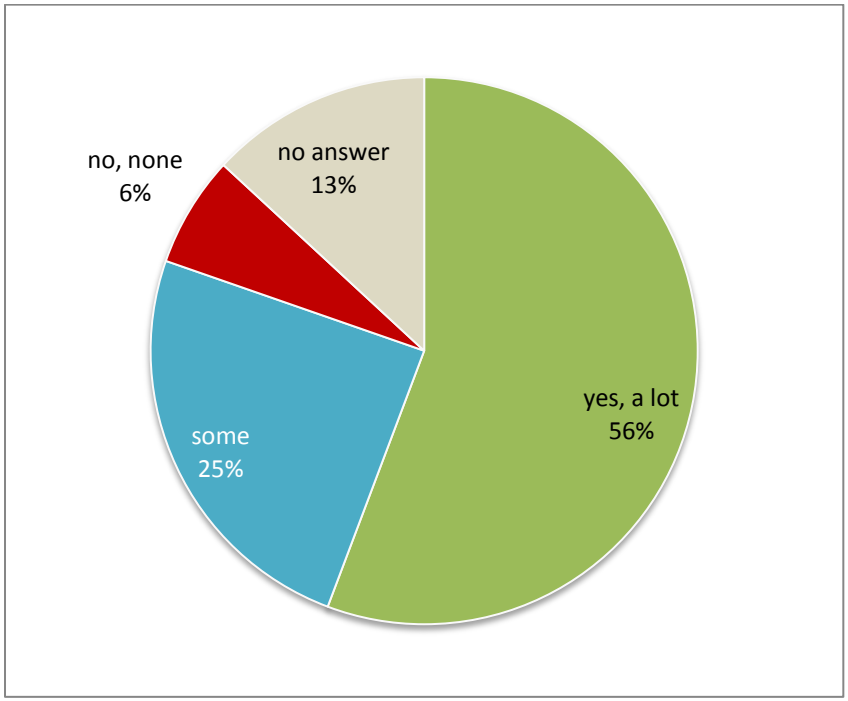
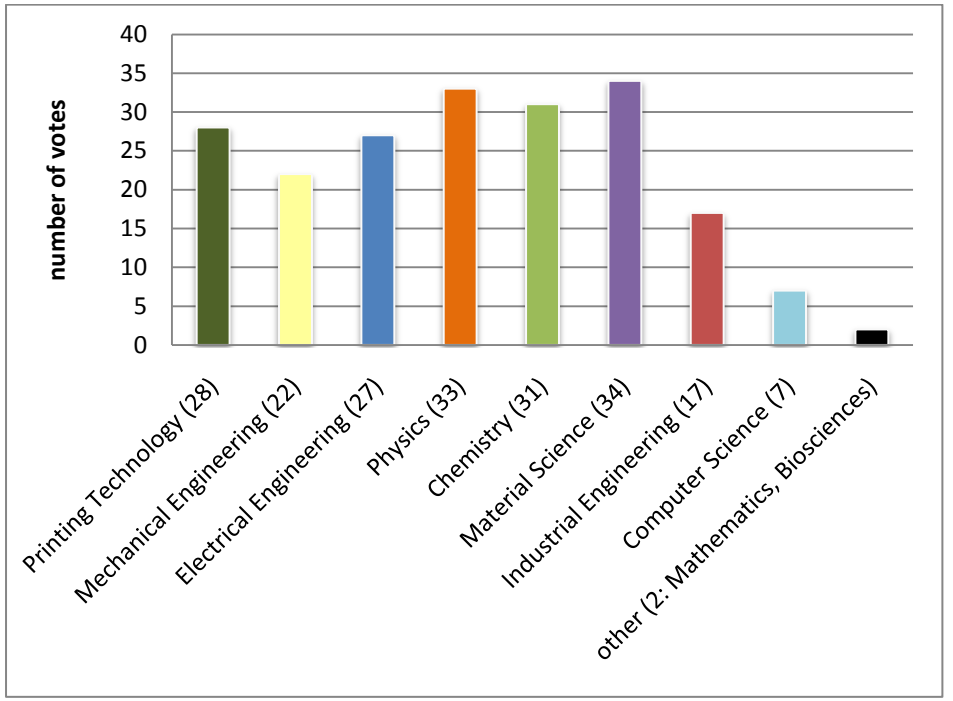


Figure 10: Rating of university degrees best suited for employment in FOLAE



4.3 PROFESSIONAL SKILLS/ KNOWLEDGE OF UNIVERSITY GRADUATES

The next two sections of this report are the biggest part of the investigation. Figures 11 to 28 provide detailed information on the respondents' opinion about existing professional knowledge of university graduates in certain selected fields and the importance of these fields for working in FOLAE.

Figure 11 Importance of knowledge and Existing knowledge of graduates in: CHEMISTRY of MATERIALS, DEVICE PHYSICS and OPTICS: Inorganic Materials: metals; semiconductors; nanoparticles

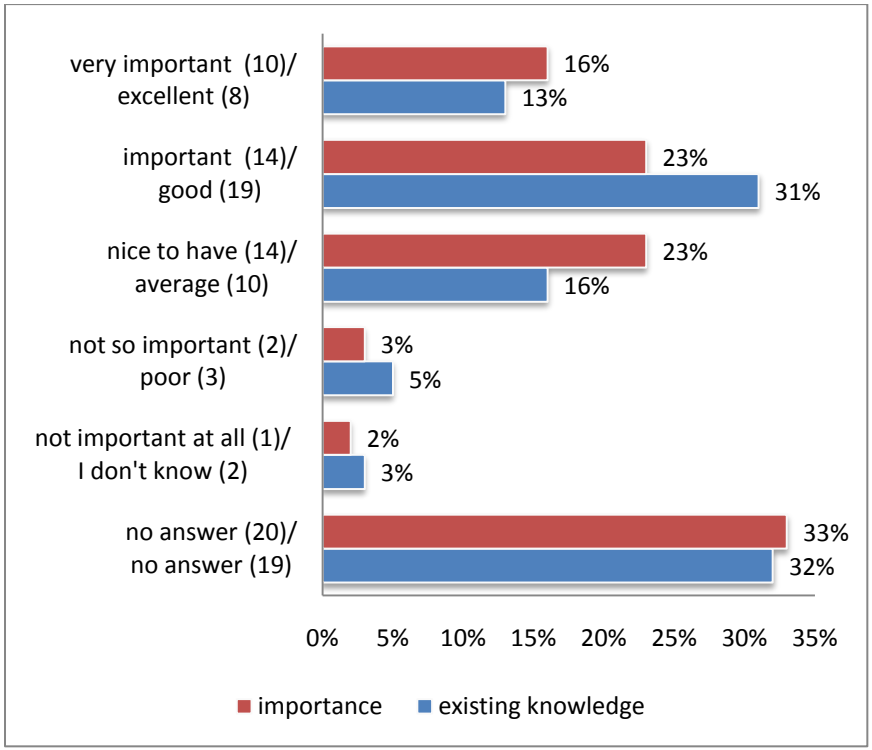
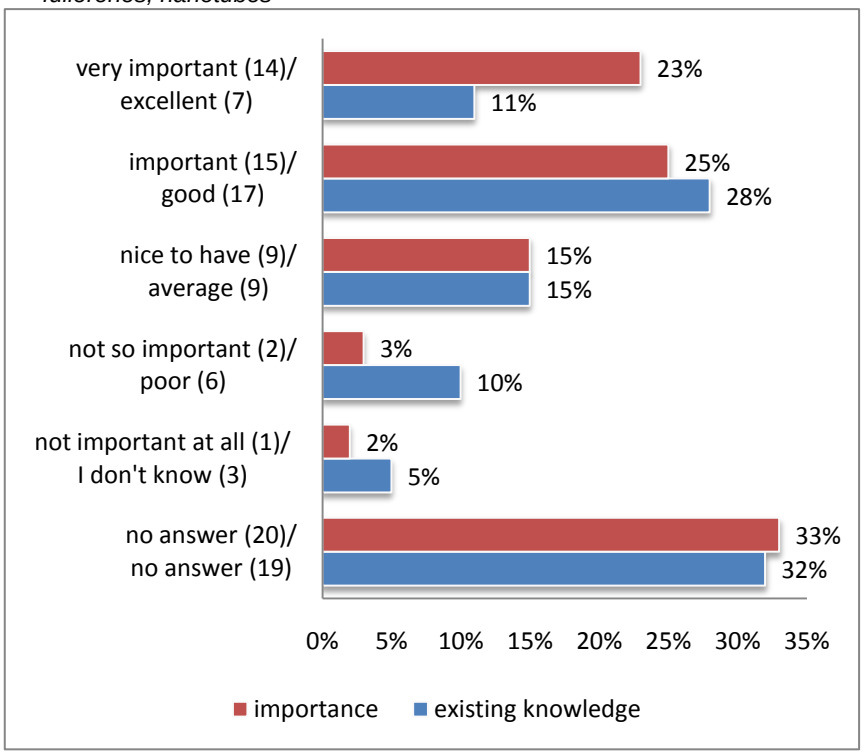


Figure 12: Importance of knowledge and Existing knowledge of graduates in: CHEMISTRY of MATERIALS, DEVICE PHYSICS and OPTICS: Appropriate Organic Materials: small molecules; polymers; fullerenes; nanotubes



Figures 11 and 12 indicate that in *CHEMISTRY OF MATERIALS, DEVICE PHYSICS AND OPTICS: Inoranic Materials (metals; semiconductors;nanoparticles)* and A*ppropriate Organic Materials (small molecules; polymers; fullerenes; nanotubes)* are of educational importance for FOLAE whereas P*hysics of Semiconductors* (Figure 13); *Physical Chemistry of Organic Molecules* (Figure 14); *Light Sources* (Figure 15); *Light induced effects, Photochemistry* (Figure 16) and Q*uantum Optics* (Figure 17) might be of less importance. Figures 11 to 14 (*CHEMISTRY OF MATERIALS, DEVICE*

PHYSICS AND OPTICS: Inoranic Materials (metals; semiconductors; nanoparticles) (Figure 11); *Appropriate Organic Materials (small molecules; polymers; fullerenes; nanotubes)* (Figure 12); *Physics of Semiconductors* (Figure 13); *Physical Chemistry of Organic Molecules* (Figure 14)) show that whilst the individual topics are considered very important by the respondents from the industry, the degree of existing knowledge graduates have still falls short of the existing demand.

Figure 13: Importance of knowledge and Existing knowledge of graduates in: CHEMISTRY of MATERIALS, DEVICE PHYSICS and OPTICS: Physics of Semiconductors

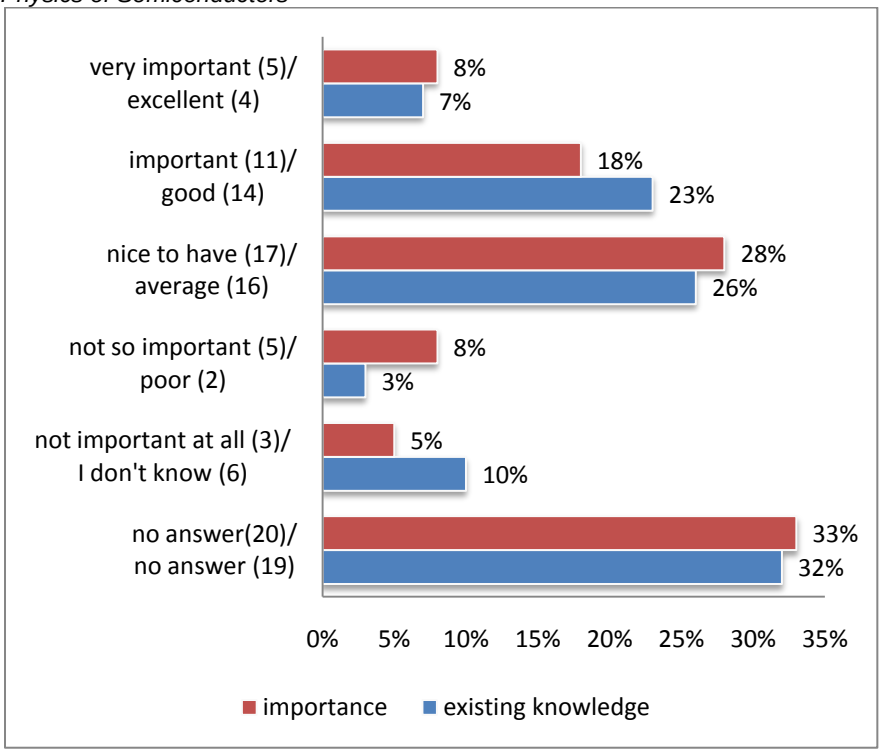


Figure 14: Importance of knowledge and Existing knowledge of graduates in: CHEMISTRY of MATERIALS, DEVICE PHYSICS and OPTICS: Physical Chemistry of Organic Molecules

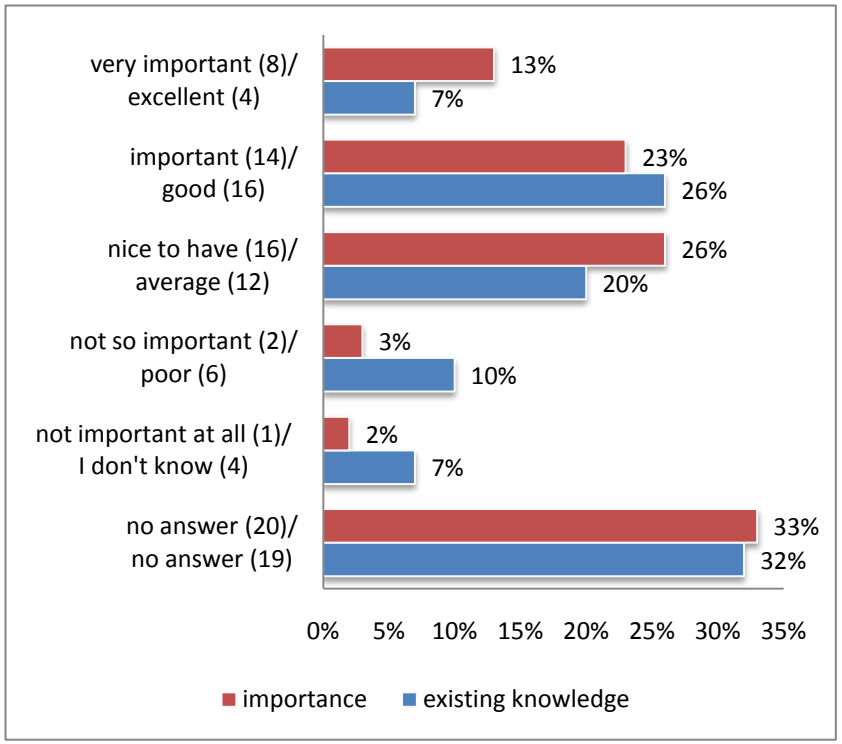


Figure 15: Importance of knowledge and Existing knowledge of graduates in: CHEMISTRY of MATERIALS, DEVICE PHYSICS and OPTICS: Light Sources

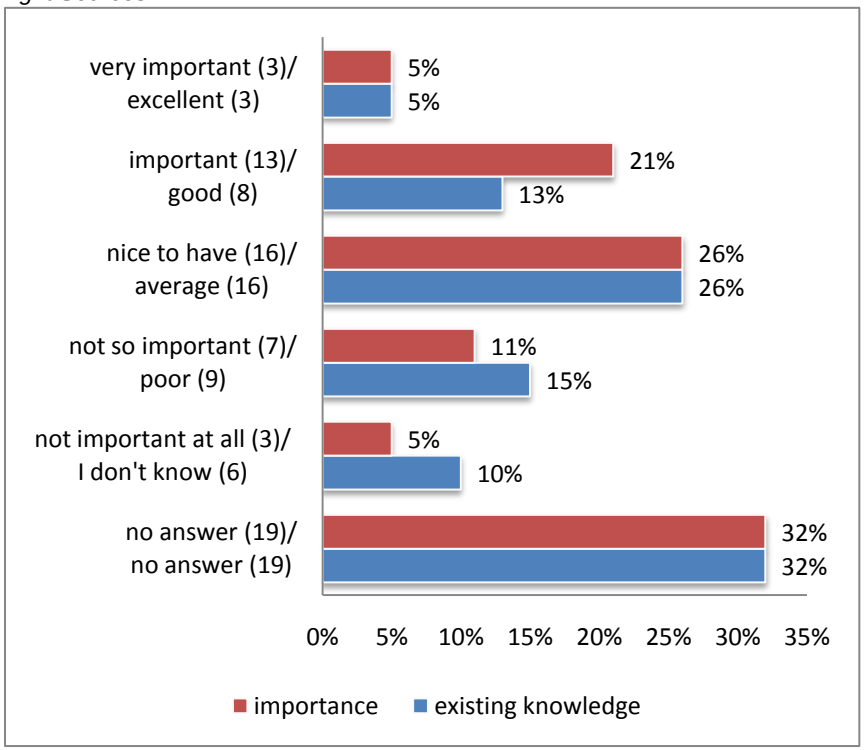


Figure 16: Importance of knowledge and Existing knowledge of graduates in: CHEMISTRY of MATERIALS, DEVICE PHYSICS and OPTICS: Light-Induced Effects; Photochemistry

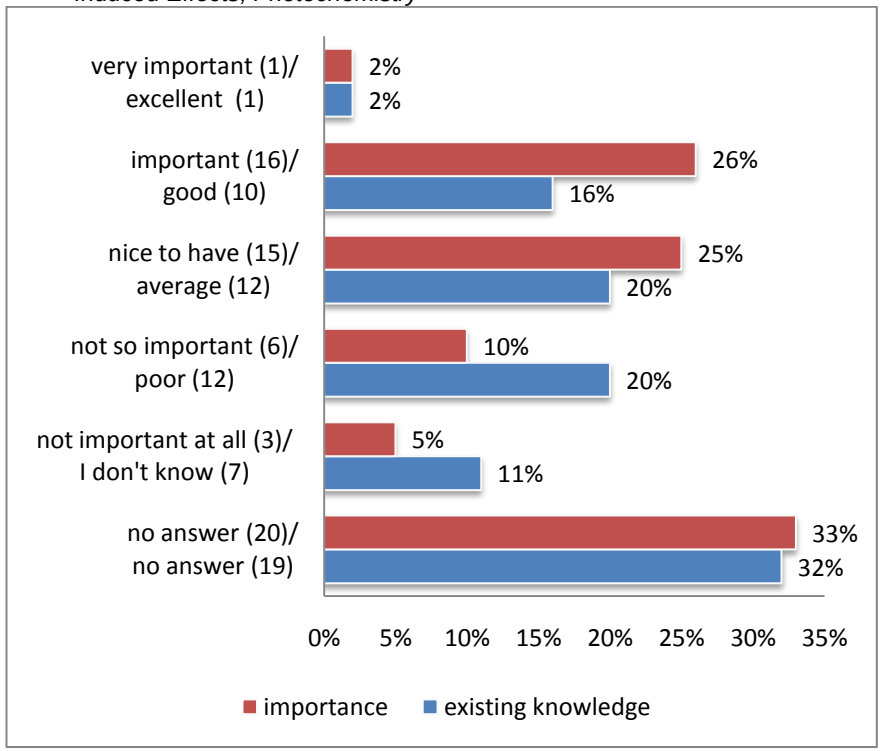


Figure 17: Importance of knowledge and Existing knowledge of graduates in: CHEMISTRY of MATERIALS, DEVICE PHYSICS and OPTICS: Quantum Optics

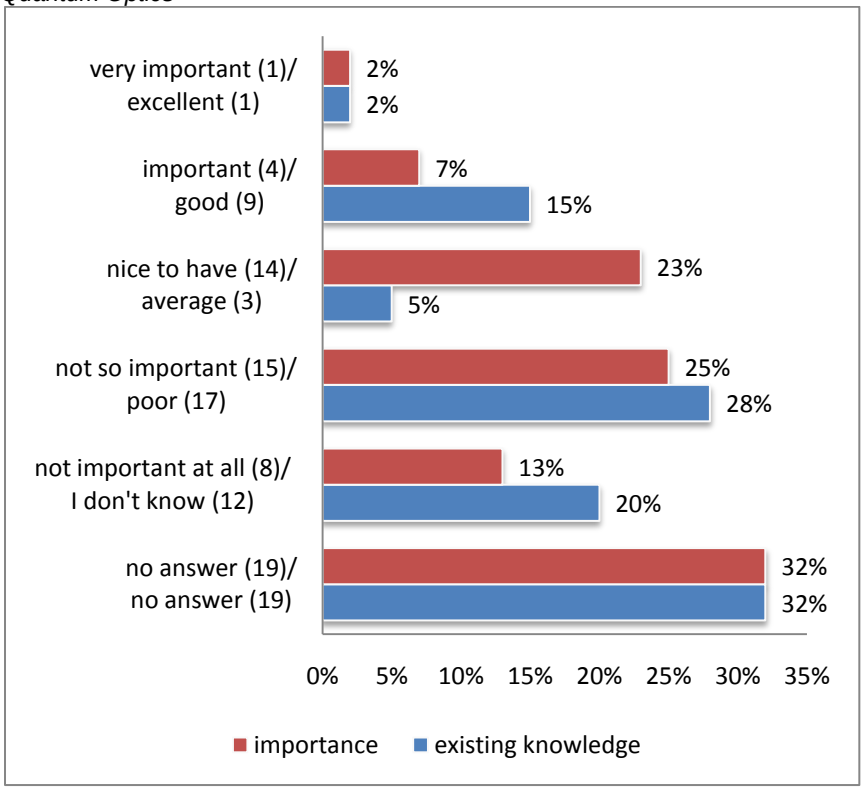
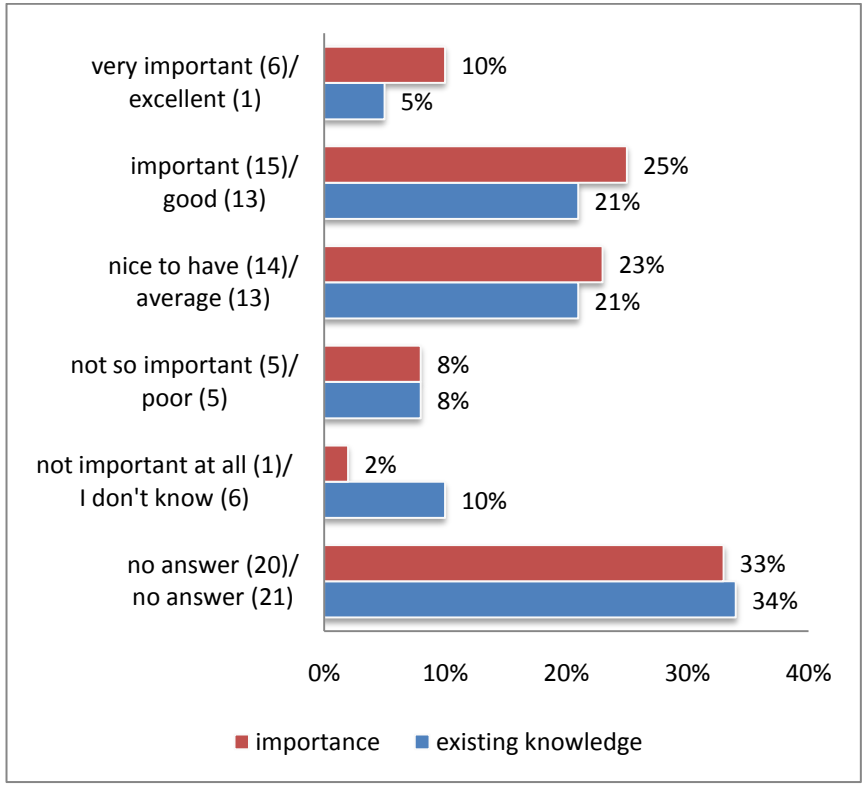


Figure 18: Importance of knowledge and Existing knowledge of graduates in: Chemistry and Physics of Nanosystems



The results of figures 18, 19 and 20 (*Chemistry and Physics of Nanosystems* (Figure 18); *Circuit Design* (Figure 19); and *Vapor-Based Materials Deposition Technologies: sputtering; evaporation* (Figure 20)) show that these fields are not of utmost importance. However also in this case, one can see that the ascribed importance is throughout higher than the existing degree of knowledge university graduates have to offer in these fields.

Figure 19: Importance of knowledge and Existing knowledge of graduates in: Circuit Design

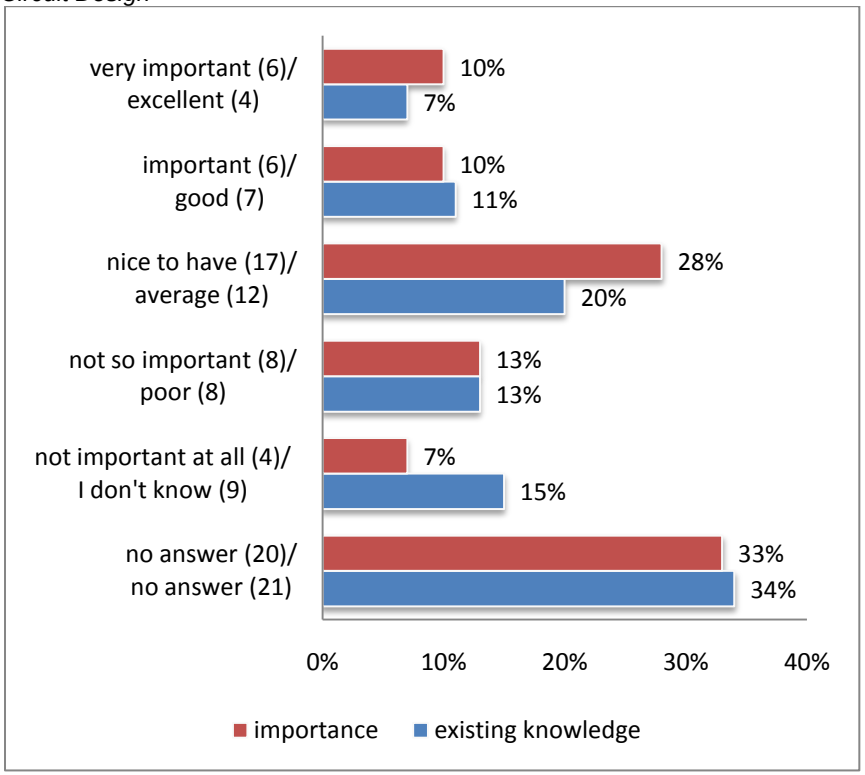


Figure 20: Importance of knowledge and Existing knowledge of graduates in: Vapor-Based Materials Deposition Technologies: sputtering; evaporation

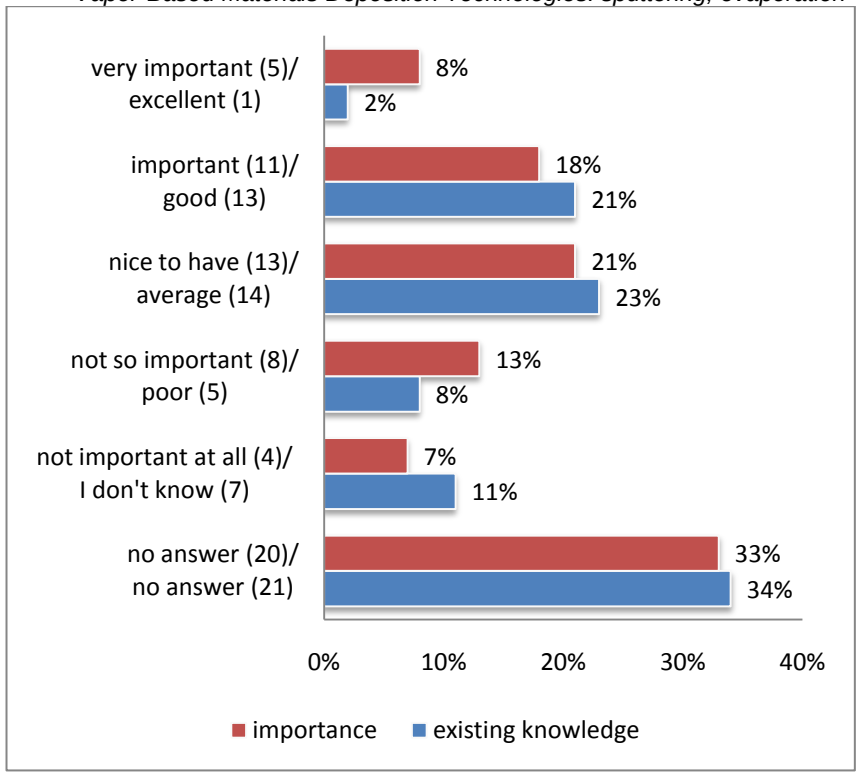


Figure 21: Importance of knowledge and Existing knowledge of graduates in: Solution-Based Materials Deposition Technologies: coating; printing; dispensing

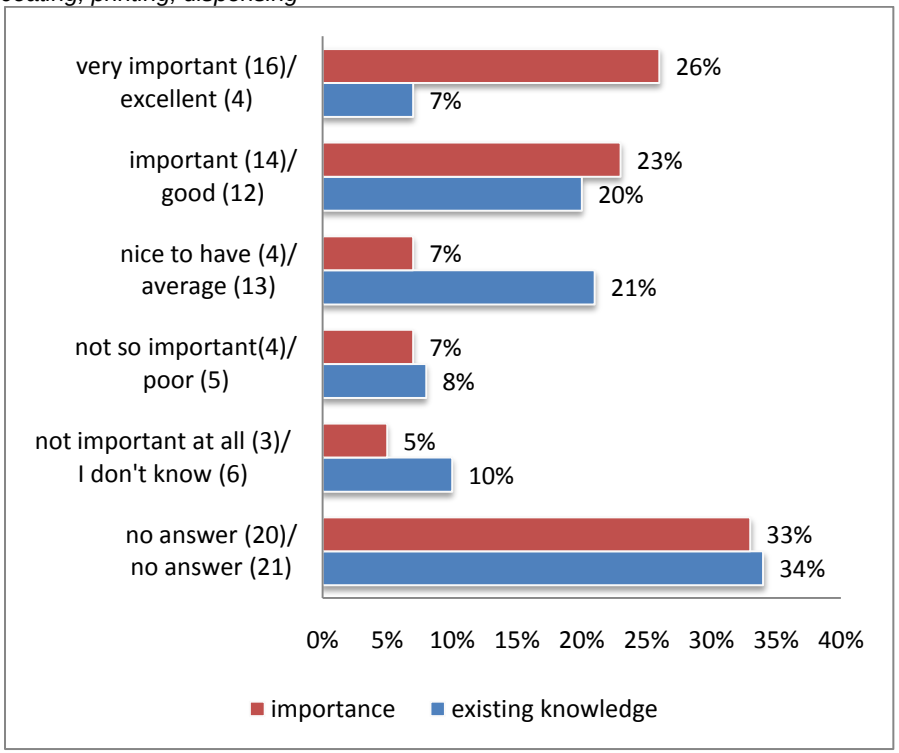
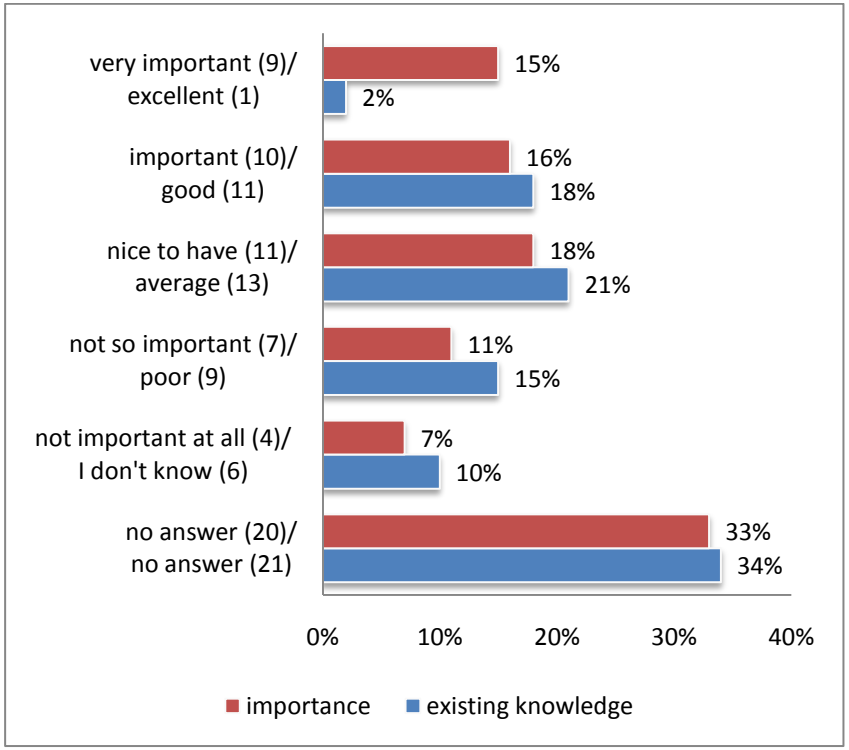


Figure 22: Importance of knowledge and Existing knowledge of graduates in: Machinery for Material Patterning: laser; photolithography; printing



Striking is what is shown in figures 21 to 28 (*Solution-Based Materials Deposition Technologies: coating; printing; dispensing* (Figure 21); *Machinery for Material Patterning: laser; photolithography; printing* (Figure 22); *Machinery for Material Deposition: vacuum; coating; printing* (Figure 23); *Machinery for Material Deposition: inline measurements; quality control* (Figure 24); *Post Deposition Treatment: drying; annealing; sintering* (Figure 25); *Back-End of line: bonding; distributing; packaging; sealing* (Figure 26); *Experimental Setups* (appropriate measuring methods; automation of experiments) (Figure 27); *Design of Experiments* (Figure 28)): the importance of these fields is tremendously higher than the existing knowledge of university graduates which means that first, students need more training in these fields in order to be able to be employed in the field of FOLAE later on and second, universities need to improve education in these fields.

Figure 23: Importance of knowledge and Existing knowledge of graduates in: Machinery for Material Deposition: vacuum; coating; printing

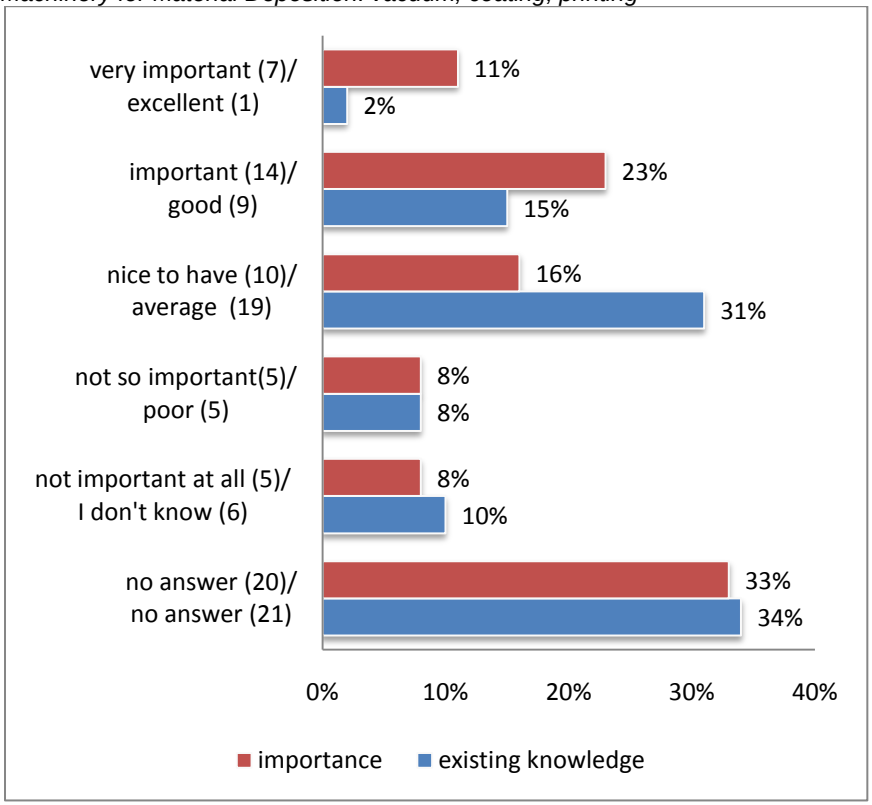


Figure 24: Importance of knowledge and Existing knowledge of graduates in: Machinery for Material Deposition: inline measurements; quality control

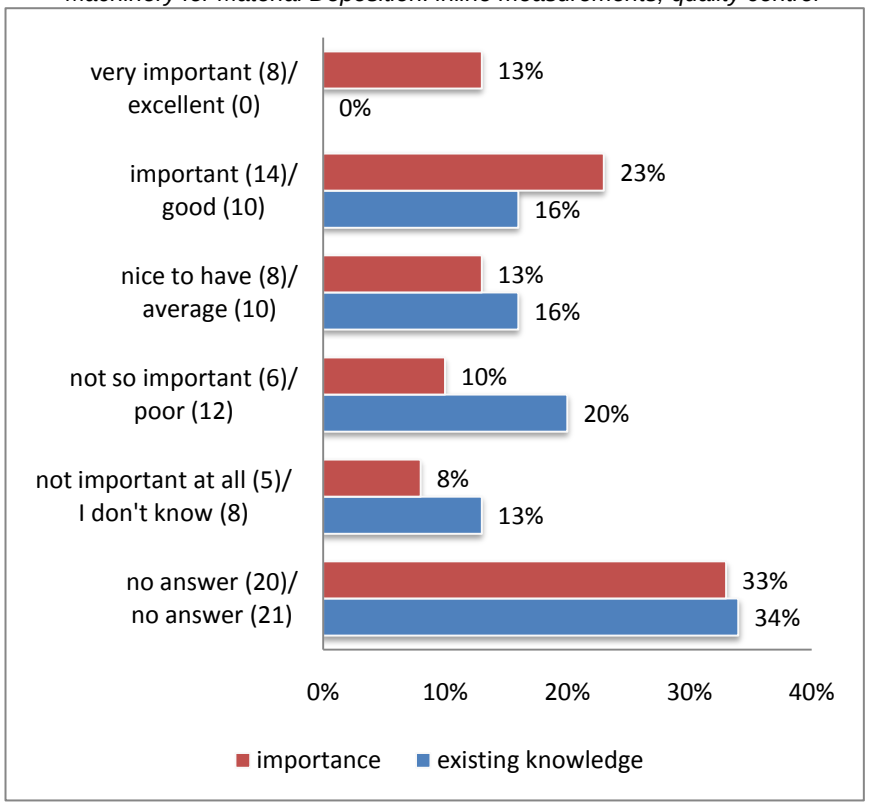


Figure 25: Importance of knowledge and Existing knowledge of graduates in: Post Deposition Treatment: drying; annealing; sintering

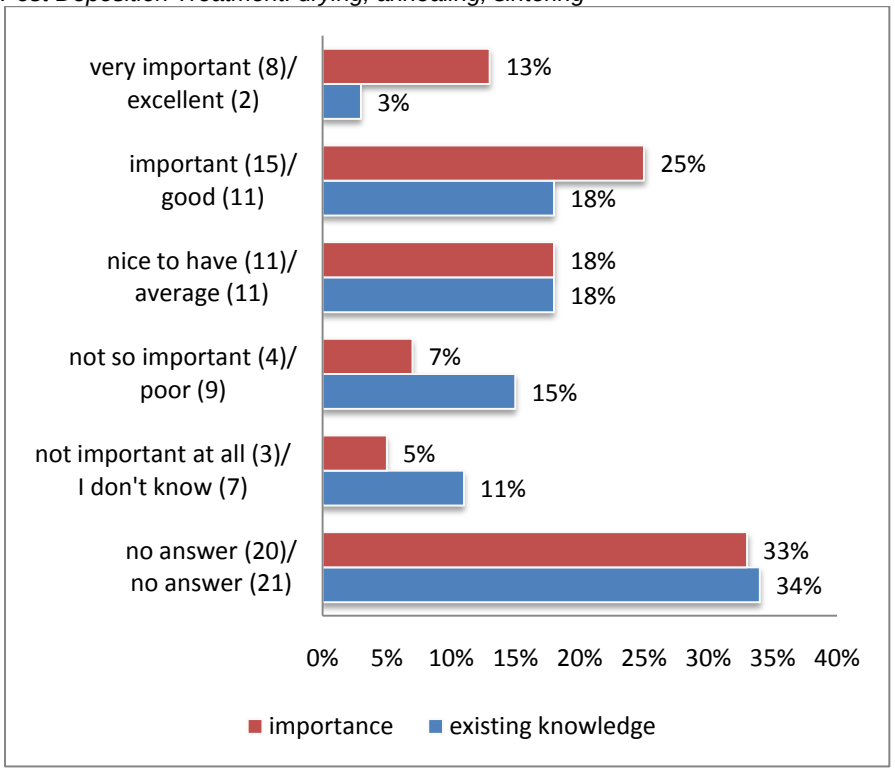


Figure 26: Importance of knowledge and Existing knowledge of graduates in: Back-End of line: bonding; distributing; packaging; sealing

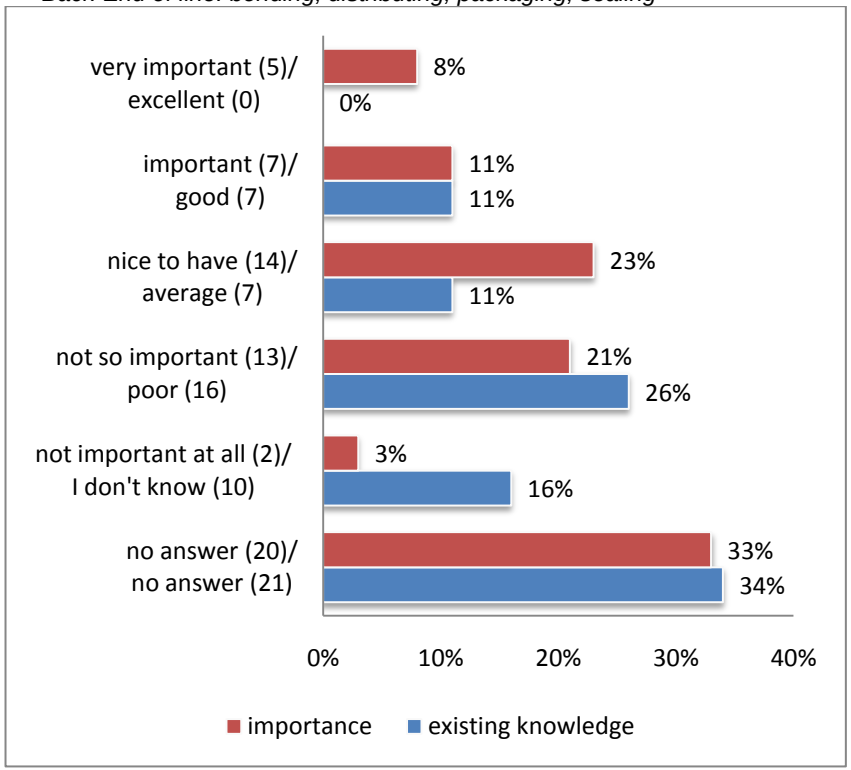


Figure 27: Importance of knowledge and Existing knowledge of graduates in: Experimental Setups (appropriate measuring methods; automation of experiments)

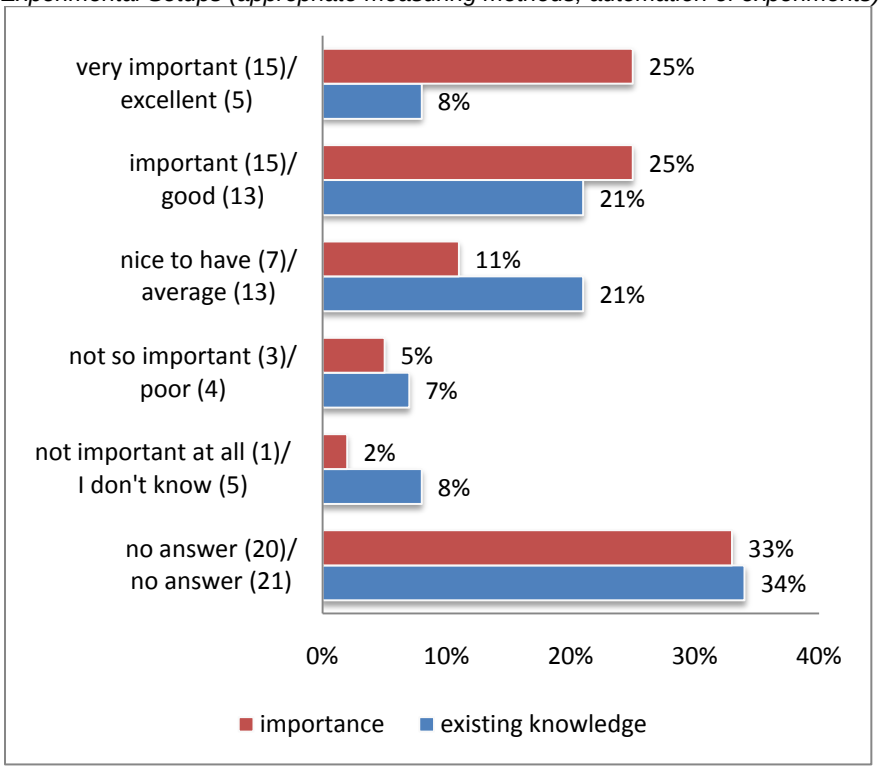
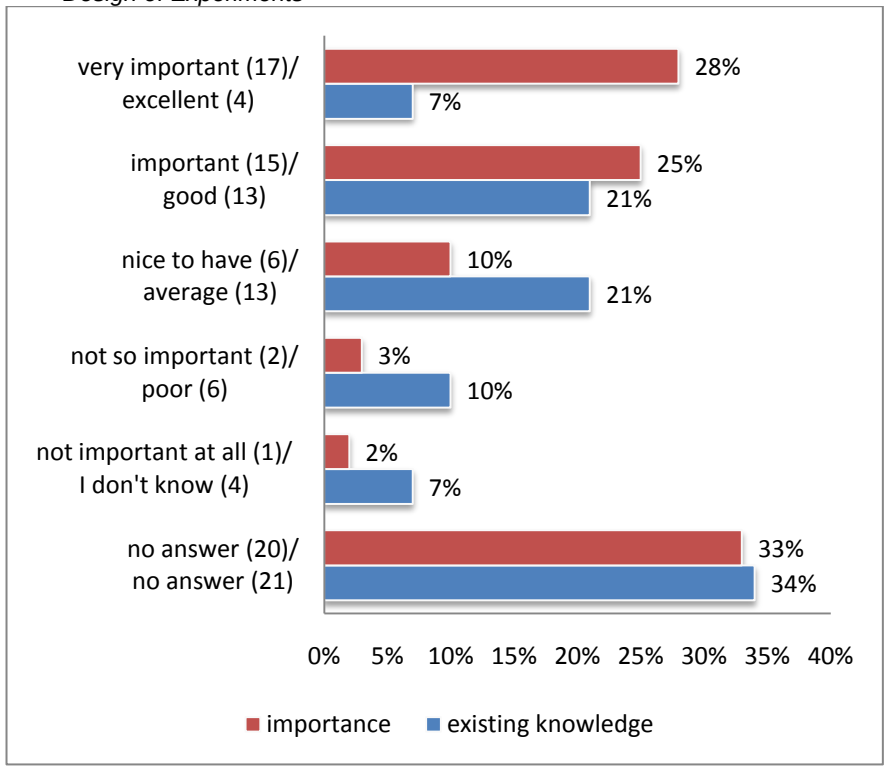


Figure 28: Importance of knowledge and Existing knowledge of graduates in: Design of Experiments

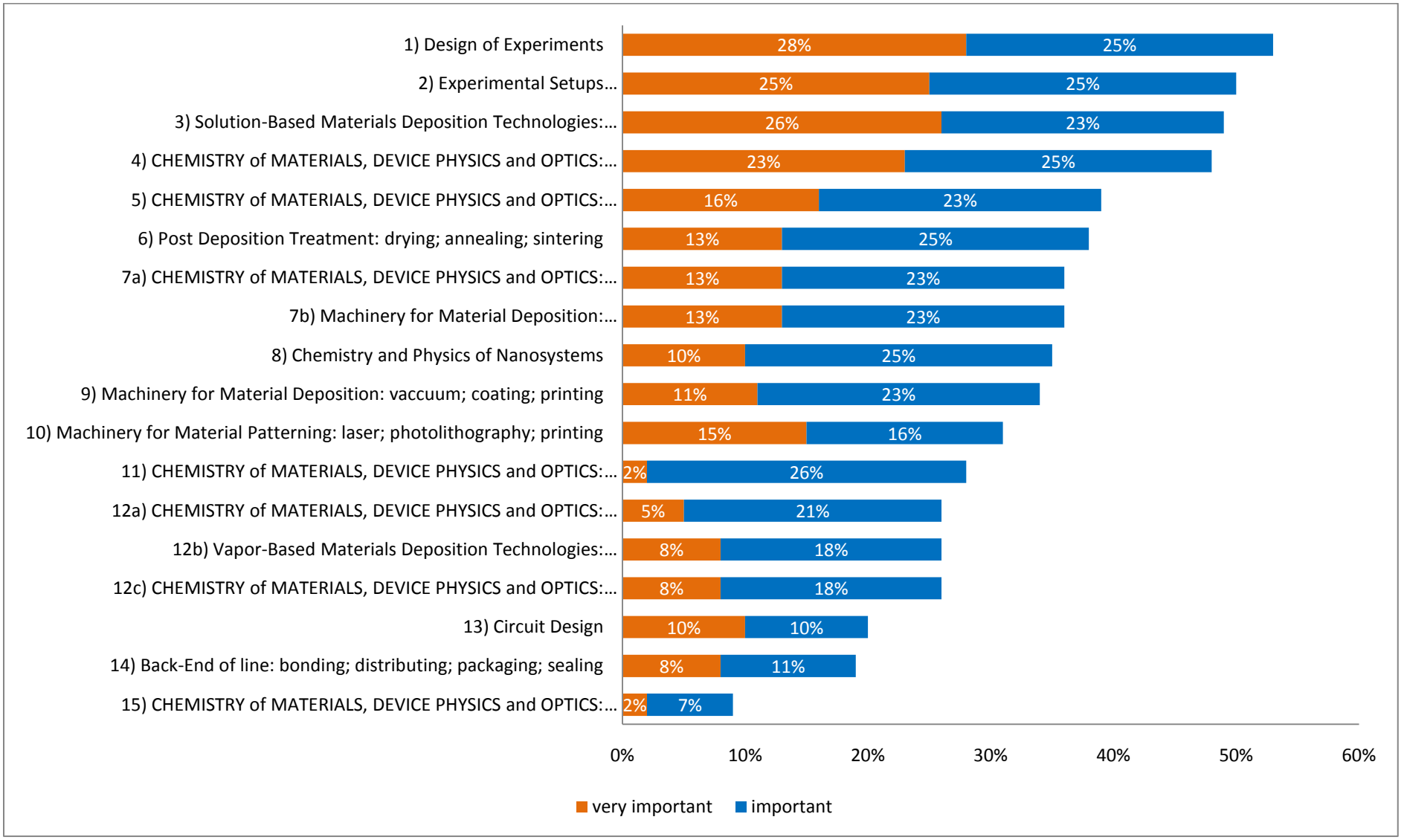


Moreover, it can be said that in some field the existing knowledge of graduates is primarily rated as average to poor in fields such as: *CHEMISTRY of MATERIALS, DEVICE PHYSICS and OPTICS: Light Sources* (Figure 15), *CHEMISTRY of MATERIALS, DEVICE PHYSICS and OPTICS: Light-Induced Effects; Photochemistry* (Figure 16), *Machinery for Material Patterning: laser; photolithography; printing* (Figure 22), *Machinery for Material Deposition: inline measurements, quality control* (Figure 24), *Back-End of line: bonding; distributing; packaging; sealing* (Figure 26). At the same time, most of the fields are not rated as very important which puts the result in a different perspective. Nevertheless, it can be recommended that basic knowledge in these fields should be improved.

Figure 29 is an arrangement of the importance of professional skills for the industry only taking into account the rating option *important* and *very important.* It can be concluded that the *Design of Experiments*, the *Experimental Setups (appropriate measuring methods; automation of experiments)*, the *Solution-Based Materials Deposition Technologies: coating; printing; dispensing* and the *CHEMISTRY of MATERIALS, DEVICE PHYSICS and OPTICS: Appropriate Organic Materials: small molecules; polymers; fullerenes; nanotubes* are the most important fields of professional knowledge for industry and should therefore

definitely be included in the curriculum of the education in FOLAE. Least important for industry is *CHEMISTRY of MATERIALS, DEVICE PHYSICS and OPTICS: Quantum Optics*, *Back-End of line: bonding; distributing; packaging; sealing* and *Circuit Design.*

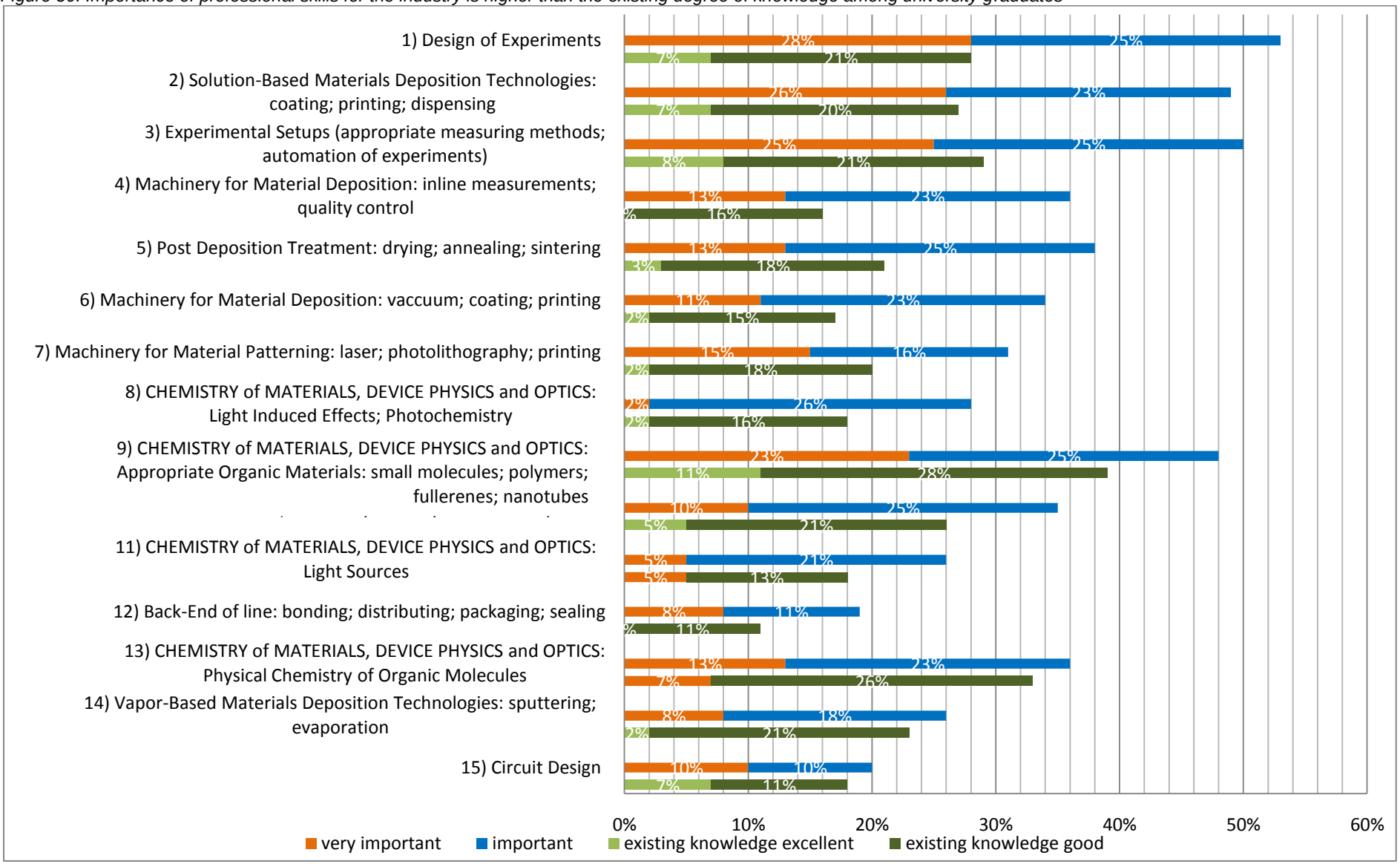
Figure 29: Rating of most important professional skills for the industry



Importance of knowledge in:	*very important*	*important*
15) CHEMISTRY of MATERIALS, DEVICE PHYSICS and OPTICS: Quantum Optics	*2%*	*7%*
14) Back-End of line: bonding; distributing; packaging; sealing	*8%*	*11%*
13) Circuit Design	*10%*	*10%*
12c) CHEMISTRY of MATERIALS, DEVICE PHYSICS and OPTICS: Physics of Semiconductors	*8%*	*18%*
12b) Vapor-Based Materials Deposition Technologies: sputtering; evaporation	*8%*	*18%*
12a) CHEMISTRY of MATERIALS, DEVICE PHYSICS and OPTICS: Light Sources	*5%*	*21%*
11) CHEMISTRY of MATERIALS, DEVICE PHYSICS and OPTICS: Light Induced Effects; Photochemistry	*2%*	*26%*
10) Machinery for Material Patterning: laser; photolithography; printing	*15%*	*16%*
9) Machinery for Material Deposition: vacuum; coating; printing	*11%*	*23%*
8) Chemistry and Physics of Nanosystems	*10%*	*25%*
7b) Machinery for Material Deposition: inline measurements; quality control	*13%*	*23%*
7a) CHEMISTRY of MATERIALS, DEVICE PHYSICS and OPTICS: Physical Chemistry of Organic Molecules	*13%*	*23%*
6) Post Deposition Treatment: drying; annealing; sintering	*13%*	*25%*
5) CHEMISTRY of MATERIALS, DEVICE PHYSICS and OPTICS: Inoranic Materials: metals; semiconductors; nano particles	*16%*	*23%*
4) CHEMISTRY of MATERIALS, DEVICE PHYSICS and OPTICS: Appropriate Organic Materials: small molecules; polymers; fullerenes; nanotubes	*23%*	*25%*
3) Solution-Based Materials Deposition Technologies: coating; printing; dispensing	*26%*	*23%*
2) Experimental Setups (appropriate measuring methods; automation of experiments)	*25%*	*25%*
1) Design of Experiments	*28%*	*25%*

In Figure 30, the importance (only rating option *important* and *very important*) of professional skills for working in FOLAE is presented together with the degree of knowledge (only rating option *existing knowledge good* and *very existing knowledge excellent*) university graduates have according to industry respondents. Three fields of professional knowledge are rated as well enough according to industry: all three in CHEMISTRY of MATERIALS, DEVICE PHYSICS and OPTICS, first: *Quantum Optics*; second: *Physics of Semiconductors* and third*: Inoranic Materials: metals; semiconductors; nanoparticles*. All other fields were rated to be important, but the degree of knowledge among university graduates was lagging behind expectations. The fields which need the most improvement in university education are *Design of Experiment; Solution-Based Materials Deposition Technologies (coating; printing; dispensing)* and *Experimental Setups (appropriate measuring methods; automation of experiments)*.

Figure 30: Importance of professional skills for the industry is higher than the existing degree of knowledge among university graduates



4.4 ADDITONAL (SOFT) SKILLS OF UNIVERSITY GRADUATES

As mentioned in 4.3, this is the second of the two sections of this report which provides detailed information on the respondents' opinion about existing knowledge of university graduates in certain selected fields and the importance of these fields for working in FOLAE. This time the educational topics belong to the field of additional skills which include methodological skills, social/ interpersonal skills as well as personal attributes.

Striking is that almost in all questions the importance of having sufficient knowledge in the respective field is rated much higher than the existing knowledge in the certain fields. One could conclude that especially *Project Management* (Figure 31), *Effective Communication Skills* (Figure 34), *Leadership Qualities & Motivation Psychology* (Figure 35), *Hands-On Know-How* (Figure 36), *Language Skills in English* (Figure 37), *Networking* (Figure 38), *Transfer of Academic Knowledge to Professional Work Assignments* (figure 39), *Research Experience* (Figure 40), *Target-Oriented, Structured Thinking* (Figure 42), *Self-Management; Time Management; Organisation* (Figure 43), *Sense of Responsibility* (Figure 44), *Teamwork; Teambuilding; Willingness to Cooperate* (Figure 45), *Enthusiasm* (Figure 44) and *Critical Thinking; Problem Solving; Decision Making* (Figure 47) need to be embedded in a curriculum for FOLAE.…

Financial Management (Figure 32), *Software (handling and programming skills)* (Figure 33) and *Scientific Writing* (Figure 41) seem to be important but not very important and university graduates' experiences in most of these fields are sufficient enough.

Most improvement in education is necessary in *Project Management* (Figure 31), *Effective Communication Skills* (Figure 34), *Target-Oriented, Structured Thinking* (Figure 42) and *Self-Management; Time Management; Organisation* (Figure 43) since these skills are considered very important, but the knowledge of graduates is described to be average or poor.

The existing knowledge in *Financial Management* (Figure 32) was rated as the field with the worst existing knowledge of all fields/questions, but on the other hand this field was also rated among the less important fields when working in FOLAE. Despite that, one could recommend that at least basic knowledge of financial management needs huge improvement.

Figure 31: Importance of knowledge and Existing knowledge of graduates in: Project Management (setting targets; prioritising; working to schedule; reviewing performance)

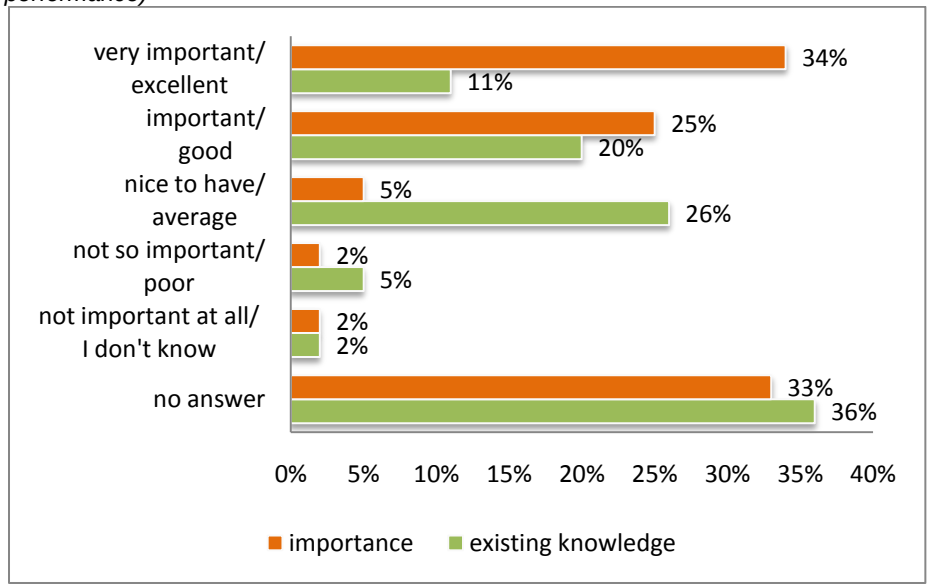


Figure 32: Importance of knowledge and Existing knowledge of graduates in Financial Management

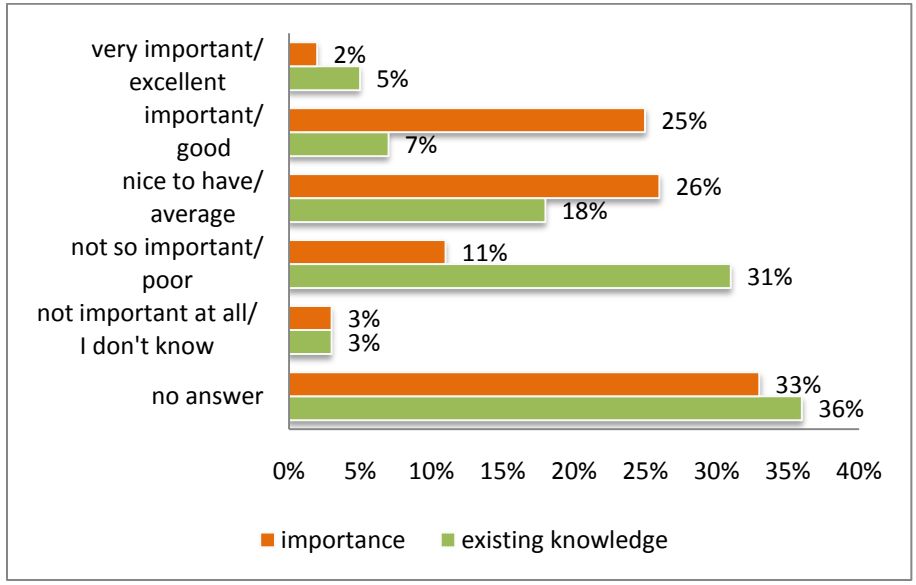


Figure 33: Importance of knowledge and Existing knowledge of graduates in: Software (handling and programming skills)

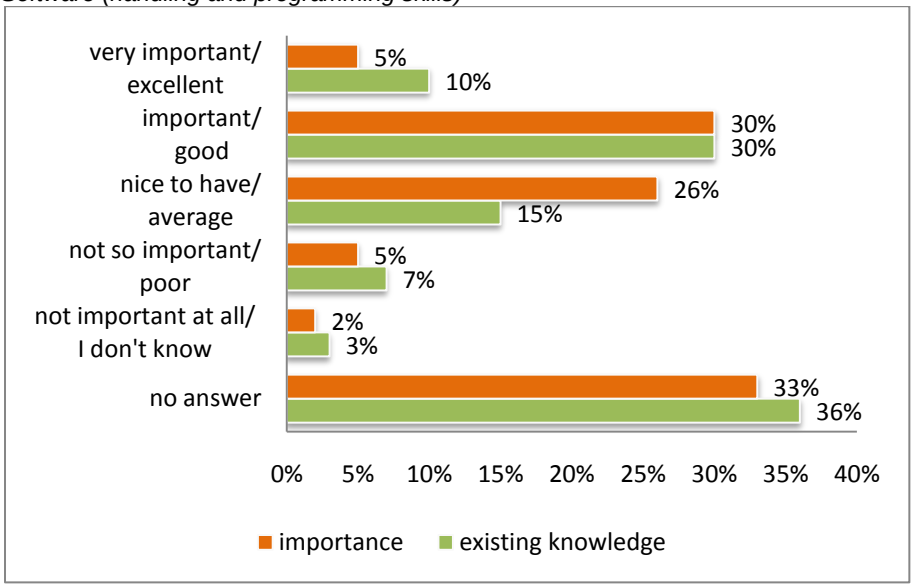


Figure 34: Importance of knowledge and Existing knowledge of graduates in: Effective Communication Skills (written & presentation)

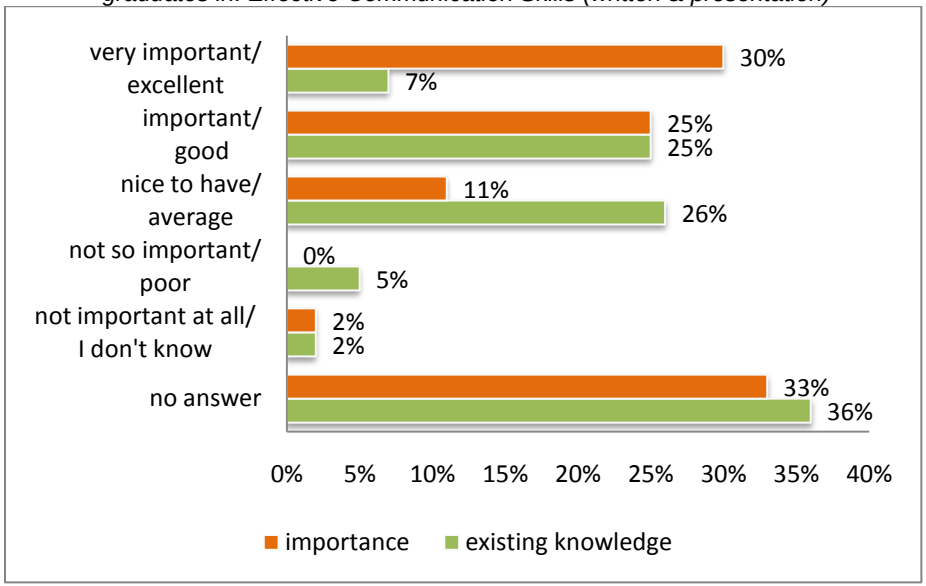


Figure 35: Importance of knowledge and Existing knowledge of graduates in: Leadership Qualities & Motivation Psychology

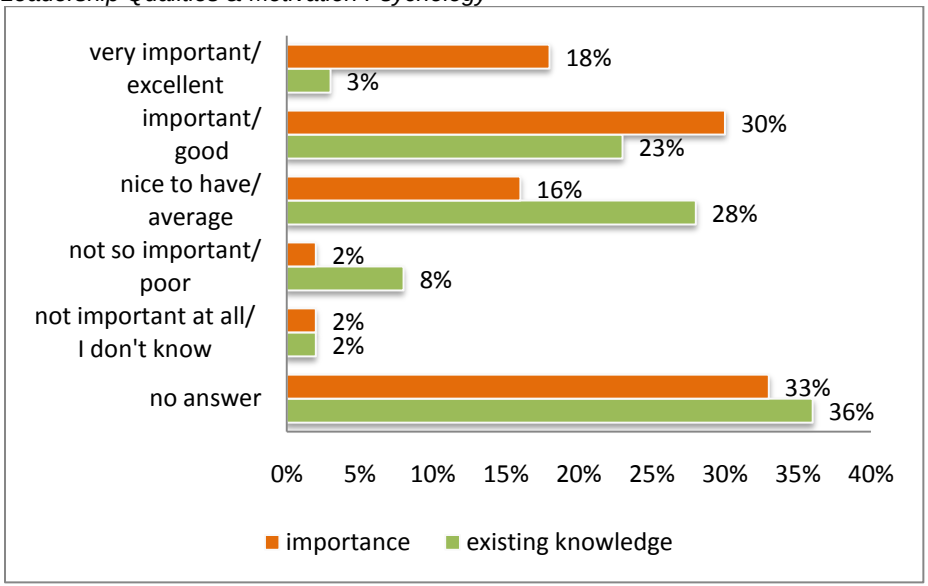


Figure 36: Importance of knowledge and Existing knowledge of graduates in Hands-On Know-How:

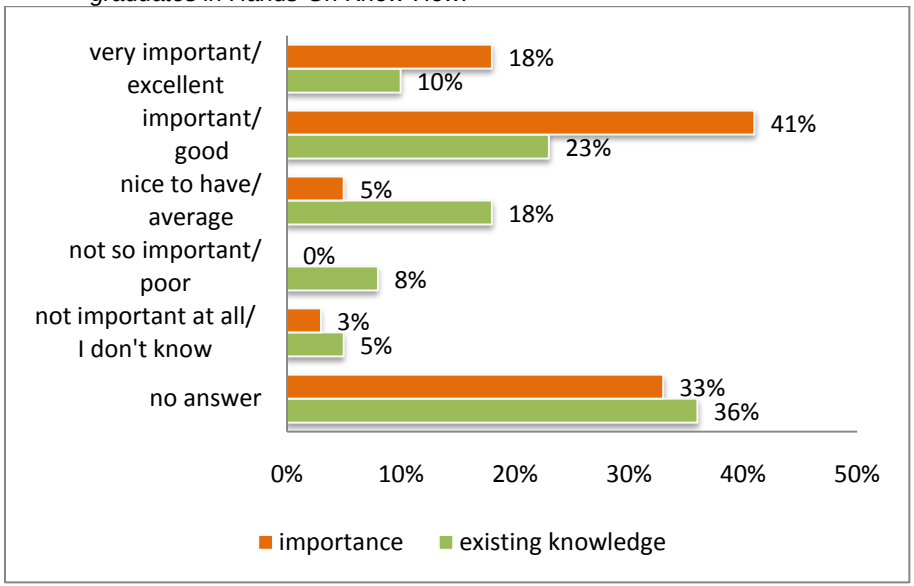


Figure 37: Importance of knowledge and Existing knowledge of graduates in: Language Skills in English

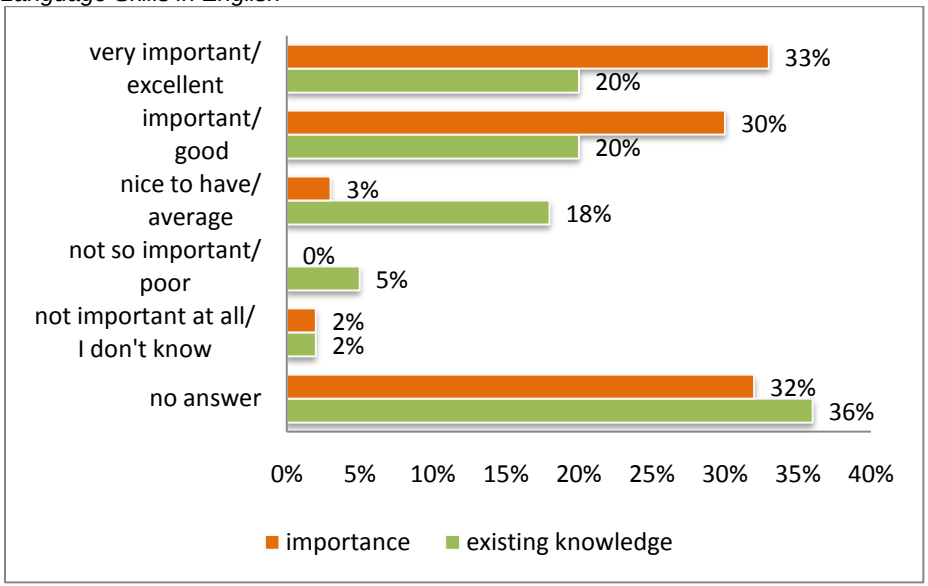


Figure 38: Importance of knowledge and Existing knowledge of graduates in Networking

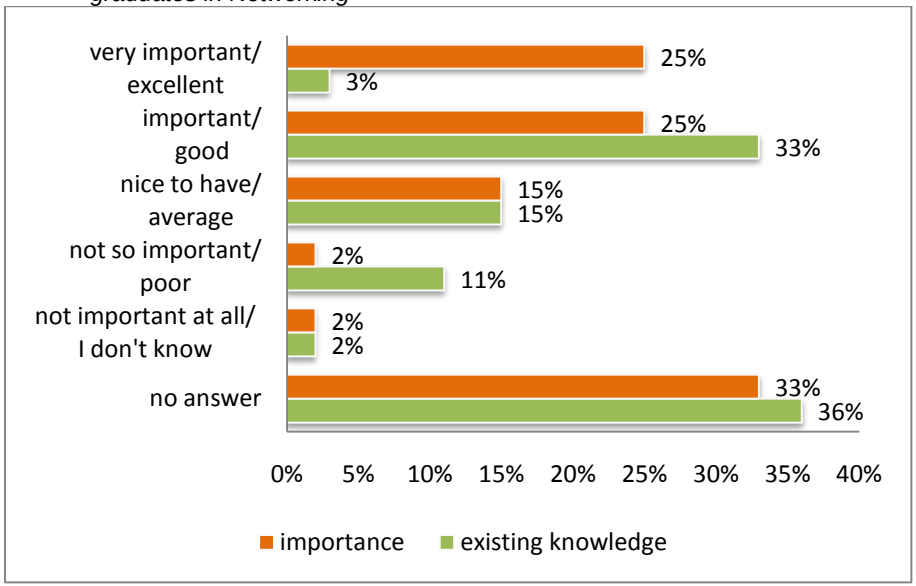


Figure 39: Importance of knowledge and Existing knowledge of graduates in: Transfer of Academic Knowledge to Professional Work Assignments

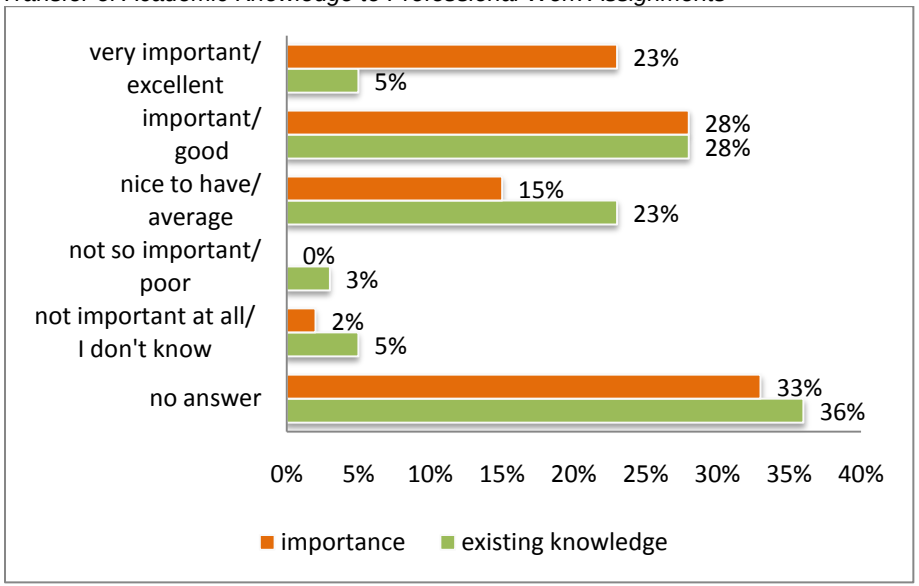


Figure 40: Importance of knowledge and Existing knowledge of graduates in: Research Experience

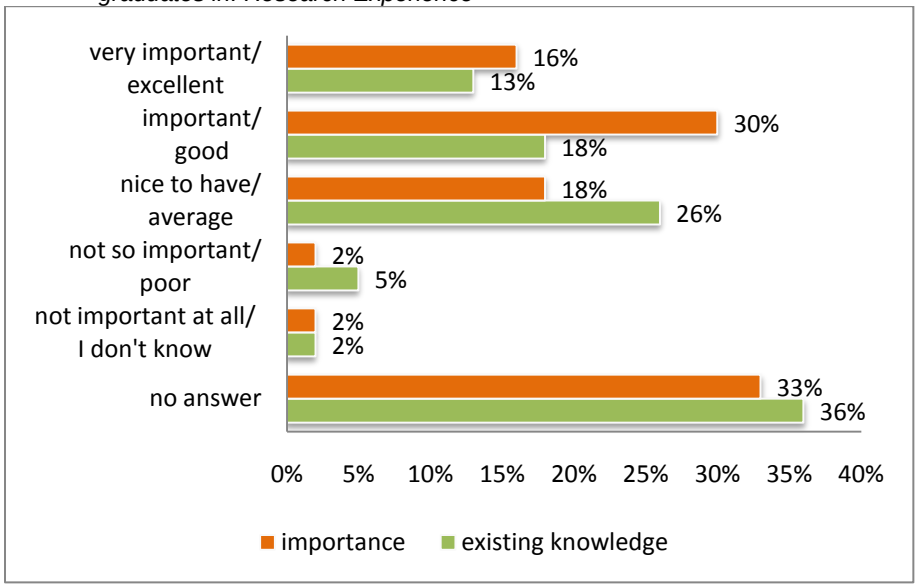


Figure 41: Importance of knowledge and Existing knowledge of graduates in: Scientific Writing

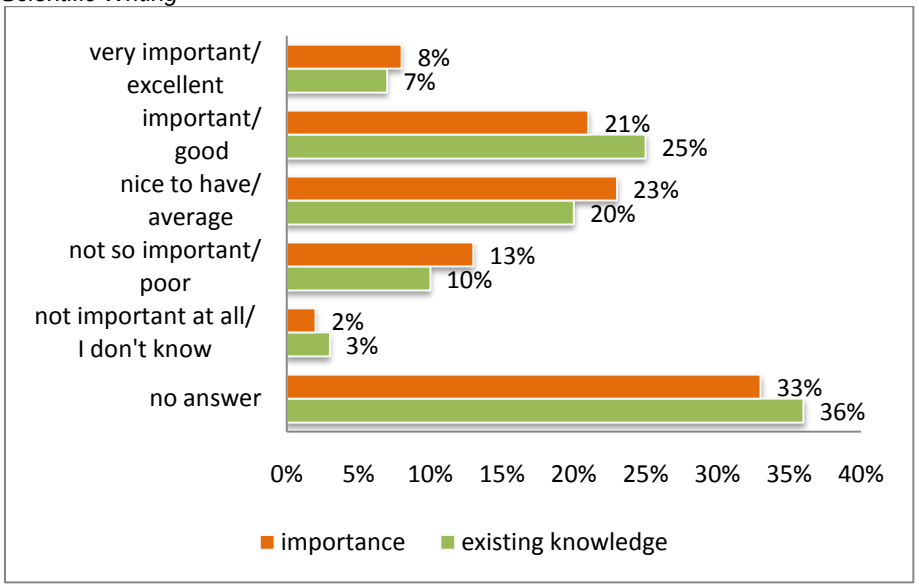


Figure 42: Importance of knowledge and Existing knowledge of graduates in: Target-Oriented, Structured Thinking

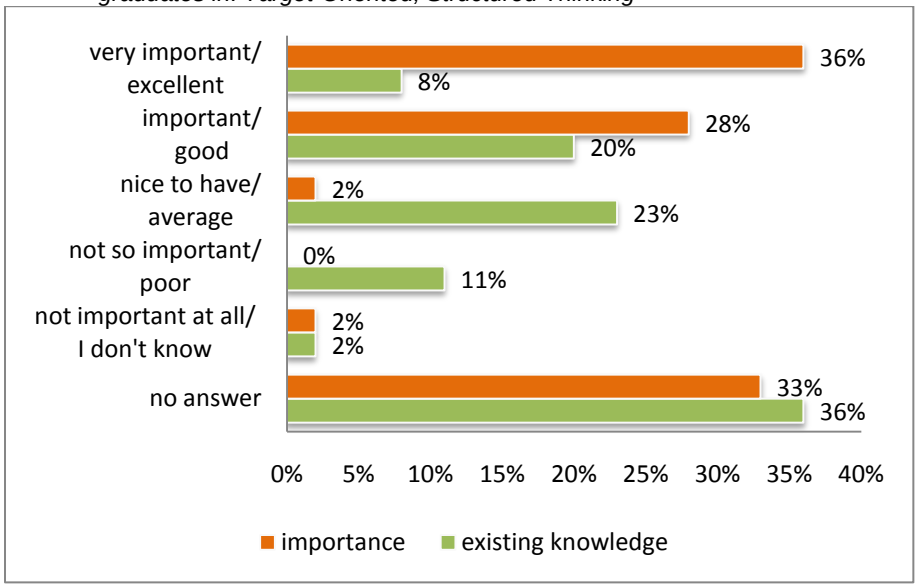


Figure 43: Importance of knowledge and Existing knowledge of graduates in: Self-Management; Time Management; Organisation

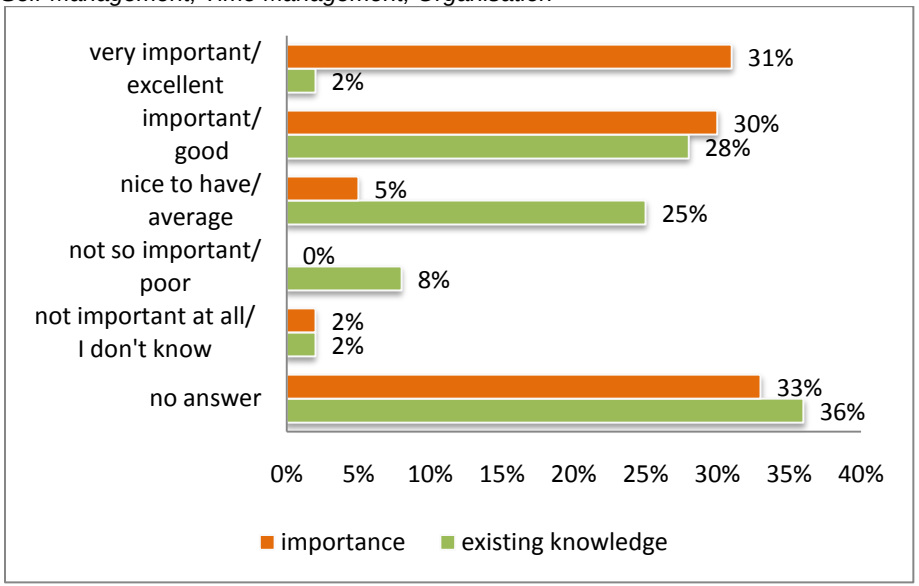


Figure 44: Importance of knowledge and Existing knowledge of graduates in: Sense of Responsibility

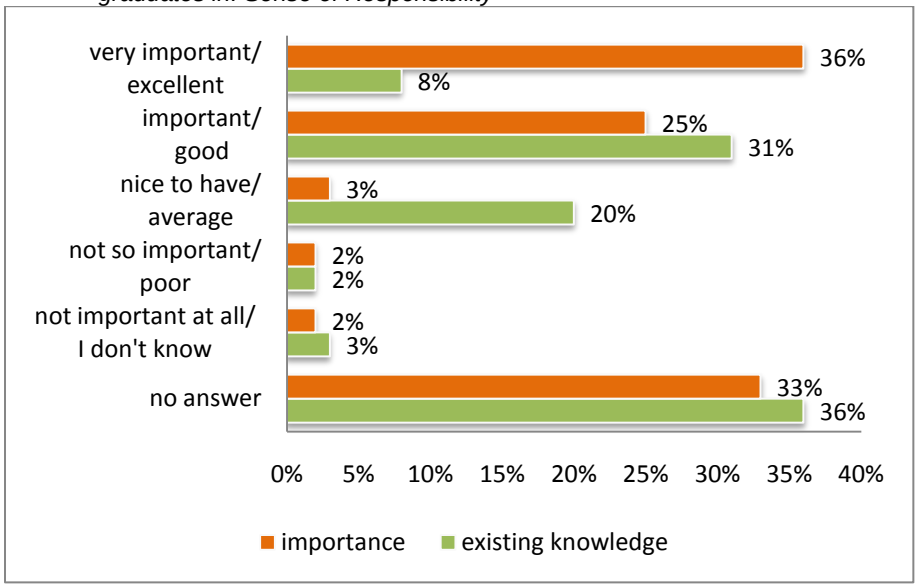


Figure 45: Importance of knowledge and Existing knowledge of graduates in: Teamwork; Teambuilding; Willingness to Cooperate

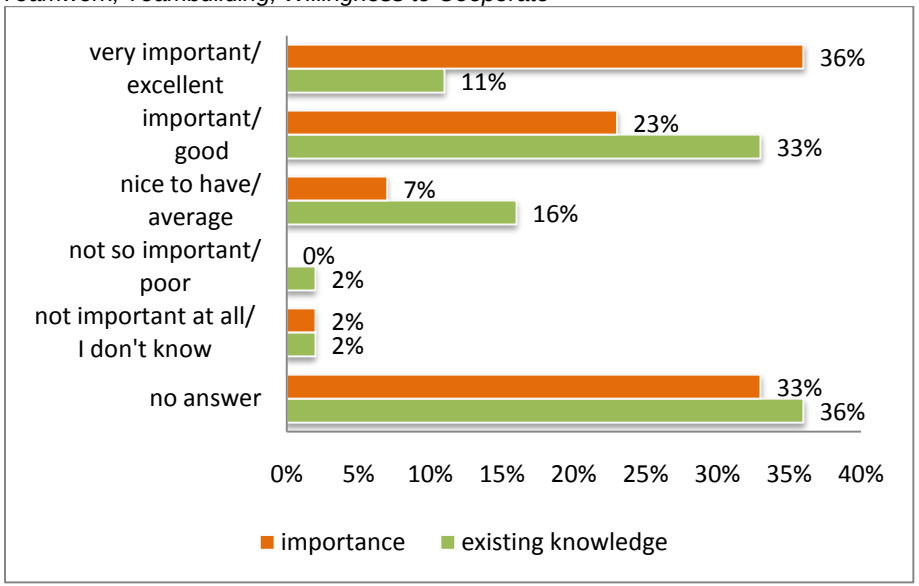


Figure 46: Importance of knowledge and Existing knowledge of graduates in: Enthusiasm

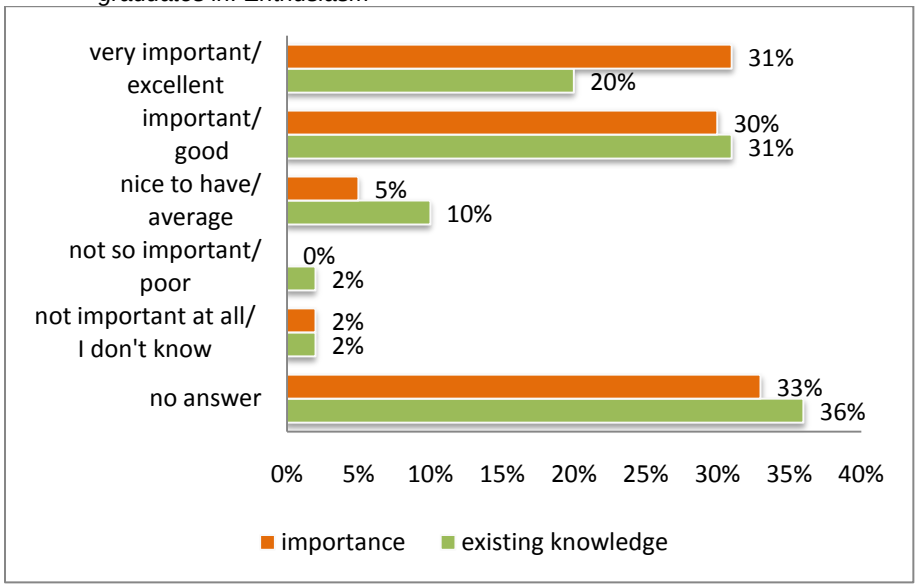


Figure 47: Importance of knowledge and Existing knowledge of graduates in: Critical Thinking; Problem Solving; Decision Making

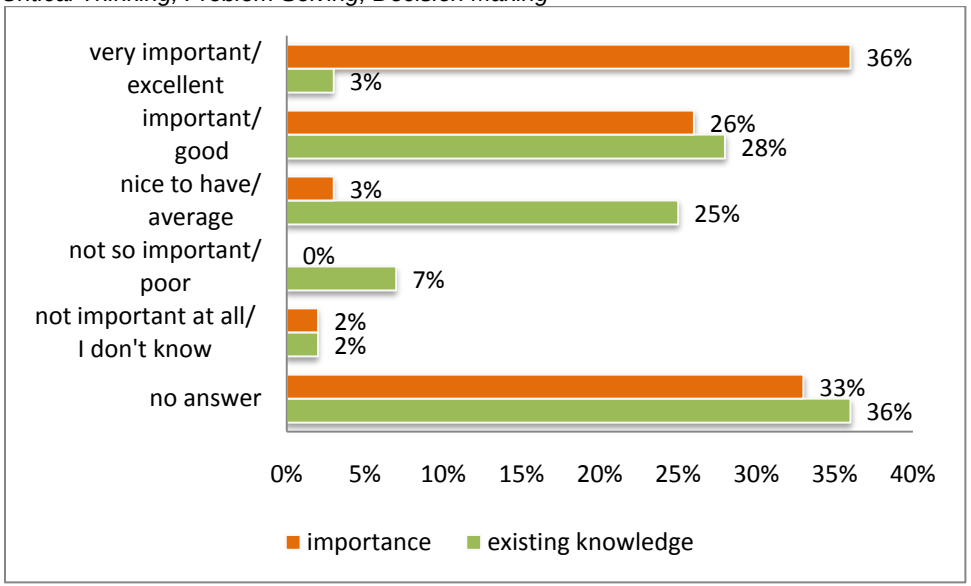


Figure 48 is an arrangement of the importance of additional skills for the industry only taking into account the rating option *important* and *very important.* It can be concluded that the top six additional skills are very close together. The first three which are the most important in the field of additional knowledge for industry are: *Target-Oriented, Structured Thinking*; *Language Skills in English* and *Critical Thinking, Problem Solving and Decision Making*. When only considering the rating option *very important*, this would change the priorities and among the top three would still be *Target-Oriented, Structured Thinking* but also *Sense of Responsibility* and *Teamwork, Teambuilding and Willingness to cooperate*. One can recommend that these skills might be worth being included in the curriculum of the education in FOLAE - considering that they can never be a self-contained subject but these skills can be trained when more focus is placed on them.

Least important for the industry is *Financial Management, Scientific Writing* and *Software handling and programming skills.*

In Figure 49, the importance (only rating option *important* and *very important*) of additional skills for working in FOLAE is presented together with the degree of knowledge (only rating option *existing knowledge good* and *very existing knowledge excellent*) university graduates have according to industry respondents. According to industry representatives, two fields of additional knowledge do not need improvement in university education: *Scientific Writing* and *Software (handling and programming skills).* All other fields were rated to be important with the degree of knowledge among university graduates being not high enough. Definitely integrated in the university education should be: *Target-Oriented Structured Thinking*, *Critical Thinking; Problem Solving; Decision Making, Self-Management; Time Management; Organisation* and *Project Management (setting targets; prioritising; working to schedule; reviewing performance)*. Obvious, as mentioned before, is that most of these fields need to be integrated in courses in FOLAE.

Figure 48: Rating of most important additional skills for the industry

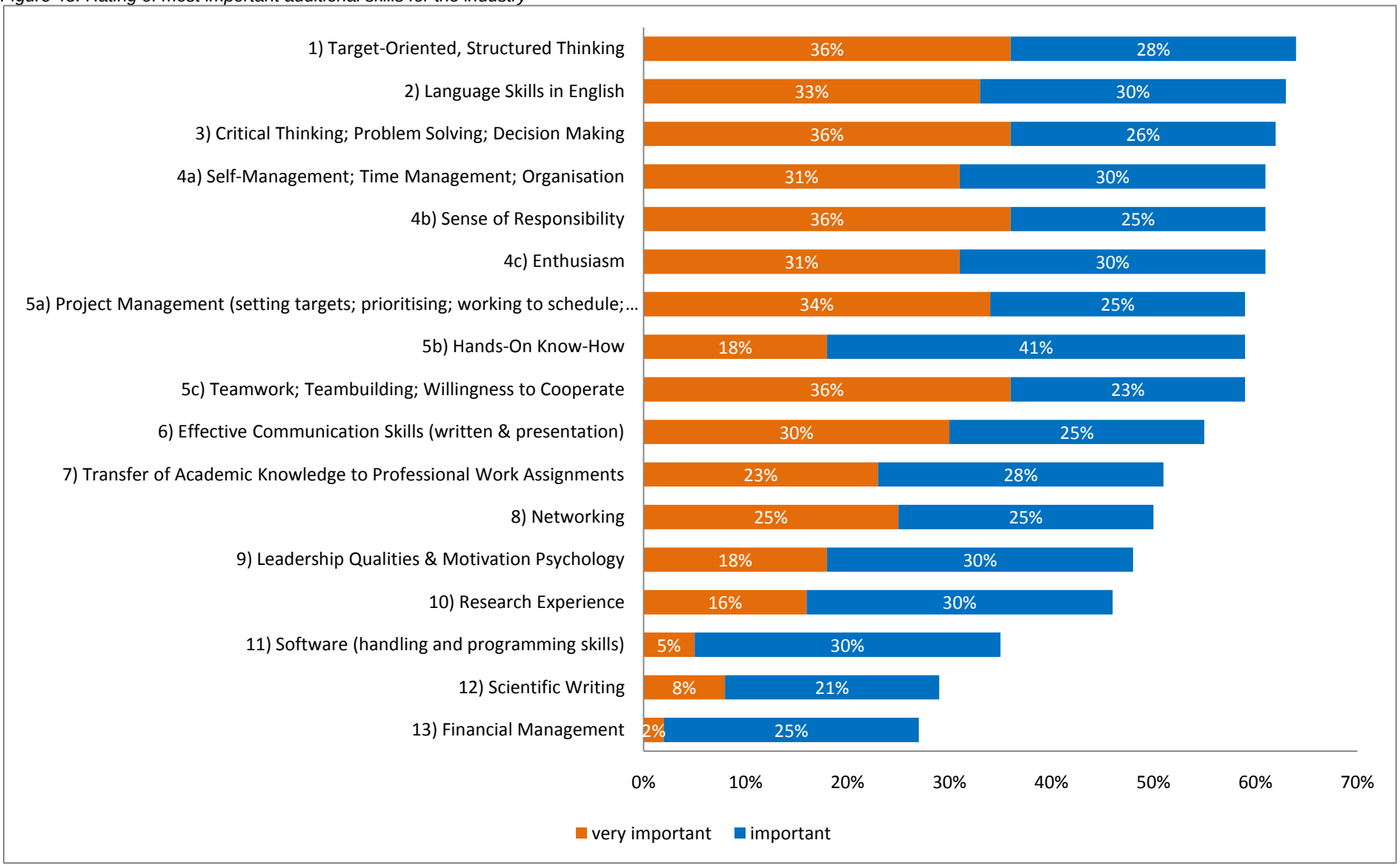
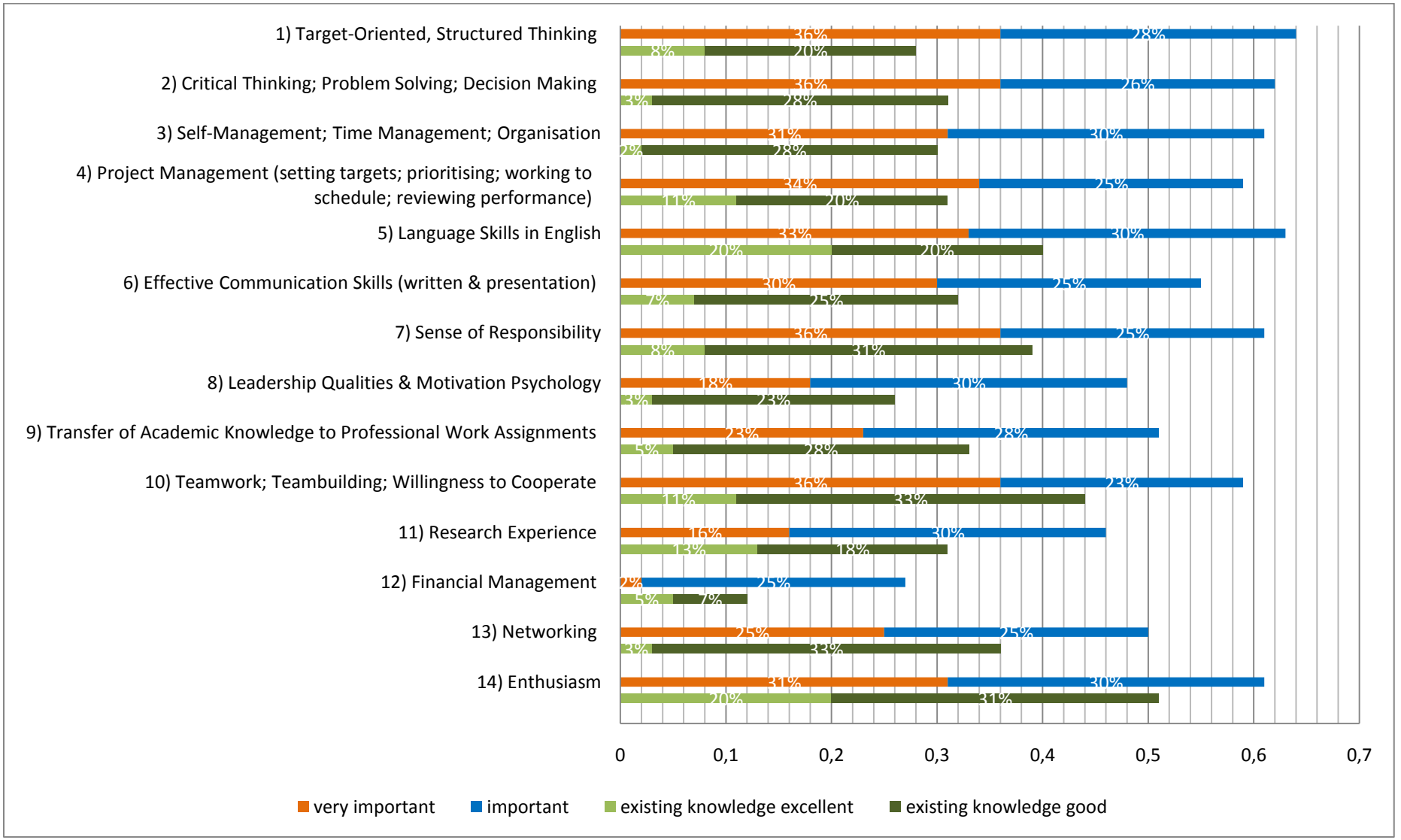


Figure 49: Importance of additional skills for the industry is higher than the existing degree of knowledge among university graduates



No one added important professional and/ or additional (soft) skills. So that it can be assumed that we covered the most important content areas in the field of FOLAE.

4.5 INTERNSHIPS

Internships are important for every student. On the one hand, internships provide the possibility to gain work experiences and on the other hand, to establish industrial networks. Moreover, students do not only learn how to transfer their academic knowledge into professional hands-on practice but also extend their knowledge in many other additional knowledge fields such as self-management or sense of responsibility (cf. Figure 52).

In Figure 50, industry representatives state their view of the importance of internships. 62 % of the respondents recommended internships. 21 % actively offer internships and 30 % of the respondents would accept interns if they applied. Only 15 % do not support students in gaining first work experiences (cf. Figure 51)

Figure 50: Industry recommendation for students to do internships

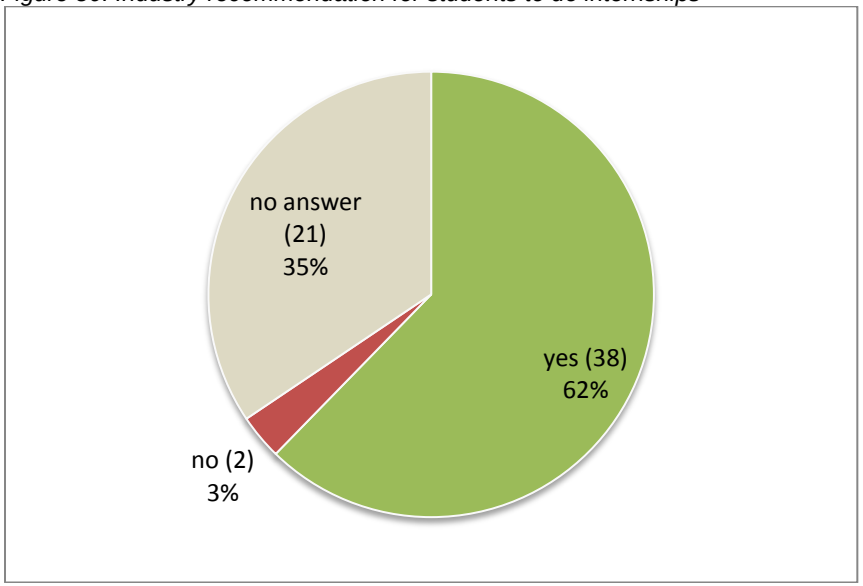


Figure 51: Distribution of industry offering internships

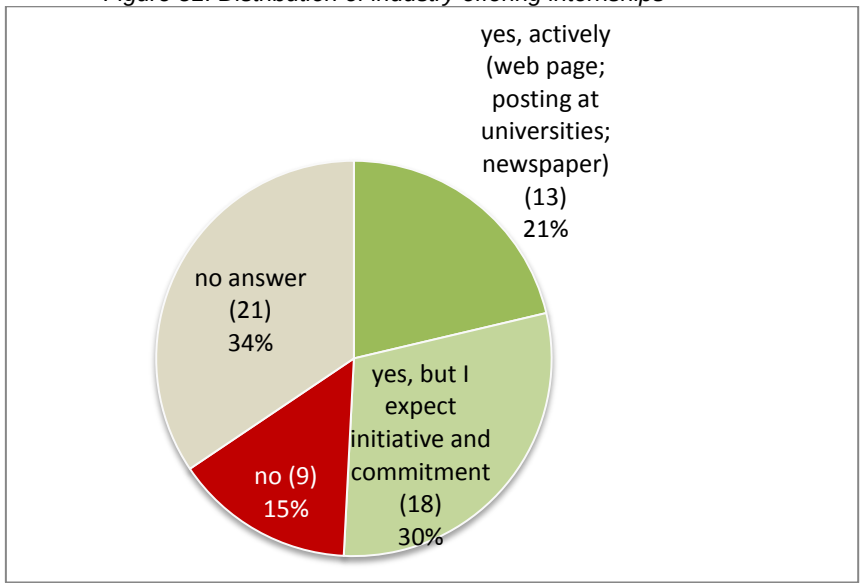
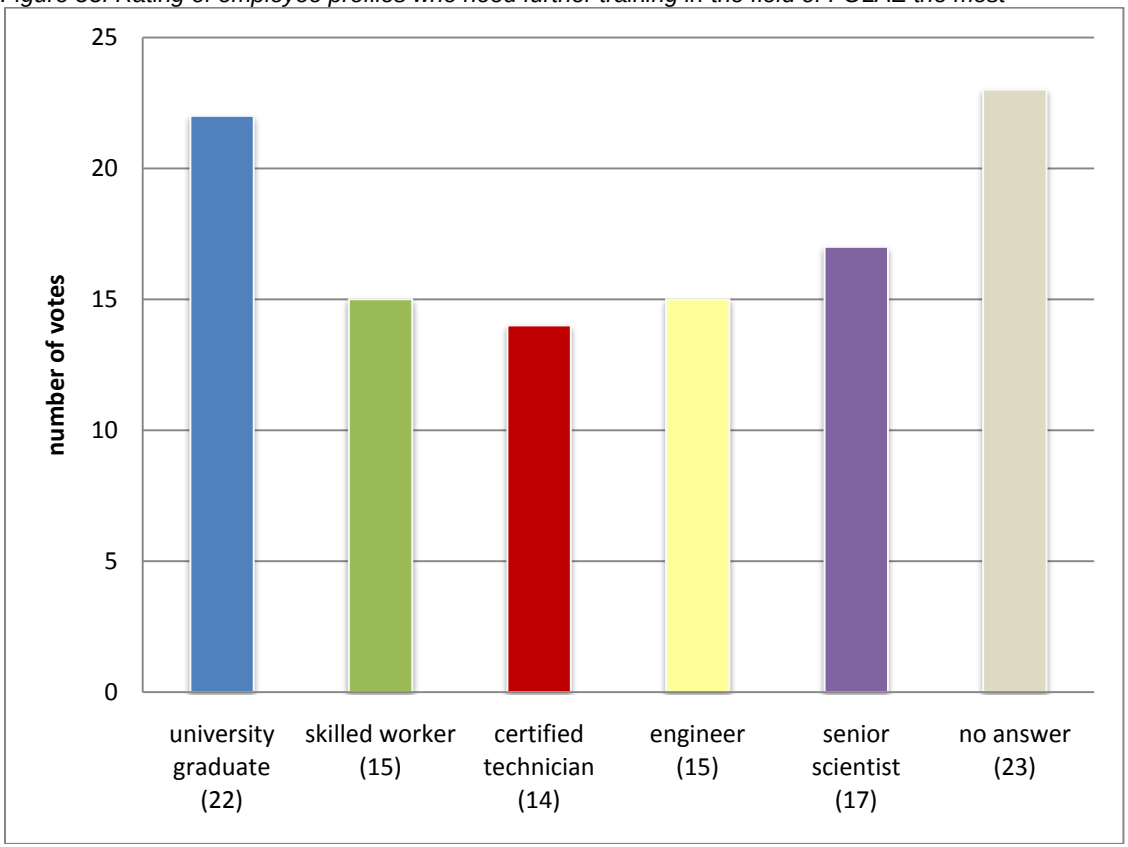


Figure 52: Rating of five additional skills (selection of skills TUC) which could be gained/improved when doing internships

4.6 FURTHER TRAINING

In the second last section of the questionnaire, we asked about further training.
First, TUC wanted to know in which field further training is required the most urgently. Most respondents (22) pointed out that university graduates need further training the most, followed by senior scientists (17), skilled workers and engineers (both 15) with the certified technician being rated last (14). But since the results are pretty close together, it seems that there is not a strong preference for a certain employee profile which needs to be trained the most.

Figure 53: Rating of employee profiles who need further training in the field of FOLAE the most



The second question in this section was concerning mandatory topics for further training (Please suggest 3-5 mandatory topics [...]). Here is a list of the given answers:

1) Material science	Optics	Basics	Design of experiments
2) Printing Techniques How to think in "printing" or "hybrids" instead than conventional electronics. Study cases (Real works).			
3) project management,	presentation skills,	leadership skills	
4) coating an drying,	polymer science,	classical optics	
5) I did the ranking only to be able to continue the questionnaire. A ranking is useless. Everybody should train. You send the people that want to go and have some kind of qualifications already			
6) Systems design, ,	Convergence of OLAE and inorganic electronics	production technologies and use cases,	**standards and limits of OLAE**
7) leadership of employees	Printing Technologies and printable materials	English language	
8) design of experiments	data analysis	surface technology	
9) Specific software training	Regulatory aspects, e.g. CE conformity Application overview		
10) Soft skills training such as management (time, employees, projects)			
11) Polymer chemistry	printing	Basic electronic circuit design	
12) understand interaction of materials	process engineering	testing and QA analysis	building prototype and analyse results
13) project management including time management	training on communication skills	alternative raw materials within paper production	
14) project management	finance	design of experiments	**intellectual property management**
15) Statistics	Project management	Design of experiments	
16) project management	time management	team working	
17) **DOE Statistics**			
18) printed electronics	quality assurance	testing	
19) project management	circuit design	quality management	
20) industrial working environment (focused approach)	**Market view & needs (more market pull less technology push)**	**Understand value chains**	
21) smart materials	deposition processes	OLAE and flexible systems	
22) process technology	design of experiment		
23) Project Management	Communication (How, When, and To Whom)	Time Mgmt	
24) specialities in printing of organic electronics	ink systems	printed electronics technologies, e.g. OPV	
25) DOE optics			
26) different printing technologies	electronics meet printing	Ink/paste formulation	
27) Specialization	Open horizons	Networking	
28) **biotechnology**	project management	process development	

29) General courses on the chemistry and physics behind printed electronics, OLED and PV			
30) English language	Presenting	Powers of persuasion	
31) Updates on analytical techniques	Project Management	New technologies training	
32) Chemistry & Physics of Nanosystems	Deposition Technologies	Post deposition treatments	
33) TECHNOLOGIES (printing)	MATERIAL	APPLICATIONS (products)	TQM
34) Update in latest state of the art technology	New methods	Build network	

Within this list, some new topic have been mentioned like Economics of FOLAE *(Market view & needs (more market pull less technology push)*, *understand value chains* as well as *standards and limits of OLAE*), *intellectual property rights* or *biotechnology*. But the sum of all answers differed too much, so it was not obvious which topic industry rated as the most important for a further training for a certain employee profile.

5. DISCUSSION, CONCLUSION AND OUTLOOK

In summary, it can be said that the results of the questionnaire in combination with the analysis of the already offered degree programs could provide sufficient information for making a concept for an international master degree program in flexible, organic and large area electronics (FOLAE). The results of the questionnaire indicate which fields of knowledge (professional and additional) are most important for the industrial respondents and which fields are less important. Moreover with the results, it is possible to suggest obligatory internships for FOLAE students. Unfortunately, the section further training only indicates that further training is necessary but it is not exactly clear which employee profile needs further training most - most respondents voted for university graduates to be in the need for the most further training.

The questionnaire was answered by 62 respondents but already the third question was only answered by 44 respondents. The response rate decreased so that at the end only 35 respondents answered all questions. This affected the section of personal questions heavily since it was the last section together with the market trend questions which could not be positioned at the beginning. For his reason, it was also not possible to track the origin of 27 completed questionnaires. For further versions, this should be considered. From the 34 respondents answering all questions, the majority was from Germany (13 respondents) followed by the United States (5 respondents) and Italy (4 respondents). Response rates were low from Austria, Belgium and the United Kingdom (each: 2 respondents) whereas very low rates were observed in Cyprus, France, Greece, Spain, Sweden, Switzerland and Japan (1 respondent each). The questionnaire was mostly answered by management and top management, and the companies were mostly bigger companies with more than 500 or between 51-500 employees. So the combination of many different dissemination channels - ranging from presentations at oe-a working group meetings and in announcements in oe-a newsletters to personalized e-mail invitations to industrial oe-a members - for this online questionnaire turned out to be necessary and important since it helped to increase the overall response rate.

When it comes to professional knowledge, the result was that *Design of Experiments*, the *Experimental Setups (appropriate measuring methods; automation of experiments)*, the *Solution-Based Materials Deposition Technologies: coating; printing; dispensing* and the *CHEMISTRY of MATERIALS, DEVICE PHYSICS and OPTICS: Appropriate Organic Materials: small molecules; polymers; fullerenes; nanotubes* were rated as the most important fields of professional knowledge for industry respondents. Least important for industry is *CHEMISTRY of MATERIALS, DEVICE PHYSICS and OPTICS: Quantum Optics*, *Back-End of line: bonding; distributing; packaging; sealing* and *Circuit Design.* Striking is that the importance of fields like *Solution-Based Materials Deposition Technologies: coating; printing; dispensing*; *Machinery for Material Patterning: laser; photolithography; printing*; *Machinery for Material Deposition: vacuum; coating; printing*; *Machinery for Material Deposition: inline measurements; quality control*; *Post Deposition Treatment: drying; annealing; sintering*; *Back-End of line: bonding; distributing; packaging; sealing*; *Experimental Setups* (appropriate measuring methods; automation of experiments); *Design of Experiments* is tremendously higher than the existing knowledge of university graduates which means that first, students need more training in these fields in order to be able to be employed in the field of FOLAE. The top three additional skills were *Target-Oriented, Structured Thinking*, *Sense of Responsibility* and *Teamwork, Teambuilding and Willingness to cooperate.* Least important for the industry is *Financial Management, Scientific Writing* and *Software handling and programming skills.* Most improvement in education is necessary in *Project Management*, *Effective Communication Skills*, *Target-Oriented, Structured Thinking* and *Self-Management; Time Management; Organisation* since these skills are considered very important, but the knowledge of graduates is described to be average or poor. According to industry representatives, two fields of additional knowledge do not need improvement in university education: *Scientific Writing* and *Software (handling and programming skills).*So it can be concluded that these professional and additional knowledge fields need to be included in a curriculum for FOLAE.

The final questionnaire questions were about industry's market views. The respondents were asked whether they could employ new people in the last year and the reasons for the possibility of employment. The result was interpreted as indicating that the field of FOLAE still has an excellent potential for further research. Moreover, new products are on the way which are also selling much more than in the previous year.

A difficulty for some respondents might have been a language barrier since some claimed not to understand some terms. Maybe misunderstandings might have also occurred because hardly anyone answering the questionnaire (apart from 5 American and 2 British respondents) was a native speaker of English and so the respondents might have misinterpreted some terms.

As mentioned before, the majority of questionnaire respondents were European but we also had some feedback from America and even Asia. A distinction of the different continents in the evaluation has not been made. This might be a good starting point for further investigations. Even differences between countries within Europe could be analyzed. So, it has to be pointed out that the results can only show a tendency regarding the educational situation in Europe/ worldwide since a separate interpretation of the findings for different countries or even different continents has not been made. But, as mentioned before, this could be the starting point of further investigations in order to give a comprehensive view on the educational situation and the educational needs of the industry.

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