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NAMA

Validation of NAMA formal and informal learning materials (O4-A1)

&

External Evaluation

August 2016

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1 Executive summary

This report aims to validate NAMA formal and informal learning materials and is part of output O4 of project NAMA. In general, output O4 within the project NAMA aims to provide tools for the validation, endorsement, and mutual recognition of NAMA learning materials. To be more precise, O4 includes the production of tools and materials capable of promoting and facilitating the valorisation of NAMA results during and, most importantly, after the life of the project. This will be achieved through developing a validation methodology that includes actual target groups and external experts, thus steering the optimisation of materials towards real-life needs.

After the outcomes of the validation process of learning materials have been developed, stakeholders involved in VET provision and Advanced Manufacturing will conclude through a consultation process with the development of a Memorandum of Understanding (MoU) to endorse the use of NAMA results, as a form of "soft" commitment to harmonise VET in the EU for Advanced Manufacturing jobs. The MoU will then support the NAMA position paper that will be developed and distributed to policy-makers, with the aim to influence decision making towards the needs of learners and stakeholders in the sector.

The output is anticipated to set the ground for further consultation on a framework for the certification and accreditation of numerical skills for Advanced Manufacturing jobs, and to bridge sectoral needs with the world of VET and policy-making. It is also anticipated that it will significantly contribute to the uptake of NAMA learning materials, thus maximising project impact.

Moving on from the description of O4 as a whole to the presentation of activity O4-A1, i.e. the 'Validation of NAMA formal and informal learning materials', it is important to point out that the activity consists of the following steps:

- a) The definition of methodology and the identification of the most suitable internal validation & evaluation tools, i.e. the two training pilots (Events E1) conducted in Poland and the UK, to be prepared before these events.
- b) The preparation and delivery of a validation report based on the assessment of NAMA materials by trainers and learners
- c) The inclusion in the validation report of an evaluation account developed and drafted by an external expert which will comprise the external evaluation of the NAMA project results



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The validation report will have a two-fold purpose: a) to provide the potential signatories of the MoU (O4-A2) with evidence on the involvement of target groups in the validation of NAMA materials and the integration of feedback, based on their actual needs, and b) to drive the optimisation/revision procedures of O2 and O3 learning materials.



2 Internal validation

2.1 Validation methodology

To construct an efficient validation methodology it is necessary to take into account the following three factors:

1. The methodology should explain how to reach the necessary target groups of the project at hand.
2. The methodology should consist of the appropriate data collection methods.
3. The methodology should make use of an efficient set of data analysis methods.

In the case of NAMA, the key method chosen for the evaluation of its materials was the conduction of two training pilots, one in Poland and one in the UK. The following sections evaluates each of the two training pilots for the three factors above.

2.1.1 The UK training pilot

Reaching the correct target groups

The partner responsible for the UK training pilot, i.e. USFD-AMRC mostly approached various apprentices in the industry to be part of the training pilot. This is the reason why USFD-AMRC decided to evaluate during the training pilot the NAMA materials that had to do with trigonometry and geometry, since they were the most relevant to the industry apprentices who participated in the pilot. In the end 14 industry apprentices participated in the pilot. This is less than the number demanded by the NAMA proposal, but sufficient for the production of useful data.

Beyond these 14 apprentices, USFD-AMRC managed to reach four trainers from its training centre. This was a key addition, since it made sure that people who occupied different niches in the VET process would contribute to the evaluation of the NAMA materials. The reason why this is important is that successful educational materials consist of a combination of high quality and fast transmission of knowledge. The latter often depend on the appealing character of educational information to both trainers and learners. The participation of people who occupy different niches in the VET process means that the NAMA materials were evaluated by people with different dispositions in terms of what they find appealing. Evaluating something like educational materials based on the responses of people with different dispositions and positions means that it is possible to develop a more objective¹

¹ Bourdieu and Wacquant, 1992. *An Invitation to reflexive sociology*. Chicago, IL, USA: University of Chicago Press



understanding of the appealingness of NAMA educational materials and of the differences in how learners and trainers evaluated the latter.

Data collection methodology

In the UK training pilot two methods were applied to data collection. A survey of those who participated in the training pilot and a small number of qualitative interviews. The interview guide used in the interviews can be seen in Annex 1 whereas the questionnaire used in the survey can be seen in Annex 2. In the survey participated mostly the industry apprentices, whereas the qualitative interviews were used to collect data from USFD-AMRC trainers.

What that means is that the UK training pilot made use of social science research triangulation. Triangulation in social research is defined in the following way² :

“Triangulation is broadly defined by Denzin (1978: 291) as "the combination of methodologies in the study of the same phenomenon." The triangulation metaphor is from navigation and military strategy that use multiple reference points to locate an object's exact position... It is largely a vehicle for cross validation when two or more distinct methods are found to be congruent and yield comparable data. For organizational researchers, this would involve the use of multiple methods to examine the same dimension of a research problem.” (p. 602)

As can be seen in the quote above, triangulation is the use of more than one methods to address a specific research aim. In the case of the NAMA training pilot in the UK, the methods of the survey and the interviews were chosen for different reasons. More precisely the questionnaire-based survey was chosen as the method to collect data from industry apprentices for the following reasons³:

- It is a method that can reach many diverse respondents fast enough without incurring additional costs.
- It is a method that allows for the collection of more personal and less bureaucratic types of data, than secondary data research (e.g. desk research). This fact is even more exacerbated if the questionnaire used in the survey includes some open

² Todd D. Jick, 1979. "Mixing Qualitative and Quantitative Methods: Triangulation in Action", *Administrative Science Quarterly*, Vol. 24, No. 4, Qualitative Methodology (Dec., 1979), pp. 602-611)

³ <https://www.infona.pl/resource/bwmeta1.element.springer-a567335a-b069-3542-a2b9-106dadbf4ddc>



questions, as is the case for the questionnaire used in the training pilots in the UK and Poland.

- It is a method that allows for the collection of streamlined data in similar and comparable form that allow for a fast and easy data analysis.
- The absence of an interviewer facilitates the provision of answers on behalf of those participating in the survey.

On the contrary, qualitative interviews are a much 'slower' process, with more extensive and case-specific data. USFD-AMRC decided to use the method of qualitative interviews to collect data from its trainers. This means that two samples with different dispositions and positions in the VET process, have provided data through different research methods. These differences in the populations and research methods make similarities in the data even more important, and allow for a more complete understanding of the differences in the responses of the participants in the training pilot.

Data analysis

The data analysis in the UK training pilot consisted of mostly open coding and simple statistical evaluation methods. Open coding was applied in the data conducted in the interviews and the open questions of the questionnaire whereas simple statistical methods were used to evaluate the results of the latter. Open coding is a type of data analysis that is not guided by researchers' theoretical assumptions, but by the data themselves. What that means is that researchers do not chose to pick and code the patterns that fit their own theoretical assumptions, but on the contrary they have to identify, note and code all patterns that emerge from the data, even if they contradict the researchers' assumptions. After assembling the data, USFD-AMRC started to match similar data and create categories for chunks of data that summarise various aspects of green public procurement processes.

Simple statistical methods were applied to summarise and evaluate the findings of the survey. By matching similar data, the raw data was grouped into categories. To best summarise the data, USFD-AMRC visualised the findings using graphs, particularly column charts.



2.1.2 The Polish training pilot

Reaching the correct target groups

CKUNT used similar data collection and data analysis methods during its training pilot. The main difference between the two training pilots was that CKUNT attempted to attract even more diverse participants in the training pilot. At the event there were over 100 people representing various environments:

- approx. 20 vocational education and training institutions,
- approx. 27 companies,
- approx. 15 students/learners,
- approx. 6 institutions responsible for or supporting vocational education and training in the region (such as Lodz Special Economic Zone, Lodz City Hall, Local Examination Commission, foundations realizing project on VET).

In the end, 45 participants in the training pilot organized by CKUNT provided answers to the survey questionnaire. The questionnaire used in the survey can be seen in Annex 2 and is the same used in the UK training pilot. The majority of respondents were teachers/ trainers and, as a result, managed to provide data that can be easily compared and juxtaposed with the results of the training pilot in the UK.



2.2 Internal validation results

2.2.1 Survey questionnaire results

Answers related to the questions concerning the learning materials per se, i.e. questions 1-9 of the questionnaire and questions in Part A of the interview guide, produced data that:

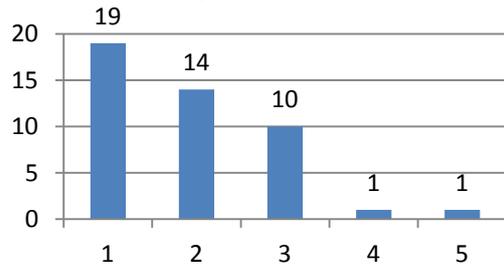
- a) Are in general more or less in agreement with statements in the questionnaire, and thus view NAMA learning materials more favourably.
- b) Slightly diverge both between the two training pilots and among participants within the same pilot.

More precisely, the evaluation of the learning materials by participants in the survey of the UK training pilot had shown that most of them had opted to stay neutral with regards to most questions. Neutrality was especially predominant in questions about whether the material made clear to all participants the learning goals and how they could relate it to their advanced manufacturing workplace tasks. Votes that were not neutral in general agreed with the statements in the questionnaire, thus generating a distribution slightly skewed towards agreeing with the statements in the questions and, hence, towards finding NAMA learning materials more efficient. On the contrary, in the survey conducted in the Polish training pilot, the vast majority of respondents (over 80%) described NAMA learning materials as valuable learning tools both for students and current or prospective employees, thus producing results that are heavily skewed towards finding NAMA materials more appealing and efficient. This difference in the degree of support for NAMA materials is evident in the following histograms representing the answers to questions 1,2,3,5, 6,7 and 8 of the survey questionnaire. The only question in which the degree of support is almost the same is question 4. Histograms with blue coloured bars represent the results of the Polish training pilot whereas those with orange coloured bars represent the pilot conducted in the UK:

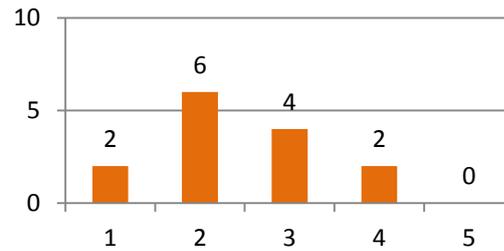


LEARNING MATERIAL ASSESSMENT QUESTIONS

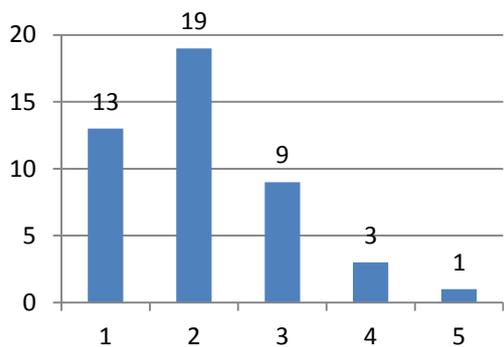
1. The learning materials are clearly linked to Advanced Manufacturing workplace realities (concepts, skills, tasks).



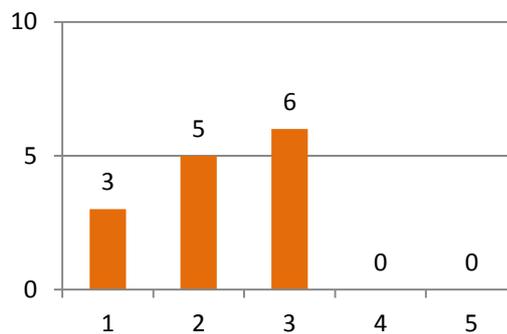
1. The learning materials are clearly linked to Advanced Manufacturing workplace realities (concepts, skills, tasks).



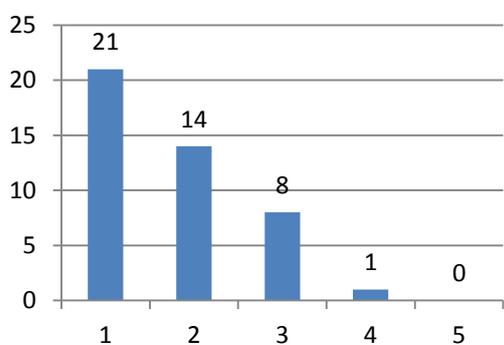
2. The learning goals and objectives to be attained by learners are clear.



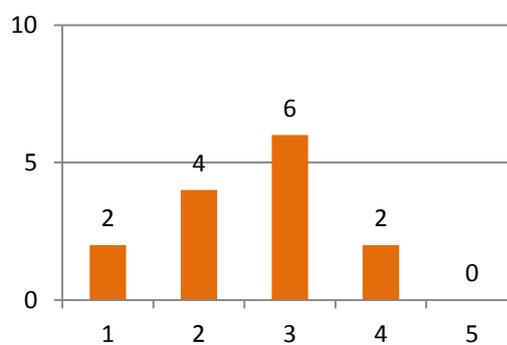
2. The learning goals and objectives to be attained by learners are clear.



3. The learning materials are wellwritten and concise

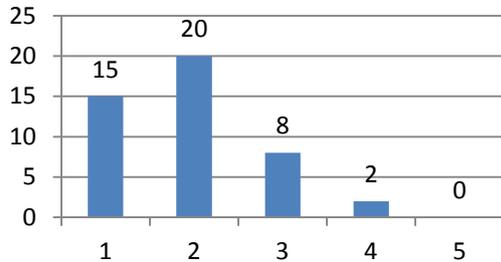


3. The learning materials are well-written and concise.

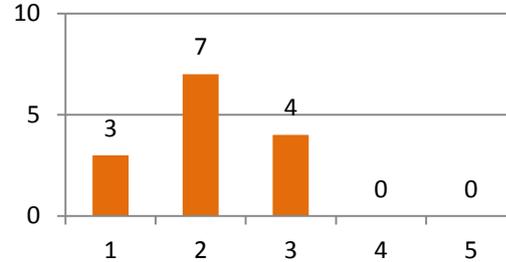




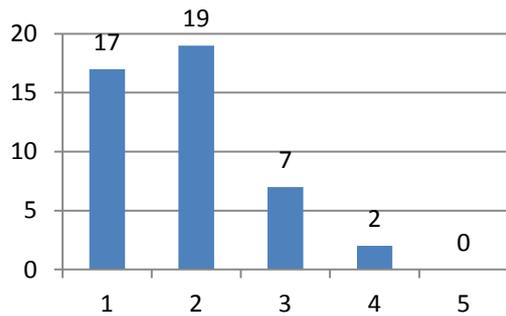
4. The learning content is appropriately structured and organised for the provision of vocational education & training.



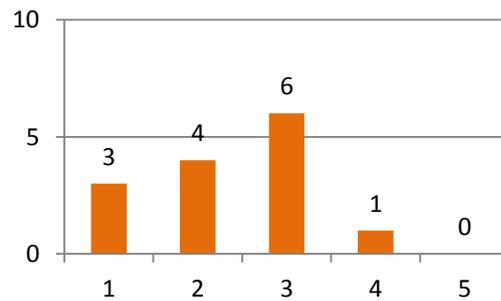
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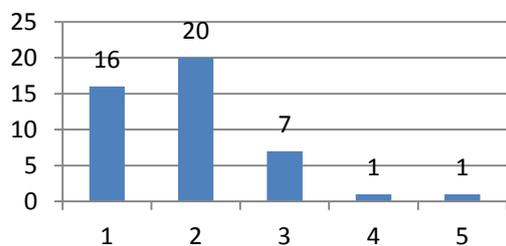
5. The learning materials address all aspects of numerical skills required for Advanced Manufacturing jobs.



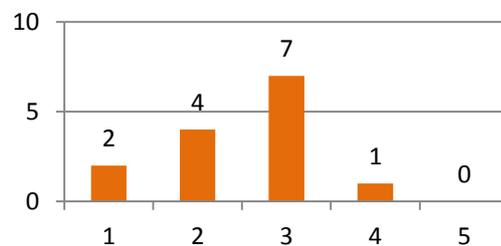
5. The learning materials address all aspects of numerical skills required for Advanced Manufacturing jobs.



6. The learning materials are balanced between the different numerical skills required in the Advanced Manufacturing workplace.

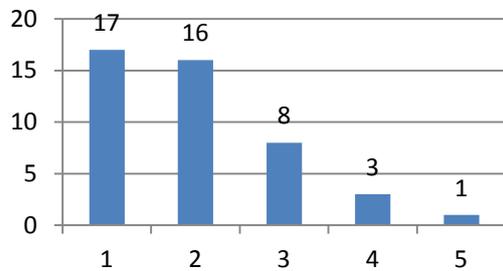


6. The learning materials are balanced between the different numerical skills required in the Advanced Manufacturing workplace.

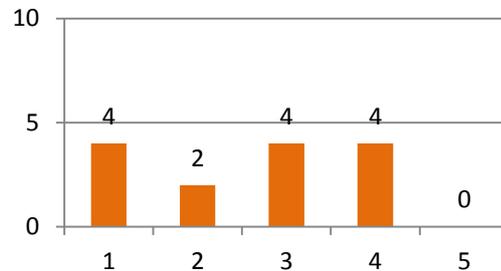




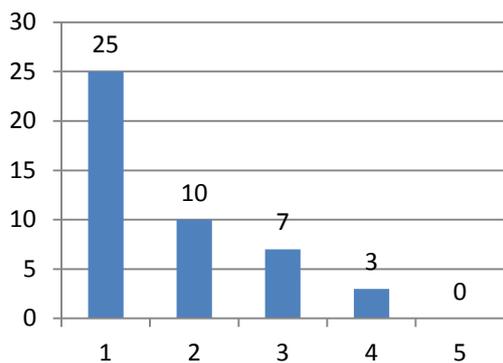
7. The learning materials have the proper difficulty for workers and learners in Advanced Manufacturing sector.



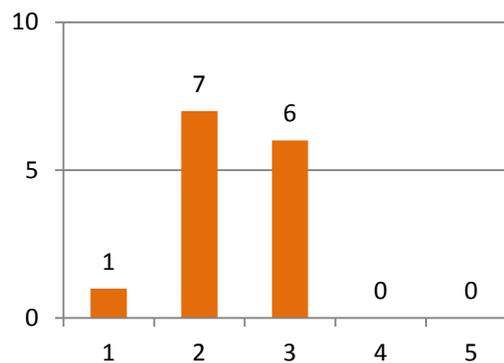
7. The learning materials have the proper difficulty for workers and learners in Advanced Manufacturing sector.



8. The learning materials can improve existing courses for Advanced Manufacturing jobs.



8. The learning materials can improve existing courses for Advanced Manufacturing jobs.



Interestingly, the results from the survey in the Polish training pilot bore a greater similarity to the results from qualitative interviews in the UK and Polish training pilots. Trainers in the UK argued that integration of the NAMA learning material into learning courses would be definitely beneficial to the participants of the course and that they were aware of other existing generalised courses that can help manufacturing industry apprentices, that could be combined with NAMA learning materials. Polish interviewees expressed an equal degree of support for NAMA learning materials as the respondents of the survey.

The difference in the results outlined in the previous paragraph can be understood in the following ways:

- a) Trainers/teachers are more familiar than industry apprentices with other learning courses in which the NAMA learning materials can be integrated, and, as a result, are capable of understanding better their potential positive contribution.



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- b) Industry apprentices are less familiar with materials presented in the form of the NAMA learning materials and as a result found them more difficult to use during the pilot.



2.2.2 Online learning materials/MOOC

The divergence in views between industry apprentices and teachers/trainers observed previously was also present in the issue of the NAMA online learning materials as they were presented through the NAMA MOOC, as can be seen in the diagrams representing the answers to questions 10-14 of the survey questionnaire, at the end of this section. Industry apprentices participating in the UK training pilot evaluated the MOOC as easy to use and claimed that they were able to locate and identify the correlation between the MOOC materials and the tasks they have to conduct in their workplace. This positive evaluation of the NAMA online learning materials was, however somewhat mitigated by the fact that industry apprentices found the NAMA MOOC to be less attractive and suggested the inclusion of animations and interactive media to the course material in order to overcome this problem. Furthermore they made a number of other suggestions towards modifying the material, such as the following:

- Simplifying text with more illustrative diagrams
- Embolden the text for it to stand out (Especially important text)
- More work related questions in exercises

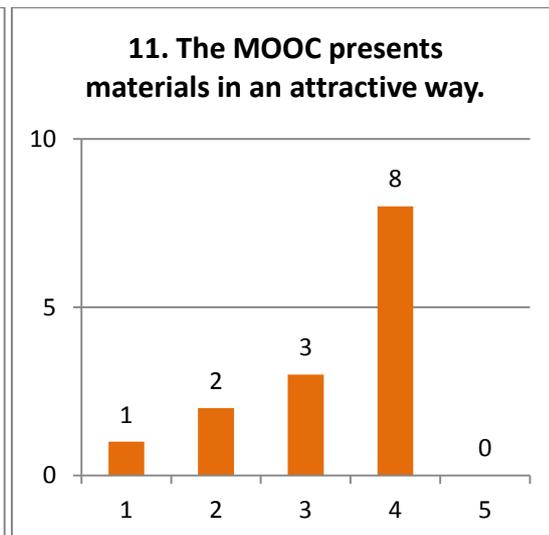
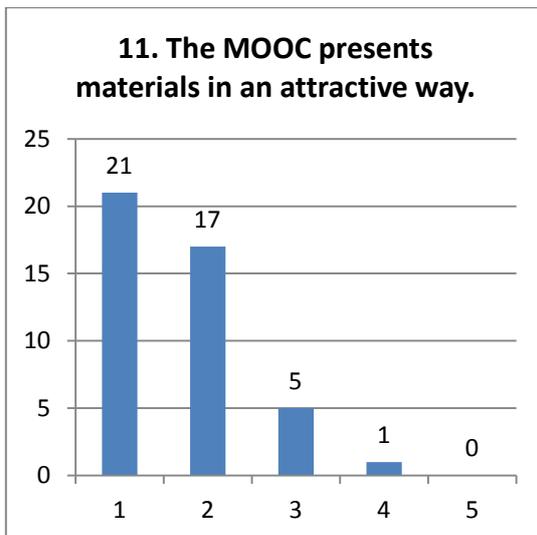
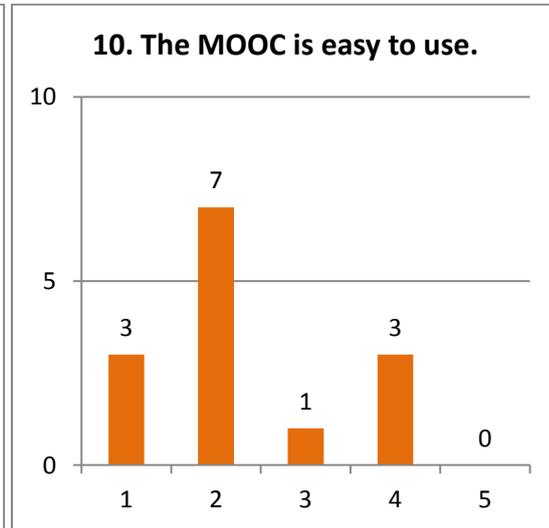
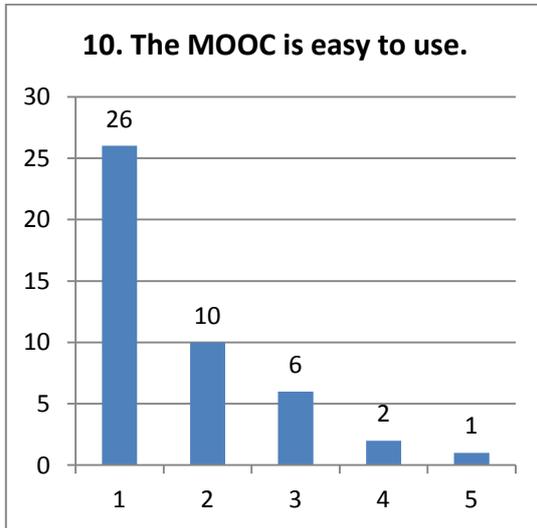
Beyond the apprentices, trainers/teachers both in Poland and the UK strongly claimed that the NAMA online learning materials were relevant to workplace tasks in the industry, especially with regards topics such as trigonometry and basic maths. Compared with the apprentices, trainers in the UK and Poland were much more favourable towards the MOOC's attractiveness, especially in Poland where almost half respondents found the MOOC to be very attractive. They described it as moderate, user-friendly and very useful to continuous learners.

Nevertheless they also made some suggestions for potential improvements in the NAMA MOOC. More precisely, trainers in the UK pilot a) claimed that algebra and the transposition of formulae could have been more fully integrated in the NAMA MOOC, since they are skills which prove to be very useful in advanced manufacturing jobs, b) expressed their concern about how the older generation would be able to cope with using a resource such as the NAMA MOOC, even though it could ultimately help them improve their I.T. Skills, c) suggested some improvements to the material which included standardising the format for videos used in the NAMA MOOC and making it more 'dynamic, and d) brought up the idea of making the material friendly to dyslexic users which would extend the reach of the online



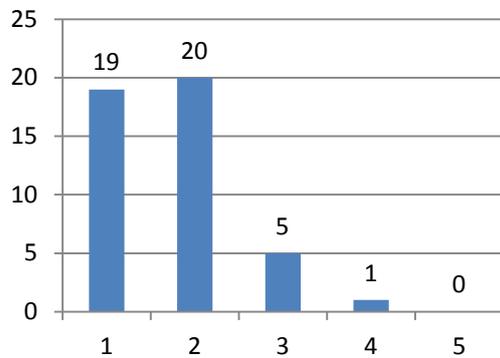
NAMA materials. Polish trainers added to these suggestions the observation that the NAMA MOOC should provide participants the opportunity to record and review their results.

MASSIVE OPEN ONLINE COURSE (MOOC) (blue: Polish training pilot results, orange: UK training pilot results)

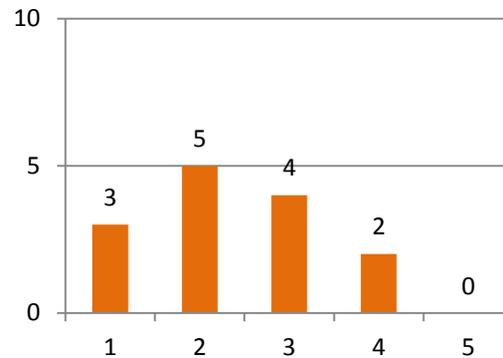




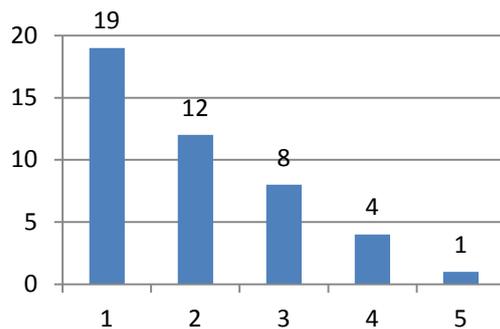
12. The MOOC can significantly contribute to the improvement of numerical skills.



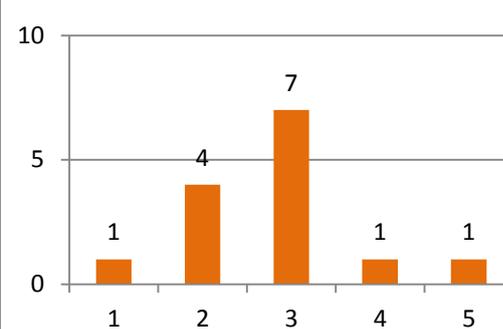
12. The MOOC can significantly contribute to the improvement of numerical skills.



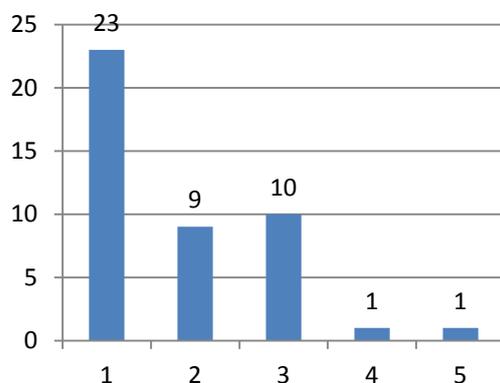
13. I would use the MOOC on a frequent basis for the improvement of numerical skills.



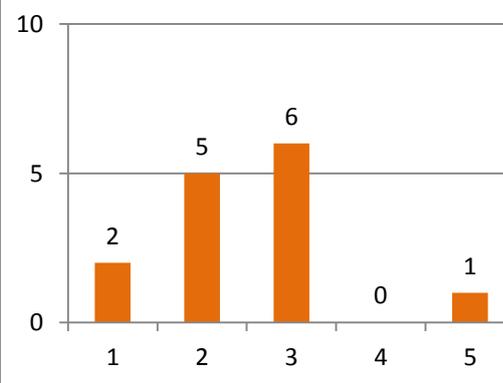
13. I would use the MOOC on a frequent basis for the improvement of numerical skills.



14. I would suggest use of the MOOC to a colleague.



14. I would suggest use of the MOOC to a colleague.



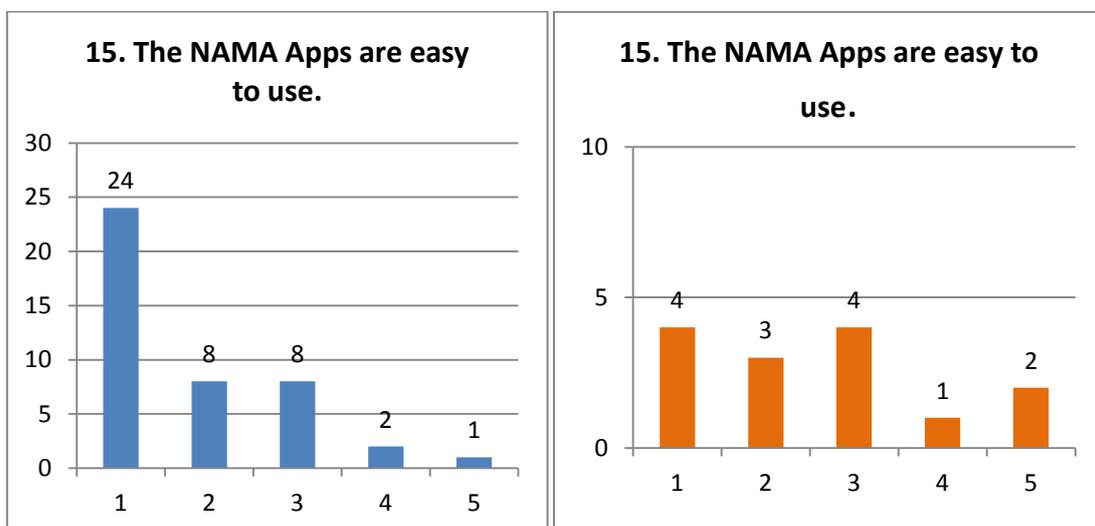


2.2.3 NAMA mobile applications

As can be seen in the histograms at the end of this sections, representing answers to questions 15-19, the Mobile apps were well received by all participants in the training pilots. In fact, industry apprentices found the NAMA mobile applications to be attractive and pleasantly interactive. This trend can be observed in the graphs 15-17 where the participants agree with the statements. In the case of the UK training pilot Graphs 18-19 show a more wide-spread response which targets the perception of the participants about the use of NAMA Apps. Such a widespread response could be a result of the mixed review people have about using apps to study and not particularly towards the use of NAMA Apps. As a suggestion, a good portion of the participants recommended the apps to be made available for Apple and Windows mobile operating software as soon as possible.

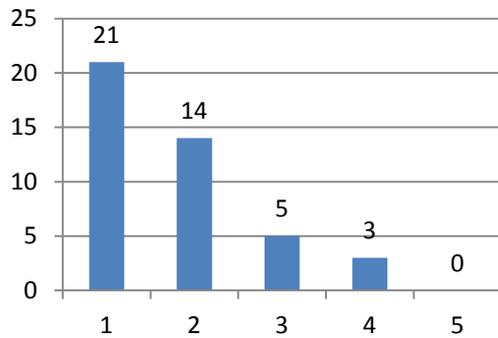
The positive attitude of industry apprentices in the UK pilot was even more exacerbated by the support of participants in the survey and interviews in Poland and of the trainers in the UK. In fact, the trainers found the apps to be the most useful output from NAMA. The apps were found to be simple to navigate and the practise material in the app presented effectively many different practical situations in work areas. The App was judged to be useful for both continuous and initial learners by the trainers. One small suggestion made by Polish participants to further enhance the NAMA mobile apps was to increase their level of competitiveness. It has to be noted that the Polish training pilot did not provide data for question 19 of the survey questionnaire.

MOBILE APPLICATIONS (Apps) (blue: Polish training pilot results, orange: UK training pilot results)

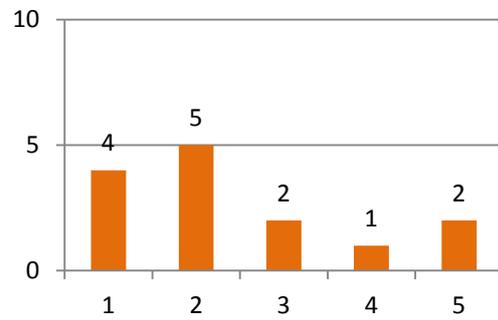




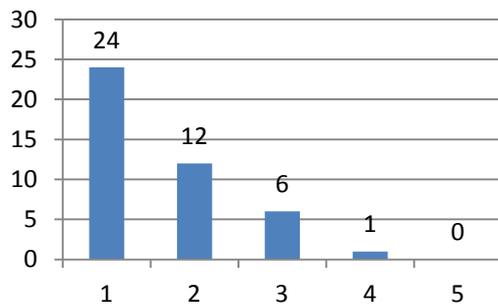
16. Users of NAMA app present materials in an attractive way.



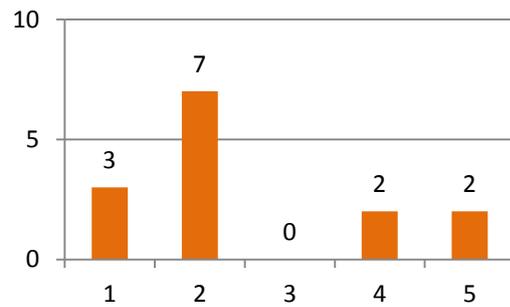
16. Users of NAMA app present materials in an attractive way.



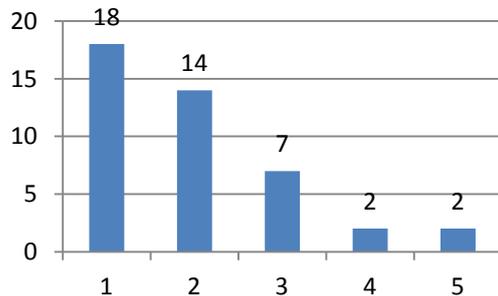
17. The NAMA Apps can significantly contribute to the improvement of numerical skills.



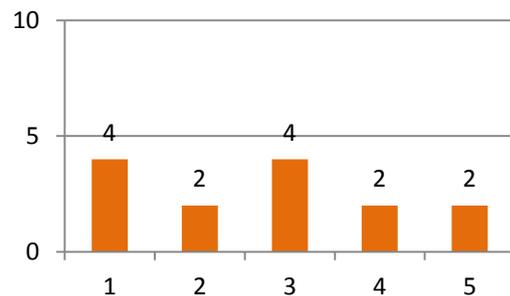
17. The NAMA Apps can significantly contribute to the improvement of numerical skills.



18. I would use the NAMA apps on a frequent basis for the improvement of numerical skills.

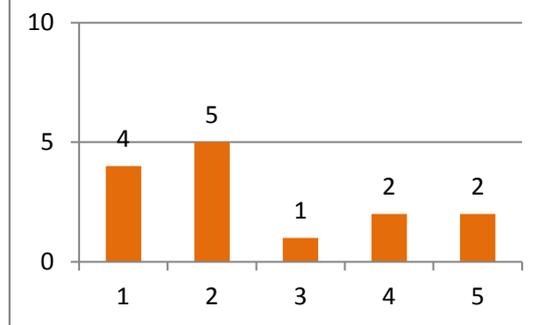


18. I would use the NAMA apps on a frequent basis for the improvement of numerical skills.





**19. I would suggest use of the
NAMA apps to a colleague.**

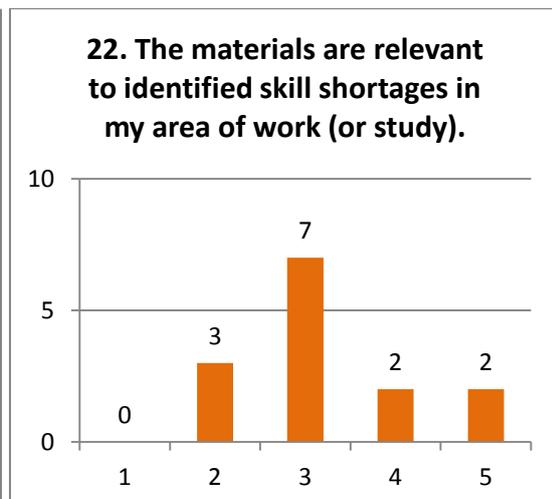
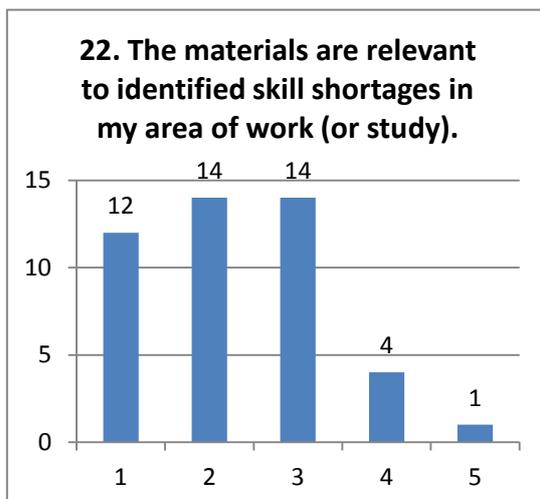
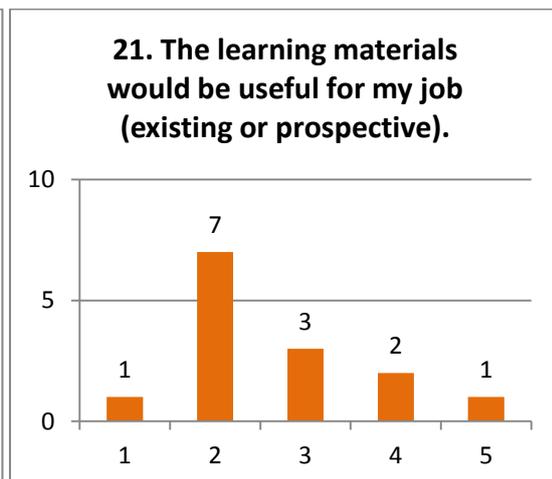
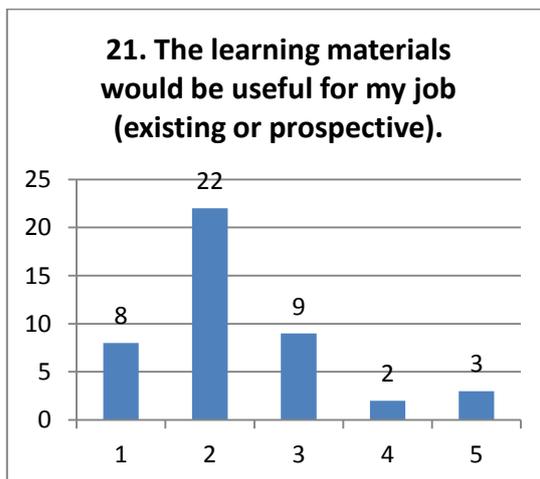




2.2.4 Overall assessment

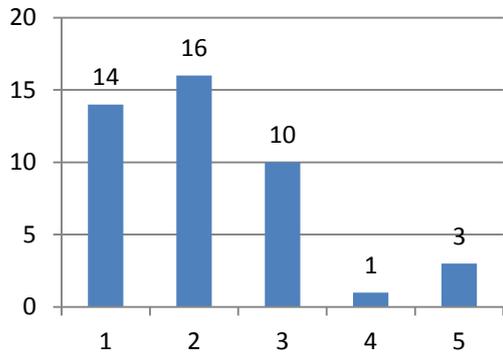
The final set of questions 21-28, summarised by the histograms provided in the end of this section for questions which were not open ended, by gives the views of the participants about the potential effectiveness of the NAMA material towards equipping advanced manufacturing employees with mathematical skills. Most of the participants in both the UK and Polish training pilots agreed that the material met the set objectives and would help advanced manufacturing employees improved their skills on the job. However, industry apprentices in the UK were not always sure that all the material was relevant to identified skill shortages in their area of work (or study) and a significant number among them were unsure about sharing the material with their colleagues.

POTENTIAL EFFECTIVENESS (blue: Polish training pilot results, orange: UK training pilot results)

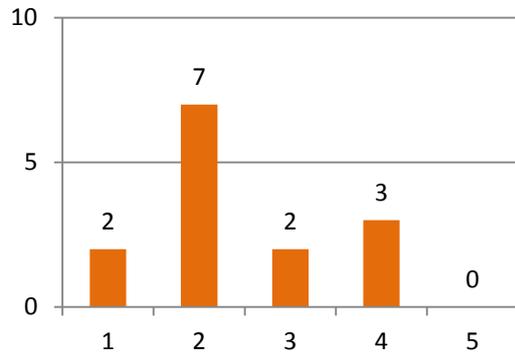




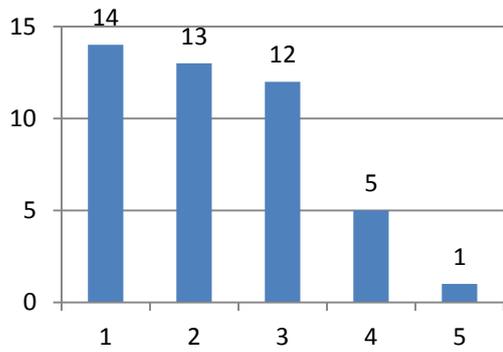
23. The materials can improve my numerical skills.



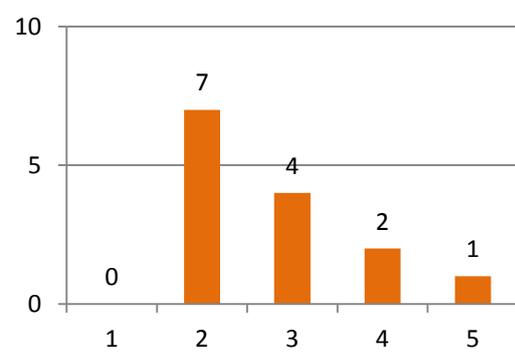
23. The materials can improve my numerical skills.



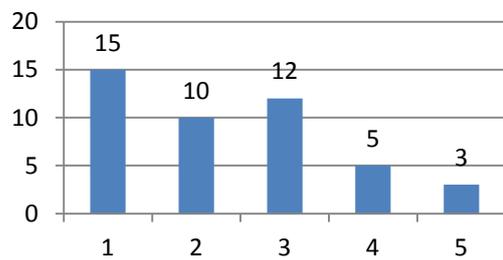
24. The materials can improve the way I would carry out my job tasks.



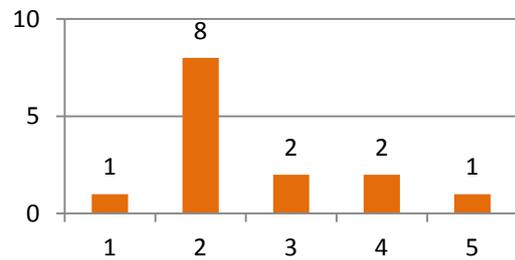
24. The materials can improve the way I would carry out my job tasks.



25. The materials can improve my job or learning performance.

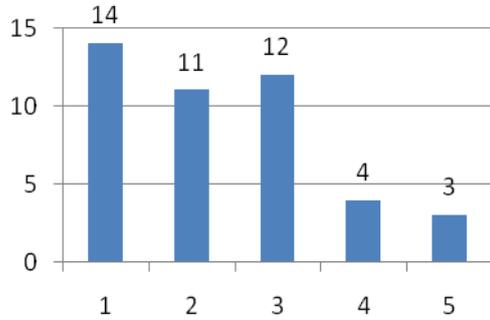


25. The materials can improve my job or learning performance.

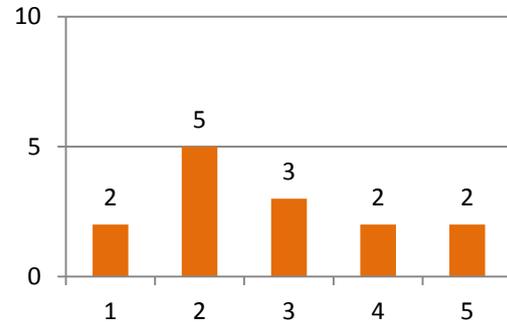




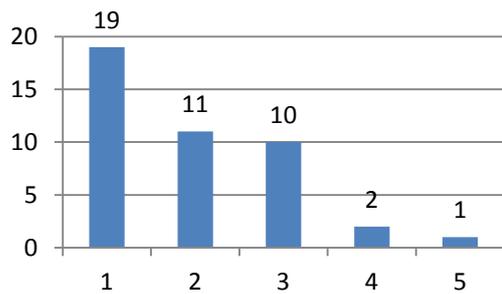
26. The apps motivate me to improve my numerical skills in a recurring manner.



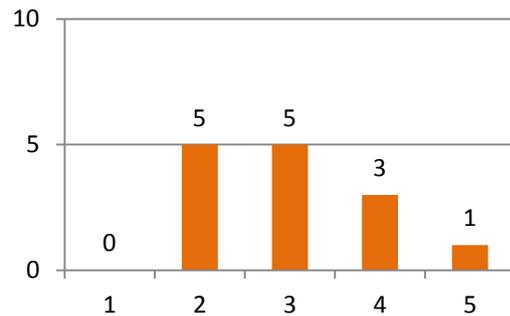
26. The apps motivate me to improve my numerical skills in a recurring manner.



27. I would highly recommend my colleagues to use any of the NAMA learning materials to improve their numeracy skills.



27. I would highly recommend my colleagues to use any of the NAMA learning materials to improve their numeracy skills.





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2.2.5 Discussion and room for improvement

The results of the internal validation procedures have demonstrated that most participants in the training pilots viewed in a favourable way the NAMA learning materials and considered them a useful tool that, if included in their training processes, would improve their performance in the workplace. Of course there were differences in the degree of support for NAMA learning materials: the support was higher among teachers/trainers and slightly lower among industry apprentices. Nevertheless, the overall picture remains that participants in both the Polish and UK training pilot considered the NAMA learning materials a positive contribution to vocational education and training in the advanced manufacturing sector.

This positive attitude towards the materials is confirmed by the fact that questions that received the least positive responses were those that had to do with presentation issues in the learning materials. What that means is that participants in the training pilots, especially in the UK, were highly supportive about the content of learning materials and sceptical about their presentation. On the other hand, it is important that teachers and trainers both in the UK and Poland found the NAMA learning materials appealing. What this means is that, since teachers and trainers are a critical group for the generation of demand for specific educational resources, NAMA learning materials can use this perception of trainers/teachers as a good starting point for their integration in VET programs in the advanced manufacturing sector. To put it bluntly, if teachers don't like the format and appearance of educational resources, they find it more difficult to use them and hence, avoid integrating them in the teaching processes.

At this point, it is important to comment on the divergence among the answers provided by industry apprentices and the answers provided by trainers/teachers. Industry apprentices expressed a lower degree of agreement with the statements in the questions than teachers/trainers. It is remarkable that this was the dominant divergence in the data and not the one between findings in the UK and findings in Poland. The difference in the support expressed by these groups is significant and leads to the conclusion that they are samples that represent populations with different tastes depending on their positions in the VET procedures and the dispositions they have developed therein. Hence, it is possible to hypothesise that teachers/trainers have a better understanding of the importance of producing useful content for the learning materials, thus reducing the relative importance of



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presentation issues. Furthermore, teachers/trainers are due to their position aware of other VET programs which could integrate NAMA learning materials, thus increasing their usefulness. This is the reason why they persistently argued that they would recommend NAMA learning materials to their colleagues. On the other hand, industry apprentices, when using NAMA learning materials, come into contact with 'unfamiliar territory'. What this means is that they find them more difficult to work with because they are involved in a learning process which can sometimes be difficult. Hence, they focus more on the presentation the function of which is exactly to ease the learning process.

Furthermore, it is important to analyse two greatly useful features of NAMA learning materials. First of all, NAMA learning materials make use of e-learning through the NAMA MOOC and of mobile communications technology through the use of the NAMA mobile apps. The positive reception of these materials by all participants (especially the NAMA apps) means that NAMA learning materials constitute a positive application of latest technologies in the domain of VET. This fact will improve the potential reusability of the NAMA learning materials. Last but not least, even though industry apprentices found it sometimes hard to identify the exact tasks in the advanced manufacturing sector that the NAMA learning materials desired to address, the overall content and presentation of the learning materials made it possible for participants in the training pilots to identify themselves areas and tasks where the knowledge gained through NAMA could be applied. This is a very positive feature of the NAMA learning materials since they are structured in a way that facilitates advanced manufacturing employees to adapt them themselves to their workplace tasks. This way, the applicability and reusability of the NAMA learning materials increases significantly.

Finally, even though it was evident that support for NAMA learning materials was firmly proven by the data, the two training pilots revealed a number of areas where there is some room for improvement. As has been hinted in the previous paragraphs a very important area for improvement for NAMA learning materials is the presentation, especially with regards to the NAMA MOOC. More precisely, the materials could be improved in the following ways:

1. The audio in the online learning materials could be improved in order to keep the user's attention.
2. The online materials could make use of animations to make them more appealing.



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3. The solutions provided for the exercises were not fully broken down and failed to explain solving steps in detail.
4. The material could use more diagrams in most topics.

These potential improvements highlight the fact that NAMA learning materials are a useful tool for VET in the advanced manufacturing sector.



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3 External validation

3.1 Summary

External evaluators were professionals experienced in training delivery and development as well as educational materials design and applying online and mobile learning materials in vocational education and training. They evaluated the NAMA learning materials during the design and testing phase, i.e. after their final versions were published.

Actions taken by external evaluators included the following:

- 1) Evaluation of the learning outcomes and learning units during the design phase:
 - a) Quality review of the research used to identify learning outcomes
 - b) Quality of the designed learning units in terms of:
 - i) Epistemological rigour
 - ii) Absence of contradictory statements
 - iii) Provision of solutions for the exercises found in the materials
- 2) Testing of the NAMA online learning materials and especially the MOOC in terms of performance and providing an appealing experience to teachers and students.
- 3) Testing of the NAMA mobile applications in terms of performance and providing an appealing experience to teachers and students.
- 4) Evaluation of internally held validation procedures and data developed therein; reviewing the questionnaires distributed to participants and performing a separate analysis.

Evaluators' comments and observations:

The materials were evaluated as easy to use by both industry employees and trainers/teachers. Furthermore, all target groups averagely or strongly supported that the materials could significantly contribute to an improvement of their work performance. These two facts combined mean that NAMA learning materials provide a good alternative route for organisations that can ensure the participation of their employees but fail to provide the necessary numerical skills differently. The materials have the potential to be applied and improve work performance in the whole range of Advanced manufacturing. They can be utilised in different forms of learning: blended, classroom, self.

More precisely, the majority of experts, trainers and sector employees would benefit from the use of NAMA learning materials due to the following strengths:

- Learning outcomes and units were linked to workplace realities.
- The objectives of learning outcomes and units were clear, they were appropriately structured and not more difficult than necessary.
- They addressed all the necessary skills for working in the advanced manufacturing sector and their focus on different sets of skills was correctly balanced.
- They were attractive to learners, even though some improvements could be made.



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Furthermore, the NAMA online materials and the NAMA mobile applications were easy to use and could be included easily as an addendum to other learning courses for advanced manufacturing employees. It is of great importance that the provision of many different types of learning materials gives learners the opportunity to locate themselves the links between the learning materials and the workplace tasks they have to perform. Providing students with the necessary skills to understand how to apply knowledge themselves, constitutes a much more fruitful and adaptable learning approach than simple memorisation of materials provided through one medium.

Nevertheless, there is room for improvement with regards to the attractiveness of learning materials, especially from a learners' perspective. Even though industry apprentices were overall supportive for the NAMA learning materials, the fact that they found learning materials less attractive mitigated their level of support, compared to the one of teachers/trainers and experts.

A possible future development of the NAMA learning materials may be the identification of VET programs in the advanced manufacturing sector which could incorporate them. Finding such VET programs means that the NAMA learning materials will become part of greater educational corpuses, thus guaranteeing sustainability and widespread use.



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3.2 Validation topics per country

The external evaluation took place in Poland, UK, Belgium and Greece throughout the duration of the project. Necessarily, the methods of evaluation were different in each country, depending on the specific activities each corresponding partners had to carry out. The methodological approach in each of the four countries is outlined in the following sections:

3.2.1 Poland

The external evaluation in Poland focused mostly on the issue of developing learning outcomes and units. More precisely, the evaluation considered the performance of the NAMA consortium on the following activities:

- O1-A1 Definition of research methodology
- O1-A2 Data collection with field and desk research
- O1-A3 Analysis of data and preparation of VET guidelines report
- O2-A1 “Quantity” learning units
- O2-A2 “Change and relationships” learning units
- O2-A3 “Space and shape” learning units
- O2-A4 “Uncertainty and data” learning units
- O2-A7 Updating of materials based on learners and trainers feedback
- E2 NAMA infoday in Poland
- E6 NAMA training Pilot in Poland

For O1 activities, the external evaluation focused on a) the quality of research design and data robustness, b) the quality of data analysis, and c) presentation of guidelines for VET provision, i.e. the results of the research in terms of learning outcomes and training guidelines. The results were the following:

- Quality of research design: the research included both field and desk research, thus utilising triangulation. The questionnaires used in the research made sure that both personal questions and questions related to numerical skills were included, thus allowing for an evaluation of the contribution of each category of respondents.
- Data analysis: The analysis did not take place according to a specific data analysis methodology (e.g. open coding, specific statistical methods).
- Presentation: The presentation of learning outcomes and guidelines in the form of a unified report definitely facilitated the preparation of learning units in O2 activities.

For O2 activities, the main object of enquiry for the external evaluation was the preparation of learning units that would be easy to understand, explain and use so that all target groups could apply them in the VET processes. The learning units were evaluated by experts, teachers and learners as easy to use and understandable during the internal validation processes of the NAMA project. Furthermore, the presentation of each of the learning units corresponding to an O2 activity in the form of a structure, with an introduction to the topic, a presentation of the theory, provision of examples and identification of potential



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applications can help learners identify themselves the relation between the learning units and the tasks they have to tackle in their workplace in advance manufacturing. Nevertheless, the partner preparing the learning units should pay more attention in providing a step by step presentation of solutions to exercises.

Furthermore, the partner responsible for E2 and E6, the NAMA infoday and training pilot in Poland, i.e. Uniwersytet Rzeszowski, carried out these tasks successfully and managed to provide data related to the way teachers and trainers viewed and evaluated the NAMA learning materials. The views of attendees in the training pilots are of immense importance for the validation of NAMA learning materials, and, as a result will be analysed in detail in subsequent sections.

3.2.2 Greece

The external evaluation in Greece was of a significantly more technical character. The Greek partner of the NAMA consortium, i.e. PROMEA was responsible for the delivery of the NAMA online learning materials, and especially the NAMA MOOC, and the NAMA mobile applications, i.e. NAMA activities O3. Hence, the main focus of the evaluation was the preparation of NAMA online materials and mobile apps that would be easy to use, properly functioning and appealing to users.

PROMEA did prepare online materials and mobile apps that were easy to use and properly functioning. However, there is some room for improvement in terms of making them more attractive for learners, i.e. advanced manufacturing employees.

Finally, PROMEA successfully completed the NAMA infoday in Greece, part of activity E2.

3.2.3 United Kingdom

External evaluation in the UK was directed towards the quality of the UK trainer handbook and the successful conduction of a training pilot.

The trainer handbook was a very efficient tool for teachers as it explained adequately the way they could utilise the NAMA MOOC. Nevertheless, there is some room for improvement in terms of providing equivalent information for the NAMA mobile apps as well.

Furthermore, the UK training pilot was conducted successfully and, most importantly, derived quantifiable data mostly from learners, i.e. advanced manufacturing industry apprentices. This was a major contribution of the UK training pilot, since it allowed for the analysis of data derived from more than one target group. In addition, the feedback provided by industry apprentices is very important because they can be the best judges about whether or not NAMA learning materials can help improve their performance in the workplace.

3.2.4 Belgium

A key part of external evaluation in Belgium had to do with the successful deliverance of a training pilot equivalent to the ones conducted in the UK and Poland. Unfortunately, CECIMO, the partner responsible for the conduction of this pilot did not manage to organise



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the training pilot, thus weakening the quality of the evaluation and validation of NAMA learning materials.



3.3 The training pilots results: methodology, outcomes and descriptive statistics

The training pilots' results in the UK and Poland are of immense importance for the external validation. The reason is that the proper evaluation and validation of a project cannot take place without considering the views of target groups and juxtaposing them with the perspectives of a) the external experts and b) the consortium itself. Identifying divergences and convergences in the views of external experts, target groups and the consortium itself, leads to the production of safer conclusions for the applicability of the NAMA learning materials in the VET procedures in the advanced manufacturing sector.

Furthermore, the evaluation of the results of training pilots by an external expert and through different methods signifies the use of triangulation. The triangulated analysis of data collected during the training pilots guarantees the extraction of more robust and better justified conclusions.

The methods chosen to analyse the data from the training pilots by the external experts comprise a number of simple statistical inference methods. First and foremost, the evaluation starts with the presentations of the descriptive statistics of the two training pilots.

The Poland training pilot, whose descriptive statistics are presented below consisted of a sample of size 45 comprised mostly by trainers/teachers. The descriptive statistics of the level of support for the statements of all questions was calculated and produced the following results:

| <i>Poland training pilot results</i> | |
|--------------------------------------|--------------|
| Mean | 1,95768587 |
| Standard Error | 0,046260949 |
| Median | 1,922222222 |
| Mode | 1,911111111 |
| Standard Deviation | 0,226631439 |
| Sample Variance | 0,051361809 |
| Kurtosis | -0,967051993 |
| Skewness | 0,486288528 |
| Range | 0,727648579 |
| Minimum | 1,627906977 |
| Maximum | 2,355555556 |
| Sum | 46,98446089 |
| Count | 24 |



On the other hand, the UK training pilot provided data based on a sample of size 14, comprised by a number of advanced manufacturing industry apprentices, who responded to 24 quantifiable questions from the survey questionnaire. The descriptive statistics of the level of support for the statements of all questions was calculated and produced the following results:

| <i>UK training pilot results</i> | |
|----------------------------------|-------------|
| Mean | 2,580357143 |
| Standard Error | 0,059313162 |
| Median | 2,535714286 |
| Mode | 2,571428571 |
| Standard Deviation | 0,290573966 |
| Sample Variance | 0,08443323 |
| Kurtosis | 0,901107741 |
| Skewness | 0,882239943 |
| Range | 1,214285714 |
| Minimum | 2,071428571 |
| Maximum | 3,285714286 |
| Sum | 61,92857143 |
| Count | 24 |

The comparison of the two tables allows us to recognise some key differences in the findings:

- Data from Poland show a somewhat greater mean level of support for the statements in the survey questions, than data from the UK:
(1,95768587 < 2,580357143)
- The standard deviation in the responses from the UK was greater than the one from Poland:
(0,226631439 < 0,290573966)
- Responses from the UK show a much greater range:
(0,727648579 < 1,214285714)
- Unlike in Poland there are questions that did not gather the support of respondents in the UK training pilot as can be seen by the fact that in the UK there are maxima



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that are significantly larger than 2,5, and hence they show that there is a less than average support for the questions' statements:

(2,35555556 < 3,285714286)

Several conclusions can be derived from the results outlined above. First of all, there is a difference in the mean level of support for the NAMA learning materials between attendees in the training pilot in Poland and attendees in the UK. Even though both express a support that is average or greater for the NAMA learning materials, this difference needs to be further analysed and this is the topic of the next section.

Beyond this difference, the results show that the sample in the training pilot in Poland is more homogenous and shows less deviations and smaller range than the sample in the UK. The answers look more standardised and this points to the existence of differences in the qualitative characteristics among populations.

This difference could be due to the fact that the respondents in the training pilot in Poland occupy all an equivalent position in VET procedures: they are teachers. Hence, they come into contact every day with a number of diverse educational materials and, through their education and working experience, have standardised their evaluation of their characteristics. On the contrary, industry apprentices, such as the attendees of the UK training pilot have not standardised their evaluation of learning materials and hence, provide more diverse responses.

In addition, industry apprentices come into contact with a material with which they are not familiar. The difficulty of understanding the materials should be evident in their responses and this might be the reason why they show less support for the materials than teachers/trainers.

The problem however, is that the observed differences might not be due to the fact that teachers and industry apprentices have different perspectives and dispositions. They might appear because people living in Poland have different views from people living in the UK. To complete the analysis of the training pilots attendees' responses, it is necessary to find out which of the two is the real reason for the difference in the level of support. Only then it will be possible to justify the ways to improve the NAMA learning materials.



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3.4 The training pilot results: T-test

3.4.1 Why use the t-test.

The *t*-test is one type of inferential statistics. It is used to determine whether there is a significant difference between the means of two groups. The *t*-test is used when the difference between two population averages is being investigated. More precisely, a *t* test is used when we wish to compare two means (the scores must be measured on an interval or ratio measurement scale). Using the *t*-test, researchers want to argue with some degree of confidence that the obtained difference between the means of the sample groups is too great to be a chance event and that some difference also exists in the population from which the sample was drawn.

The *t*-test will be used in order to compare the support for the NAMA learning materials between attendees of training pilots in the UK and Poland and whether it is significant or not. In other words, the difference that has been found in the support for the NAMA materials between the two training pilots in our sample might have occurred by chance, or they might exist in the population. If the *t*-test produces a *t*-value that is large enough, we could say that it is unlikely that our results occurred by chance and, therefore, the difference that occurred in the samples probably exists in the populations from which it was drawn. Hence there would be a statistically significant difference in the level of support for the NAMA learning materials between respondents in Poland and the UK.

Five factors contribute to whether the difference between two groups' means can be considered significant:

1. How large is the difference between the means of the two groups? Other factors being equal, the greater the difference between the two means, the greater the likelihood that a statistically significant mean difference exists. If the means of the two groups are far apart, we can be fairly confident that there is a real difference between them.
2. How much overlap is there between the groups? This is a function of the variation within the groups. Other factors being equal, the smaller the variances of the two groups under consideration, the greater the likelihood that a statistically significant mean difference exists. We can be more confident that two groups differ when the scores within each group are close together.



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3. How many subjects are in the two samples? The size of the sample is extremely important in determining the significance of the difference between means. With increased sample size, means tend to become more stable representations of group performance. If the difference we find remains constant as we collect more and more data, we become more confident that we can trust the difference we are finding.
4. What alpha level is being used to test the mean difference (how confident do you want to be about your statement that there is a mean difference). A larger alpha level requires less difference between the means. It is much harder to find differences between groups when you are only willing to have your results occur by chance 1 out of a 100 times ($p < .01$) as compared to 5 out of 100 times ($p < .05$).
5. Is a directional (one-tailed) or non-directional (two-tailed) hypothesis being tested? Other factors being equal, smaller mean differences result in statistical significance with a directional hypothesis.

3.4.2 The t-test in the NAMA training pilots

The samples used in the NAMA training pilots were the same used to develop the descriptive statistics mentioned earlier. Hence, they were the mean level of support found in Poland and the UK for each of the quantifiable questions in the survey questionnaire. The only difference was that responses to question 24 were omitted from the data because the Poland training pilot did not provide answers for this question.

As can be seen in the table below, the t-Stat found for the mean level of support among the two samples that represent the Polish and British attendees in the training pilots shows that there is a statistically significant difference in the level of support among the two populations, which can be explained only if the difference in the samples is due to the existence of differences among the two populations. Results from Poland training pilot show a greater than average degree of support for NAMA learning materials whereas results from the UK training pilot show an average level of support. As a result it is necessary to make a number of hypotheses as to why this difference is observed.



| t-Test: Two-Sample Assuming Unequal Variances | | | | |
|--|----------------------------------|-------------|--------------------------------------|--|
| | <i>UK training pilot results</i> | | <i>Poland training pilot results</i> | |
| Mean | 2,580357143 | | 1,95768587 | |
| Variance | 0,08443323 | | 0,051361809 | |
| Observations | 24 | | 24 | |
| Hypothesized Mean Difference | | 0 | | |
| df | | 43 | | |
| t Stat | | 8,277944277 | | |
| P(T<=t) one-tail | | 9,60878E-11 | | |
| t Critical one-tail | | 1,681070704 | | |
| P(T<=t) two-tail | | 1,92176E-10 | | |
| t Critical two-tail | | 2,016692173 | | |

The difference in the mean level of support for the two populations can be due either to the fact that Polish and UK attendees live in different countries or that they occupy different niches in the VET procedure and, hence, make different evaluations for the learning materials.

The hypothesis that the observed difference is due to the distinct realities between UK and Poland is contradictory with the fact that there are parts of the NAMA learning materials that are better adapted for UK users, yet their reception in Poland has been more positive. For example, even though the MOOC contains videos that are only in English and have not been translated in Polish, Polish attendees were more supportive towards its application in VET. If the problem was that the materials somewhat alienated the UK attendees, than this effect should have been mitigated in questions 10-15 about the MOOC, since Polish attendees would have the disadvantage of coming into contact with material only in English. Therefore their support for the MOOC should have been lower. However, in Poland, the average support for the MOOC was even greater compared to the NAMA learning materials in their entirety. As a result it is highly likely that main differentiating factor among the two populations was not the distinct realities of living in the UK and Poland.

On the contrary, it is possible to hypothesise that the observed divergence in the level of support is due to the different niches the attendees in the UK and Poland training pilots



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occupy in VET procedures. This hypothesis can be confirmed if one considers the fact that the results from Poland were more similar with the qualitative results from trainers in the UK. Hence, they were more similar with data obtained from people occupying similar niches in VET procedures, as has been explained previously. Hence, the way to improve the NAMA learning materials is through increasing their attractiveness to advanced manufacturing industry employees.



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4 Annex 1

INTERVIEW GUIDE

The goal of this short interview is to gather evaluations, feedback, and suggestions from trainers, in order to optimise and make revisions (if required) to the NAMA learning materials, to maximise their usefulness and impact.

A. Learning materials assessment

- 1) Which Advanced Manufacturing workplace tasks and processes are mostly relevant to NAMA learning materials?

- 2) Based on your knowledge/experience, which numerical skills are mostly required for Advanced Manufacturing jobs? To what extent do NAMA learning materials address each of them?

- 3) Do you know any existing courses for Advanced Manufacturing workers? Do you believe that integration of NAMA learning materials will improve existing courses?

- 4) Do you have any suggestions on how learning materials could be improved?



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B. NAMA MOOC

- 1) Did you find the NAMA MOOC easy to use? If no, which features/applications did you find difficult to understand?

- 2) What skills could a learner mostly improve after attending the MOOC course?

- 3) Do you think that a MOOC is a more appropriate learning method for:
a) a continuous or an initial learner?
b) a current or a prospective employee?

- 4) Do you have any suggestions on how NAMA MOOC could be improved?



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C. NAMA apps

- 1) Did you find the NAMA apps easy to use? If no, which features did you find difficult to understand?

- 2) In which ways can the NAMA Apps contribute to the improvement of numerical skills? Do you believe that there are certain advantages compared to “traditional” teaching approaches?

- 3) Do you think that the apps are a more appropriate learning method for:
a) a continuous or an initial learner?
b) a current or a prospective employee?

- 4) Do you have any suggestions on how NAMA apps could be improved?



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D. Interviewee's characteristics

- 1) Interviewee is (or represents):
 - i. vocational learner/student in the Advanced Manufacturing industry.
 - ii. vocational education and training provider/trainer of courses related to Advanced Manufacturing industry.
 - iii. Other:

- 2) First & last name:

- 3) Organisation name:

- 4) Job title / position in the organization:

E. Additional interviewee's comments

Please note any additional comments not covered by previous topics



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5 Annex 2

Readers can see below the questions of the survey questionnaire used in the training pilots:

LEARNING MATERIALS ASSESSMENT

- 1) The learning materials are clearly linked to Advanced Manufacturing workplace realities (concepts, skills, tasks).
- 2) The learning goals and objectives to be attained by learners are clear.
- 3) The learning materials are well-written and concise.
- 4) The learning content is appropriately structured and organised for the provision of vocational education & training.
- 5) The learning materials address all aspects of numerical skills required for Advanced Manufacturing jobs.
- 6) The learning materials are balanced between the different numerical skills required in the Advanced Manufacturing workplace.
- 7) The learning materials have the proper difficulty for workers and learners in Advanced Manufacturing sector.
- 8) The learning materials can improve existing courses for Advanced Manufacturing jobs.
- 9) Please describe ways in which you think the learning materials could be improved

NAMA ONLINE LEARNING MATERIALS

- 10) The MOOC is easy to use.
- 11) The MOOC presents materials in an attractive way.
- 12) The MOOC can significantly contribute to the improvement of numerical skills.
- 13) I would use the MOOC on a frequent basis for the improvement of numerical skills.
- 14) I would suggest use of the MOOC to a colleague.

NAMA MOBILE LEARNING APPLICATIONS

- 15) The NAMA Apps are easy to use.
- 16) Users of NAMA app present materials in an attractive way.
- 17) The NAMA Apps can significantly contribute to the improvement of numerical skills.
- 18) I would use the NAMA apps on a frequent basis for the improvement of numerical skills.
- 19) I would suggest use of the NAMA apps to a colleague.
- 20) Please describe ways in which you think NAMA tools could be improved?

POTENTIAL EFFECTIVENESS

- 21) The learning materials would be useful for my job (existing or prospective).
- 22) The materials are relevant to identified skill shortages in my area of work (or study).
- 23) The materials can improve my numerical skills.
- 24) The materials can improve the way I would carry out my job tasks.
- 25) The materials can improve my job or learning performance.



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- 26) The apps motivate me to improve my numerical skills in a recurring manner.
- 27) I would highly recommend my colleagues to use any of the NAMA learning materials to improve their numeracy skills.
- 28) Please describe ways in which you think the NAMA learning materials would be more impactful in the workplace or the classroom.