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Analysis of numerical skills needs in advanced manufacturing

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Abstract

We present the results of the analysis of 179 questionnaires that were distributed electronically to three categories of people related to the advanced manufacturing sector: workers, trainees and VET providers. The results show some trends concerning the direction of training in numerical skills.

1 Methodology

The design of the questionnaires which comprised the main data collection tool was based on the desk research that was performed, enhanced by a continuous feedback by the partners who have experience in training in the AM sector. A series of questions were constructed that aimed to identify the needs of AM workers. Finally, we will present some comparisons of the above training needs as they are perceived by different categories of stakeholders.

2 Results

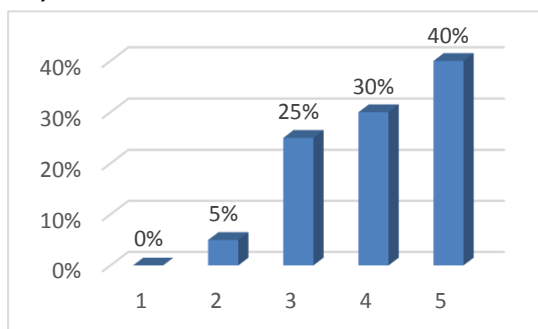
2.1 Results from the workers research

The questionnaire for workers was delivered in two languages, English and Polish. A total of 60 workers answered the online questionnaires, 52 the English and 8 the Polish version. Here are the results from four particular questions.

1. How important do you think that mathematics is in your work?

(1: not at all important – 5: very important)

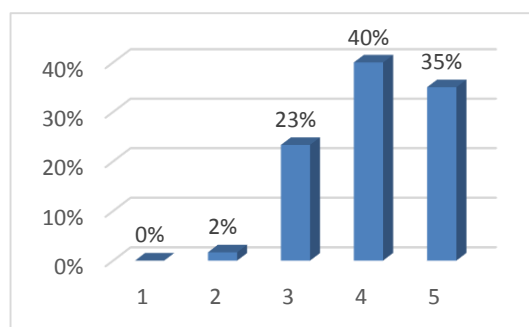
Scale	Number (EN)	Number (PL)	Total	Percentage
1	0	0	0	0%
2	3	0	3	5%
3	14	1	15	25%
4	16	2	18	30%
5	19	5	24	40%



2. Do you think that you have enough mathematical knowledge to be efficient in your work?

(1: definitely not – 5: definitely yes)

Scale	Number (EN)	Number (PL)	Total	Percentage
1	0	0	0	0%
2	1	0	1	2%
3	13	1	14	23%
4	21	3	24	40%
5	17	4	21	35%



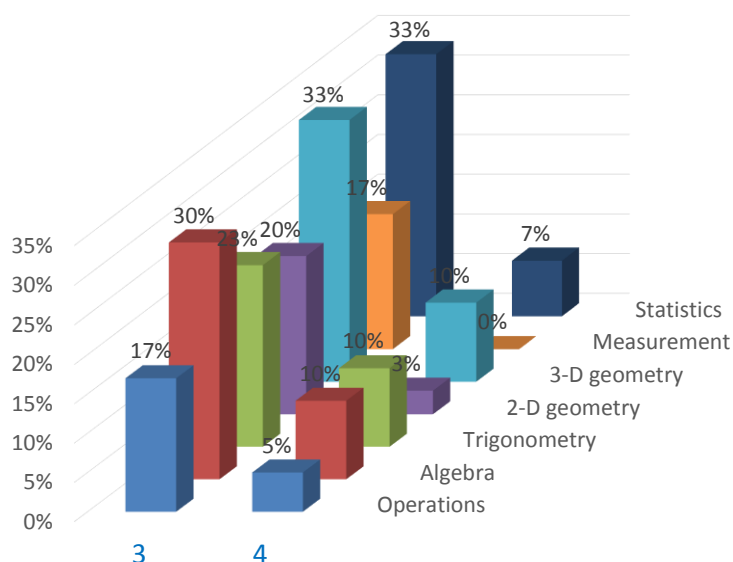
3. In which of the following areas you believe that you need further training?

(1: definitely not, 2: rather not, 3: rather yes, 4: definitely yes, 5: does not apply to my case)

Number	Mathematical field	1	2	3	4	5
1.	numbers and operations	26	20	10	3	1
2.	algebraic expressions, formulas and functions	18	17	18	6	1
3.	trigonometry	16	23	14	6	1
4.	2-D geometry	19	22	12	2	5
5.	3-D geometry	16	18	20	6	5
6.	measuring length, areas and volumes	25	24	10	0	1
7.	statistics and probability	16	16	20	4	4

If we select only the positive answers (3: “rather yes” and 4: “definitely yes”) we get the following table:

Number	Mathematical field	3	%	4	%	Total
1.	numbers and operations	10	17%	3	5%	22%
2.	algebraic expressions, formulas and functions	18	30%	6	10%	40%
3.	trigonometry	14	23%	6	10%	33%
4.	2-D geometry	12	20%	2	3%	23%
5.	3-D geometry	20	33%	6	10%	43%
6.	measuring length, areas and volumes	10	17%	0	0%	17%
7.	statistics and probability	20	33%	4	7%	40%

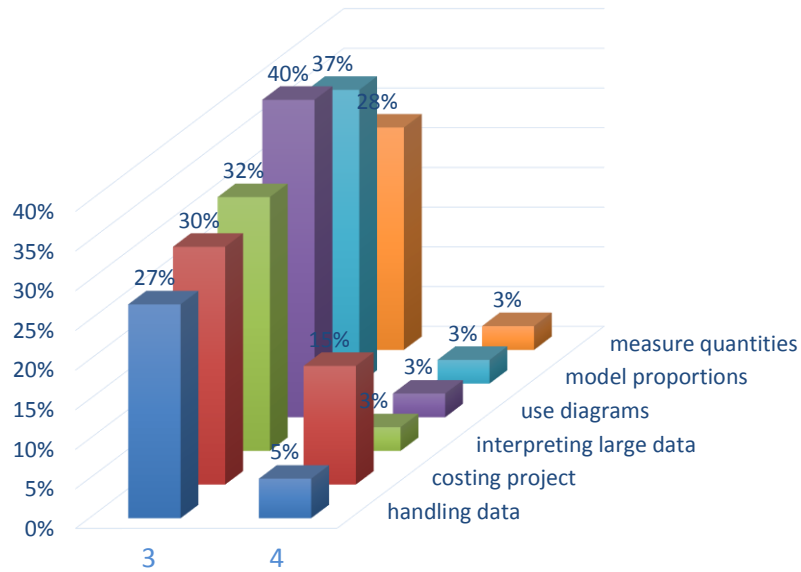


4. For which of the following general mathematical skills you would appreciate some training? (1: definitely not, 2: rather not, 3: rather yes, 4: definitely yes, 5: does not apply to my case)

Numerical skill	Scale				
	1	2	3	4	5
handling (experimental) data graphically	12	26	16	3	3
costing a project (e.g., in terms of money, materials, energy use, etc.)	9	22	18	9	2
interpreting large data sets	12	23	19	2	4
using mathematical diagrams	12	19	24	2	3
using models of direct proportion	11	20	22	2	5
measuring quantities	14	25	17	2	2

If we select only the positive answers (3: “rather yes” and 4: “definitely yes”) we get the following table:

Numerical skill	3	%	4	%	Total
handling (experimental) data graphically	16	27%	3	5%	32%
costing a project (e.g., in terms of money, materials, energy use, etc.)	18	30%	9	15%	45%
interpreting large data sets	19	32%	2	3%	35%
using mathematical diagrams	24	40%	2	3%	43%
using models of direct proportion	22	37%	2	3%	40%
measuring quantities	17	28%	2	3%	31%



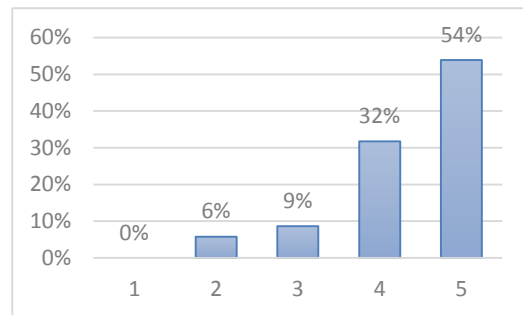
2.2 Results from the trainees research

The questionnaire for trainees was delivered in two languages, English and Polish. A total of 104 trainees answered the online questionnaires, 40 the English and 64 the Polish version. Here are the results from the same four questions.

1. How important do you think that mathematics is in your training?

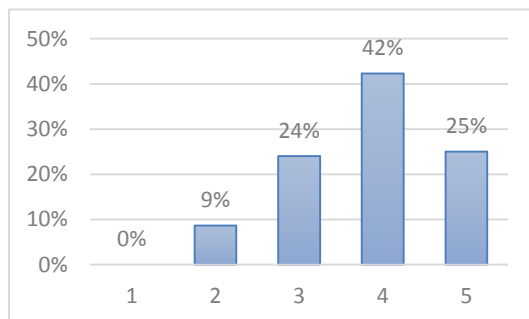
(1: not at all important – 5: very important)

Scale	Number (EN)	Number (PL)	Total	Percentage
1	0	0	0	0%
2	4	2	6	6%
3	3	6	9	9%
4	11	22	33	32%
5	22	34	56	54%



2. Do you think that you have enough mathematical knowledge to be efficient in your future work? (1: definitely not – 5: definitely yes)

Scale	Number (EN)	Number (PL)	Total	Percentage
1	0	0	0	0%
2	1	8	9	9%
3	7	18	25	24%
4	22	22	44	42%
5	10	16	26	25%



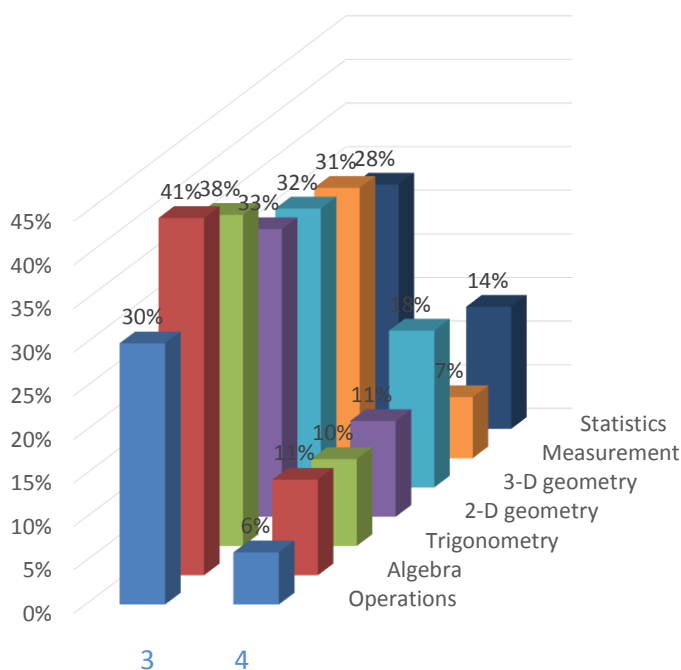
3. In which of the following areas you believe that you need further training?

(1: definitely not, 2: rather not, 3: rather yes, 4: definitely yes, 5: does not apply to my case)

Number	Mathematical field	1	2	3	4	5
1.	numbers and operations	27%	37%	30%	6%	1%
2.	algebraic expressions, formulas and functions	24%	22%	41%	11%	2%
3.	trigonometry	19%	33%	38%	10%	1%
4.	2-D geometry	21%	34%	33%	11%	2%
5.	3-D geometry	16%	31%	32%	18%	3%
6.	measuring length, areas and volumes	26%	37%	31%	7%	0%
7.	statistics and probability	17%	30%	28%	14%	11%

If we select only the positive answers (3: “rather yes” and 4: “definitely yes”) we get the following table:

Number	Mathematical field	3	4	Total
1.	numbers and operations	30%	6%	36%
2.	algebraic expressions, formulas and functions	41%	11%	52%
3.	trigonometry	38%	10%	48%
4.	2-D geometry	33%	11%	44%
5.	3-D geometry	32%	18%	50%
6.	measuring length, areas and volumes	31%	7%	38%
7.	statistics and probability	28%	14%	42%

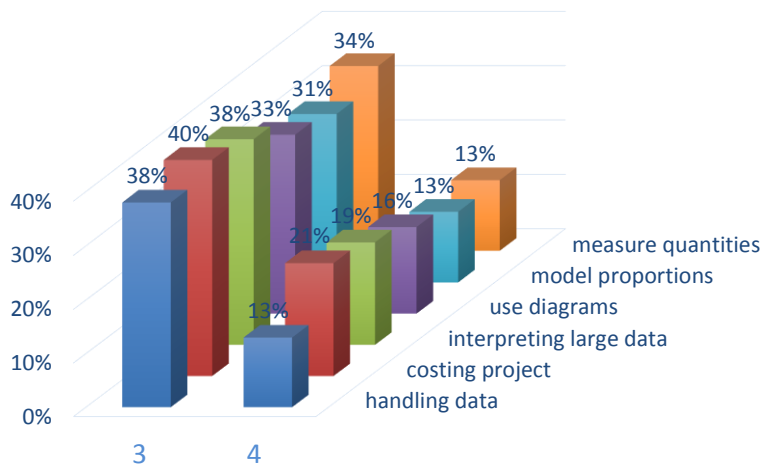


4. For which of the following skills you would appreciate some more training?
 (1: definitely not, 2: rather not, 3: rather yes, 4: definitely yes, 5: does not apply to my case)

Numerical skill	Scale				
	1	2	3	4	5
handling (experimental) data graphically	7	12	14	6	1
costing a project (e.g., in terms of money, materials, energy use, etc.)	5	10	13	9	3
interpreting large data sets	5	11	15	5	4
using mathematical diagrams	7	15	13	5	0
using models of direct proportion	4	11	14	7	4
measuring quantities	7	14	13	5	1

If we select only the positive answers (3: “rather yes” and 4: “definitely yes”) we get the following table:

Numerical skill	3	%	4	%	Total
handling (experimental) data graphically	14	38%	6	13%	51%
costing a project (e.g., in terms of money, materials, energy use, etc.)	13	40%	9	21%	61%
interpreting large data sets	15	38%	5	19%	57%
using mathematical diagrams	13	33%	5	16%	49%
using models of direct proportion	14	31%	7	13%	44%
measuring quantities	13	34%	5	13%	47%

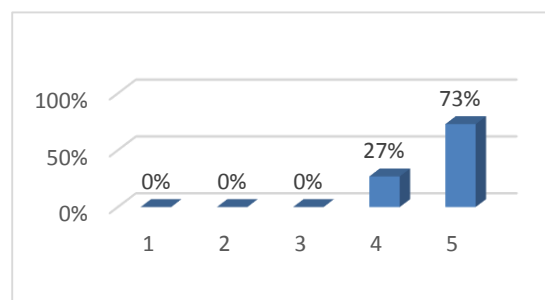


2.3 Results from the VET providers research

The questionnaire for VET providers was delivered in two languages, English and Polish. A total of 15 VET providers answered the online questionnaires, 9 the English and 6 the Polish version. Here are the results from the same four questions.

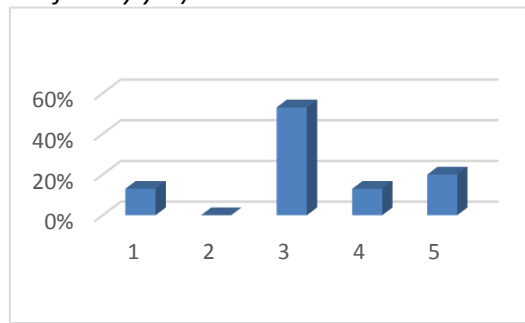
1. How important do you think that mathematics is in training for advanced manufacturing workers? (1: not at all important – 5: very important)

Scale	Number (EN)	Number (PL)	Total	Percentage
1	0	0	0	0%
2	0	0	0	0%
3	0	0	0	0%
4	3	1	4	27%
5	6	5	11	73%



2. Do you think that your school provides enough mathematical knowledge for your trainees to be efficient in their (future) work? (1: definitely not – 5: definitely yes)

Scale	Number (EN)	Number (PL)	Total	Percentage
1	0	2	2	13%
2	0	0	0	0%
3	5	3	8	53%
4	2	0	2	13%
5	2	1	3	20%



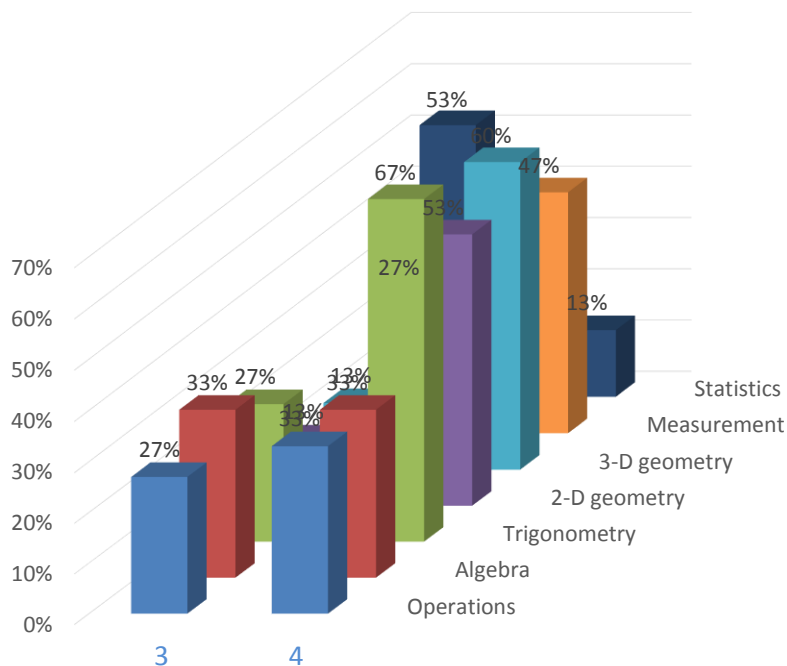
3. In which of the following areas you believe that your trainees in advanced manufacturing need (further) training?

(1: definitely not, 2: rather not, 3: rather yes, 4: definitely yes, 5: does not apply to my case)

Number	Mathematical field	1	2	3	4	5
1.	numbers and operations	7%	33%	27%	33%	0%
2.	algebraic expressions, formulas and functions	0%	20%	33%	33%	13%
3.	trigonometry	0%	7%	27%	67%	0%
4.	2-D geometry	0%	13%	13%	53%	20%
5.	3-D geometry	0%	7%	13%	60%	0%
6.	measuring length, areas and volumes	0%	13%	27%	47%	13%
7.	statistics and probability	0%	13%	53%	13%	20%

If we select only the positive answers (3: “rather yes” and 4: “definitely yes”) we get the following table:

Number	Mathematical field	3	4	Total
1.	numbers and operations	27%	33%	60%
2.	algebraic expressions, formulas and functions	33%	33%	66%
3.	trigonometry	27%	67%	94%
4.	2-D geometry	13%	53%	66%
5.	3-D geometry	13%	60%	73%
6.	measuring length, areas and volumes	27%	47%	74%
7.	statistics and probability	53%	13%	66%

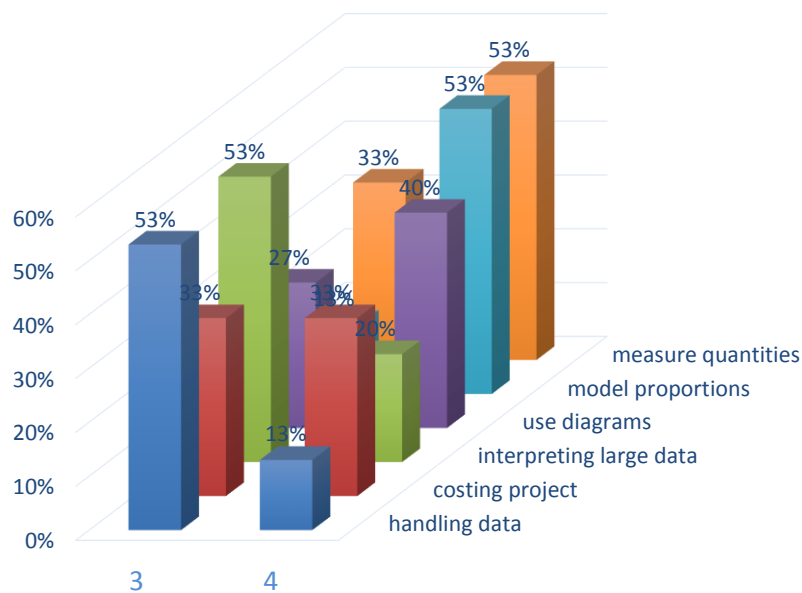


4. For which of the following skills you believe that more training is needed?

Numerical skill	Scale				
	1	2	3	4	5
handling (experimental) data graphically	0%	20%	53%	13%	13%
costing a project (e.g., in terms of money, materials, energy use, etc.)	0%	20%	33%	33%	13%
interpreting large data sets	0%	7%	53%	20%	20%
using mathematical diagrams	0%	20%	27%	40%	13%
using models of direct proportion	0%	13%	13%	53%	20%
measuring quantities	0%	13%	33%	53%	0%

If we select only the positive answers (3: “rather yes” and 4: “definitely yes”) we get the following table:

Numerical skill	3	4	Total
handling (experimental) data graphically	53%	13%	67%
costing a project (e.g., in terms of money, materials, energy use, etc.)	33%	33%	67%
interpreting large data sets	53%	20%	73%
using mathematical diagrams	27%	40%	67%
using models of direct proportion	13%	53%	67%
measuring quantities	33%	53%	87%



3 Conclusions

The results from the data collection processes described in the previous sections can be summarised as follows:

- There is a common perception among the participants from all categories related to the AM sector (workers, workers during training VET providers, higher education teachers,

employers and managers) on the high importance of mathematical knowledge in the sector. This perception has been demonstrated by the high percentages of the positive answers to the question “How important do you think that mathematics is in advanced manufacturing sector?” (1: not at all important – 5: very important)

- Although the workers feel rather confident with their mathematical knowledge, they do identify particular mathematical fields where their training should focus (in the parentheses the percentages of the positive answers to the question “In which of the following areas you believe that you need further training?” (1: definitely not, 2: rather not, 3: rather yes, 4: definitely yes, 5: does not apply to my case) are shown): algebraic expressions, formulas and functions (40%), 3-D geometry (43%) and statistics and probability (40%).
- With respect to the mathematical fields that the training should focus on, the table below summarises the results from all the categories of participants that answered the particular question:

Mathematical field	Workers	Trainees	VET providers
numbers and operations	22%	36%	60%
algebraic expressions, formulas and functions	40%	52%	66%
trigonometry	33%	48%	94%
2-D geometry	23%	44%	66%
3-D geometry	43%	50%	73%
measuring length, areas and volumes	17%	38%	74%
statistics and probability	40%	42%	66%

- With respect to numerical skills that the training should focus on, the table below summarises the results from all the categories of participants that answered the particular question:

	Workers	Trainees	VET providers	High ed. teachers	Employers
handling data graphically	32%	51%	67%	53%	76%
costing a project	45%	61%	67%	47%	88%
interpreting large data sets	35%	57%	73%	69%	89%
using mathematical diagrams	43%	49%	67%	47%	94%
using models of direct proportion	40%	44%	67%	37%	88%
measuring quantities	31%	47%	87%	21%	88%