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ASTONRail: Advanced approacheS and practices for rail training and education TO inNovate Rail study programmes & Improve rail higher education provision

WG2 – Results of the German Survey „Expectations of the Railway Industry Towards the Training of its Employees"

Technical University of Applied Sciences Wildau
14 June 2021 (revised 27 August 2021)

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Background and implementation of the survey

The EU project ASTONRail develops innovative methods, approaches and practices for university-based training and further education in the railway sector. The range of rail-related higher education in Europe is to be modernized and improved in order to be able to continue to support the rail industry with qualified personnel.

The purpose of the survey is to determine the German railway industry's expectations towards the training of its employees. The focus is on staff with an engineering background and who have completed their studies.

The survey was created in the LamaPoll software. Potential participants were contacted by email and received a link to the survey.
The survey received **41 responses** (completed surveys), which were included in the evaluation. These are referred to below as participants.

All participants have given their consent to take part in the survey and to use their answers within the framework of the "ASTONRail" project and can therefore be included in the presentation of the results.

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Question structure of the survey

Questions for all participants:
- About completed study courses that are preferred when recruiting engineers
- Whether the company is a practice partner of a dual study course and if so for which and where
- About preferred practical experience of newly hired employees
- To which participant category the company belongs

Question asked in selected participant category:
- To assess the knowledge required for graduates

Devided into:
- Infrastructure operator
- Passenger transport company
- Freight transport company
- Regulation authority
- Other administrative unit (national, international organization...)
- Manufacturer of rail vehicles or rail vehicle equipment
- Other manufacturing company of the railway industry
- Developer/manufacturer of control and safety technology in rail transport
- Development/supply of information in rail transport
- Engineering/consulting company

Questions for all participants:
- About the level of competence of university graduates
- About the skills of recruited graduates to work in international contexts
- About foreign language skills of newly hired employees
- About areas where graduates were best prepared for their current position and areas where additional preparation is required
- Comments or suggestions on the survey

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Distribution of participants

Which category does your company belong to? (Multiple choices possible)

- A participant belongs to an average of 1.3 categories

Category	Number	Frequency acc. to participants
Infrastructure operator	2	4.9%
Passenger transport company	7	17.1%
Freight transport company	5	12.2%
Regulation authority	0	0.0%
Other administrative unit (national, international organization...)	4	9.8%
Manufacturer of rail vehicles or rail vehicle equipment	7	17.1%
Other manufacturing company of the railway industry	6	14.6%
Developer/manufacturer of control and safety technology in rail transport	3	7.3%
Development/supply of information in rail transport	2	4.9%
Engineering/consulting company	16	39.0%
Total	**52 answers**	**41 participants**

- The largest group of participants are engineering/consulting companies (39.0%), followed by passenger transport companies and manufacturers of rail vehicles or rail vehicle equipment (17.1% each)
- This is followed by other manufacturing companies in the railway industry (14.6%), freight transport companies (12.2%), other administrative units (9.8%), developers/manufacturers of control and safety technology (7.3%) and infrastructure operators as well as companies in the development/supply of information in rail transport (4.9% each)
- Regulation authorities did not take part in the survey

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Study courses

- When recruiting engineers, the participants prefer a degree in:
    - Transportation system engineering/transport engineering (68% of the participants)
    - Mechanical engineering (44%)
    - Industrial engineering (37%)
- In "others", courses in the electronics discipline are primarily named
- One third of the participants (32%) are partners in a dual study course (s). Civil engineering, industrial engineering and mechanical engineering are the most frequently mentioned courses

➢ **Focusing activities to modernize higher education on the preferred courses of study**

Practical experience from employees for hiring

- 73% of the participants prefer that newly hired employees have experience from a similar position lasting more than 1 year
- 71% prefer that they have completed an internship in their company
- A completed internship in another company as well as experience from a similar position lasting up to 1 year are preferred by 59% each
- Only 5% of the participants answered that no previous knowledge is required for employment in their company
- More practical knowledge of the graduates is desired by 24.4% of the participants and is seen as an area in which more preparation is necessary

➢ **Ensuring the practical relevance of the course content and implementation of internships during the course in order to gain practical experience that is necessary for employment**

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Graduates' specialized knowledge

- The participants rate the knowledge of graduates in the following topics as "required":
  - Data analysis
  - Safety
  - Safety regulations
  - Security
  - Government regulations
  - ETCS
  - Interoperability
  - Programming and software development
  - Resource management
  - ERTMS
- 26.8% of the participants see the graduates as being best prepared for their position in specialized knowledge, while when asked about additional preparation, 41.5% say that more preparation is necessary in the area of specialized knowledge
- More preparation is required, for example, in (answers of participants):
  - "Railway-specific topics"
  - "Expertise in the railway system"
  - "Specialized knowledge of transport"
  - "Technology ETCS approvals"
  - "Legal framework"
  - "Interoperability"
  - "Approval processes"

➤ **Greater integration of rail relevant / rail related technical knowledge into the course content**

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Competencies and skills of graduates

Soft skills in which the graduates were best prepared for their current position are, for example:

- Ability to work in a team (say 24.4% of the participants)
- Problem solving skills (14.6%)
- Analytical and conceptual skills (12.2%)

Soft skills in which the graduates need further preparation are, for example:

- Independent work (say 12.2% of the participants)
- Ability to work in a team (9.8%)

Competency level of university graduates

- Most of the participants (81%) rate the level of competence as "sufficient", 12%, however, as "unsatisfactory" and only 7% as "excellent"

Graduates' abilities to work in international contexts

- While for 39% of the participants the skills of the graduates are insufficient to work in international contexts, 32% consider them to be sufficient
- For 29% of the participants, skills for working in international contexts are not necessary

Foreign language skills of new employees

- More than half of the participants (61%) answered the question of whether the foreign language skills of newly hired employees are sufficient with regard to the needs of the company with "rather yes", 27% with "rather no", 12% say "yes"

➢ **Introduce students to more independent work**

➢ **Optimization of the teaching content with regard to the ability to work in international contexts and foreign languages**

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Results of the Individual Questions

**For all participants
(n = 41)**

When recruiting engineers, does your company prefer people with a degree in
(multiple choices possible, n = 41)
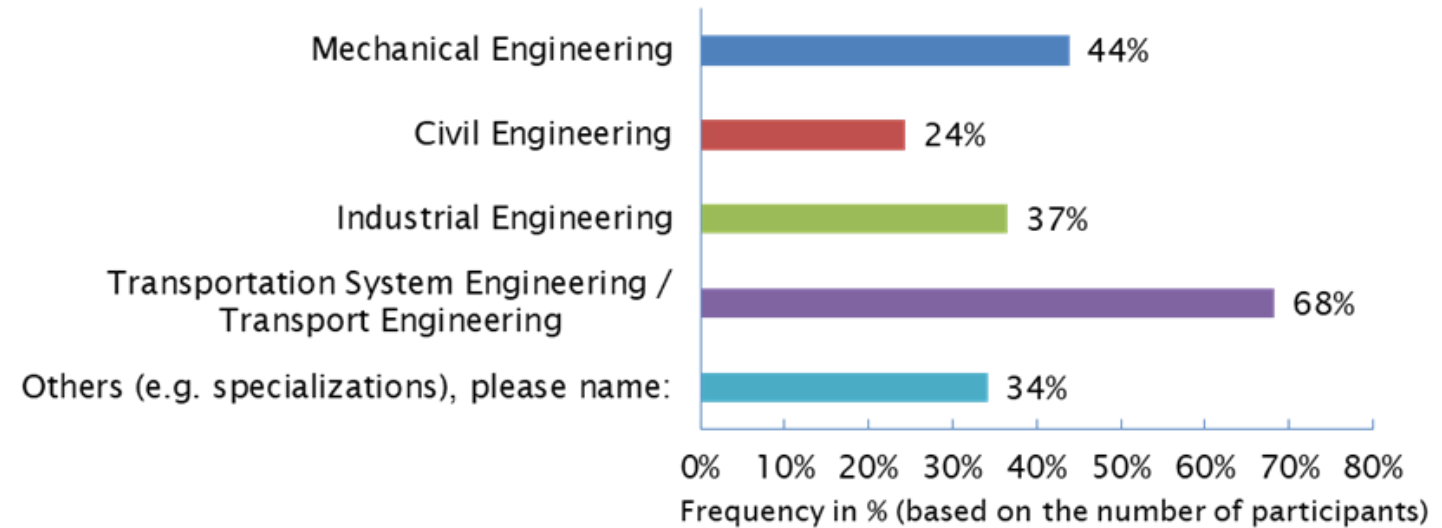
Field	Frequency
Mechanical Engineering	44%
Civil Engineering	24%
Industrial Engineering	37%
Transportation System Engineering / Transport Engineering	68%
Others (e.g. specializations), please name:	34%

Frequency in % (based on the number of participants)

- 68% of the participants prefer a degree in transportation system engineering/transport engineering when hiring engineers
- 44% prefer a degree in mechanical engineering
- Only 24% of the participants prefer a degree in civil engineering
- 34% indicated other fields of study in "others" (detailed analysis of "others" next slide)
- Each participant selected an average of 2.1 of the 5 options

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**Answers in „Others"
(n = 14)**

Answers in "Others"

- Answers as free text
- Categorization of the answers for evaluation
- 14 participants gave 23 answers according to the developed categories

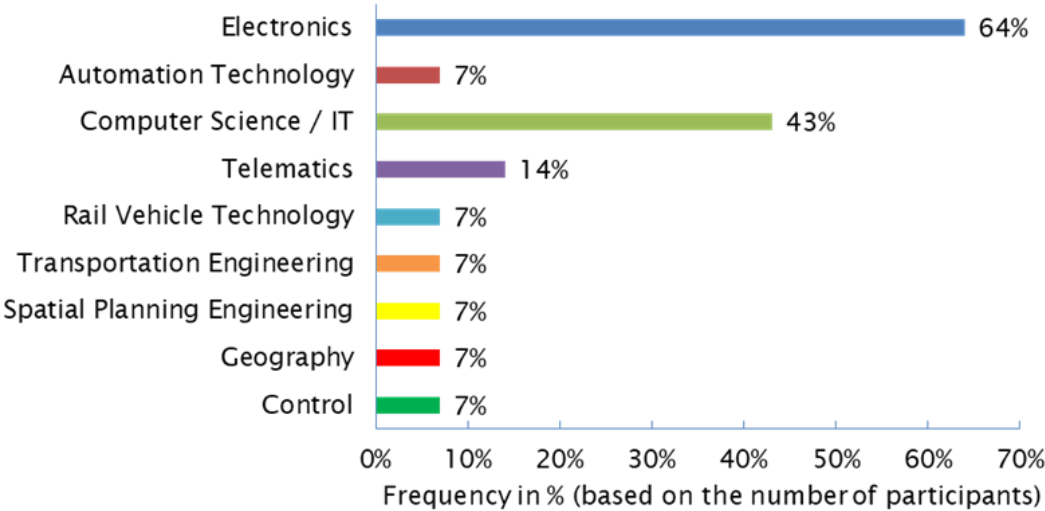| Category	Number of answers per category*
Electronics, includes: - Electronics - Electrics - Electrical engineering - Mechatronics - Communications engineering	9
Automation Technology	1
Computer science / IT, includes: - Computer science - IT - Software	6
Telematics	2
Rail vehicle technology	1
Transportation engineering	1
Spatial planning engineering	1
Geography	1
Control	1

Preferred degrees in study courses mentioned in "others"
[multiple answers possible (free text), n = 14]

Electronics	64%
Automation Technology	7%
Computer Science / IT	43%
Telematics	14%
Rail Vehicle Technology	7%
Transportation Engineering	7%
Spatial Planning Engineering	7%
Geography	7%
Control	7%

Frequency in % (based on the number of participants)

- 64% of the participants in the option "others" prefer a degree in electronics when hiring engineers
- 43% state a degree in computer science / IT

* Multiple answers of 1 participant in sub-categories of a category are calculated as 1 answer in total for the category.
Example: Answering "electrics and mechatronics" counts as 1 answer for the category "electronics".

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For all participants

Is your company a practice partner for a dual study course?
(n = 41)

13; 32%

28; 68%

- Yes - No
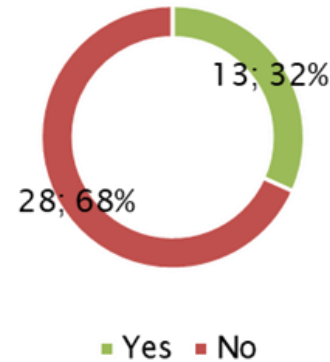
- 32% of the participants (= 13) are partners in a dual study course (s)

➢ Civil engineering, industrial engineering and mechanical engineering are mentioned most frequently as courses in which the participants are practical partners

If yes, for which course and with which university?
(limited visibility for "yes")

n = 13; all answers:

- Bachelor of Engineering
- Civil Engineering at HWR and FH Potsdam
- Civil Engineering FH Potsdam
- Civil Engineering, Industrial Engineering (various universities nationwide)
- bbw Berlin, Electrical Engineering specialization Control and Rail Automation Technology and specialization Trolley Systems
- BTU Cottbus: Civil Engineering, Industrial Engineering
- Various nationwide universities
- Computer Science at HWR Berlin, multiple faculties at DHBW in Stuttgart
- Mechanical Engineering and Electrical Engineering HWR
- Mechanical Engineering, BA Riesa
- Serviceengineering
- Technical dual study – Industrial Engineering - University Kassel, commercial dual study - Hochschule für Ökonomie und Management (FOM)
- Telematics

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Practice partners in dual study courses (2/2)

Company categories to which the 13 participants who are partners in dual study courses belong:

Category	Number	Frequency acc. to participants
Infrastructure operator	2	15.4%
Passenger transport company	1	7.7%
Freight transport company	0	0.0%
Regulation authority	0	0.0%
Other administrative unit (national, international organization...)	0	0.0%
Manufacturer of rail vehicles or rail vehicle equipment	3	23.1%
Other manufacturing company of the railway industry	4	30.8%
Developer/manufacturer of control and safety technology in rail transport	2	15.4%
Development/supply of information in rail transport	1	7.7%
Engineering/consulting company	4	30.8%
Total	**17 answers**	**13 participants**

Completed study courses they prefer when hiring engineers:

Preferred degrees in (multiple choice possible, n = 13)

Mechanical Engineering	31%
Civil Engineering	31%
Industrial Engineering	54%
Transportation System Engineering / Transport Engineering	62%
Others (e.g. specializations), please name:	46%

Frequency in % (based on the number of participants)
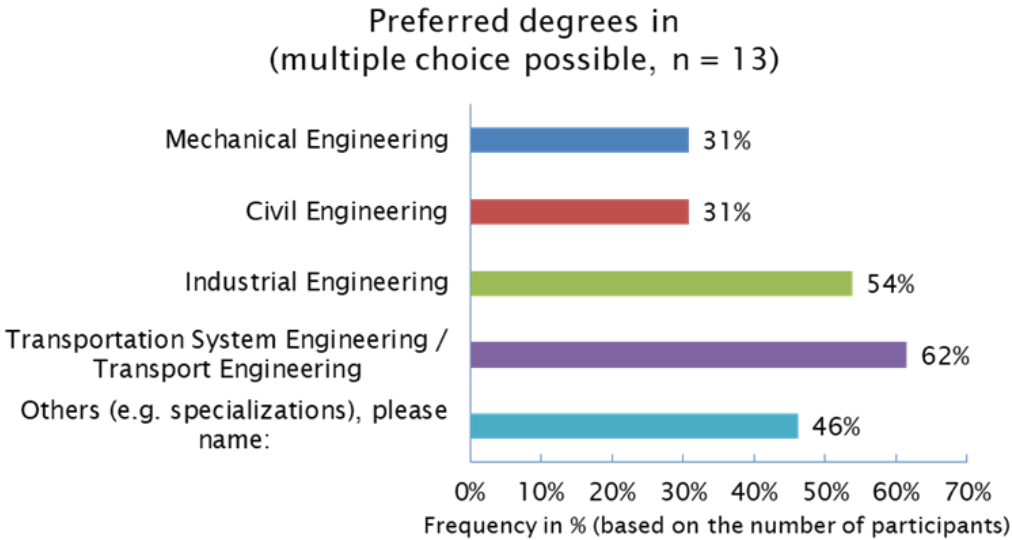
- Answers in the option "Others" are mainly courses in the field of electronics and computer science

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Preferred practical experience for new hires

For all participants (n = 41)

What practical experience gained so far by newly hired employees is preferred in your company?
(multiple choice possible, n = 41)

Option	Frequency
A completed internship in another company	59%
A completed internship in our company	71%
Experience from a similar position lasting up to 1 year	59%
Experience from a similar position lasting more than 1 year	73%
Completion of certified courses and advanced training	41%
Previous knowledge is not required	5%

Frequency in % (based on the number of participants)

➢ **Previous knowledge and completed internships are very important when hiring**

- 73% of the participants prefer that newly hired employees have experience from a similar position lasting more than 1 year
- 71% prefer that they have completed an internship in their company
- A completed internship in another company as well as experience from a similar position lasting up to 1 year are preferred by 59% each
- Only 5% of the participants answered that no previous knowledge is required for employment in their company
- On average, each participant selected 3.1 out of the 6 options

Information on the question and the evaluation

Question:
- The participants were asked to rate the required knowledge for graduates applying in their company
- Question:
  Please rate the knowledge required for graduates applying for a position in your company in the following areas on a scale of 1-4
- Scale:
  1 = unnecessary; 2 = partially required; 3 = required; 4 = highly desirable
- The answer possibilities to the question were given specifically for the individual categories of participants (infrastructure operator, passenger transport company ...) to which each participant had previously assigned his company/organization (see slide distribution of participants)
- For each category, relevant knowledge areas were given for the assessment. To add "other" information was possible in a free text field
- A participant belonging to several categories was shown the question for all selected categories

Evaluation:
- Summarized for all participant categories (see next slide); here only the knowledge areas were considered that were shown to everyone for evaluation
- Separate for the individual categories of participants (see appendix)
- The mean value per knowledge was calculated from all the answers given and the list of knowledge was presented in descending order
- The calculated mean value per knowledge was assigned to the corresponding unit of the scale (rounded)

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Required knowledge of graduates (2/3)

Evaluation for all participant categories (n = 49)

- The following knowledge areas were shown to all participants for evaluation on a scale of 1-4 within their selected participant category
- 41 participants gave 52 answers when assigning to the participant category (multiple answers were possible if they belonged to several categories)
- The question to assess the required knowledge of the graduates was answered a total of 49 times in all participant categories → basis for the evaluation

- The analysis for all participant categories shows that the following knowledge is considered as "required" (based on the mean value):

Knowledge	1 = unnecessary	2 = partially required	3 = required	4 = highly desirable	No answer	Mean value	Rating
Data analysis	1	8	29	9	2	**2.98**	
Safety	4	11	17	15	2	**2.91**	
Safety regulations	5	9	20	13	2	**2.87**	
Security	8	9	15	14	3	**2.76**	
Government regulations	4	18	15	10	2	**2.67**	
ETCS	13	6	7	17	6	**2.65**	required
Interoperability	8	11	12	11	7	**2.62**	
Programming and software development	7	16	12	11	3	**2.59**	
Resource management	7	10	21	5	6	**2.56**	
ERTMS	12	9	7	12	9	**2.48**	

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Evaluation for all participant categories (n = 49)

- Knowledge rated as "partially required" or "unnecessary":

Knowledge	1 = unnecessary	2 = partially required	3 = required	4 = highly desirable	No answer	Mean value	Rating
Legal framework of transport	9	14	17	6	3	**2.43**	
Railway costing	8	19	16	4	2	**2.34**	
Interlocking	17	7	8	10	7	**2.26**	partially required
Logistics technologies and transport chain management	12	16	13	4	4	**2.20**	
ITS (Intelligent transport system)	13	16	12	2	6	**2.07**	
Traffic control	20	11	12	1	5	**1.86**	
Magnetic levitation	27	7	4	1	8	**1.39**	unnecessary

- The evaluation shows that none of the given knowledge is rated as "highly desirable" by all participants (based on the mean value)
- The topics "data analysis", "safety" and "safety regulations" have the greatest mean value among the knowledge considered "required"
- Knowledge in the field of "magnetic levitation" is considered to be "unnecessary" (based on the mean value)

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For all participants (n = 41)

In which areas do you think the graduates were best prepared for their current position?

- Answers as free text
- Multiple answers possible
- Development of categories for the evaluation of the free text answers
- Allocation of the categories in "soft skills", "hard skills" and "others"
- The following categories (shown with the number of answers* per category and free text responses** by the participants) were developed in "soft skills":

Soft skills

Ability to work in a team: 10 answers
- Ability to work in a team
- Teamwork

Analytical and conceptual skills: 5 answers
- Analytical skills
- Draw simple conclusions
- Procedure (structure)
- Systematic work

Problem solving skills: 6 answers
- Analysis of problems, familiarization with problems
- Problem solving ability
- Solution finding
- Solving small problems
- Solving complex problems

Single answers:
- Independent development of content, e.g. rail vehicle industry standards: 1 answer
- Willingness to learn: 1 answer
- Motivation: 1 answer
- Mutual exchange: 1 answer
- Familiarization with new topics: 1 answer

* Multiple answers of one participant within one category are calculated as one answer in total for the category

** Identical free text answers are only listed as one example in the overview of free text answers

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For all participants (n = 41)

- The following categories (shown with the number of answers* per category and free text responses** by the participants) were developed in "hard skills" and "others":

Hard skills

Specialized knowledge: 11 answers
- Specialized knowledge
- Technical Know-How
- Good basic knowledge from your studies
- Technical basics
- Economic sector
- IT knowledge
- Use of standard software
- CAD-knowledge
- New technology / digitization
- Security and technology
- Modern methods of development

Project management: 3 answers
- Project work
- Project management, organization of tasks / projects
- Planning

Theoretical knowledge: 4 answers
- Theoretical knowledge
- Theoretically approaches are mostly good
- Basic theoretical knowledge
- Theory

Scientific knowledge/scientific work: 3 answers
- Work scientifically
- Scientific knowledge, methodological competence
- Research work

Single answers:
- Technological and methodological use of tools for work structuring and employee networking: 1 answer
- Development of solutions or subtasks for the systems developed by the company: 1 answer
- DHBW Stuttgart Electrical Engineering-Electronics, HWR Berlin Computer Science: 1 answer

Others

Single answers:
- In enforcing your salary claim: 1 answer
- Different: 1 answer

No information: 6 answers
- No information/no answer, space, dot, hyphen etc.

* Multiple answers of one participant within one category are calculated as one answer in total for the category
** Identical free text answers are only listed as one example in the overview of free text answers

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For all participants (n = 41)

In which areas do you think the graduates were best prepared for their current position?
[multiple answers possible (free text answers), n = 41]
includes categories with more than 1 answer

Area	Frequency
Ability to work in a team	24.4%
Problem solving skills	14.6%
Analytical and conceptual skills	12.2%
Specialized knowledge	26.8%
Project management	7.3%
Theoretical knowledge	9.8%
Scientific knowledge/scientific work	7.3%
No information	14.6%

Frequency in % (based on the number of participants)

Soft skills
Hard skills
Others

Soft skills in which the graduates were best prepared for their current position are:
- Ability to work in a team
- Problem solving skills
- Analytical and conceptual skills

The most commonly mentioned hard skills are:
- Specialized knowledge

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Areas in need of further preparation (1/3)

For all participants (n = 41)

In which areas do you think additional preparation is needed?

- Answers as free text
- Multiple answers possible
- Development of categories for the evaluation of the free text answers
- Allocation of the categories in "soft skills", "hard skills" and "others"
- The following categories (shown with the number of answers* per category and free text responses** by the participants) were developed in "soft skills":

Soft skills

Ability to work in a team: 4 answers
- Teamwork
- Interaction in teams
- Roles in teams

Problem solving skills: 2 answers
- Problem solving
- Solving complex problems, find pragmatic solutions

Independent work: 5 answers
- Independent work
- To break down complex tasks independently into solvable sub problems
- Self-reliance
- Independent solution of complex problems- many specifications are necessary here
- Development of own ideas

Communication skills: 2 answers
- Communication skills

Dealing with complexity: 3 answers
- Capture complex relationships
- Complexity reduction
- Working in a complex organizational environment

Single answers:
- Solution orientation: 1 answer
- Correct appearance in front of customers / when presenting the company: 1 answer
- Partly reduced willingness to perform: 1 answer
- That work is a part of life: 1 answer
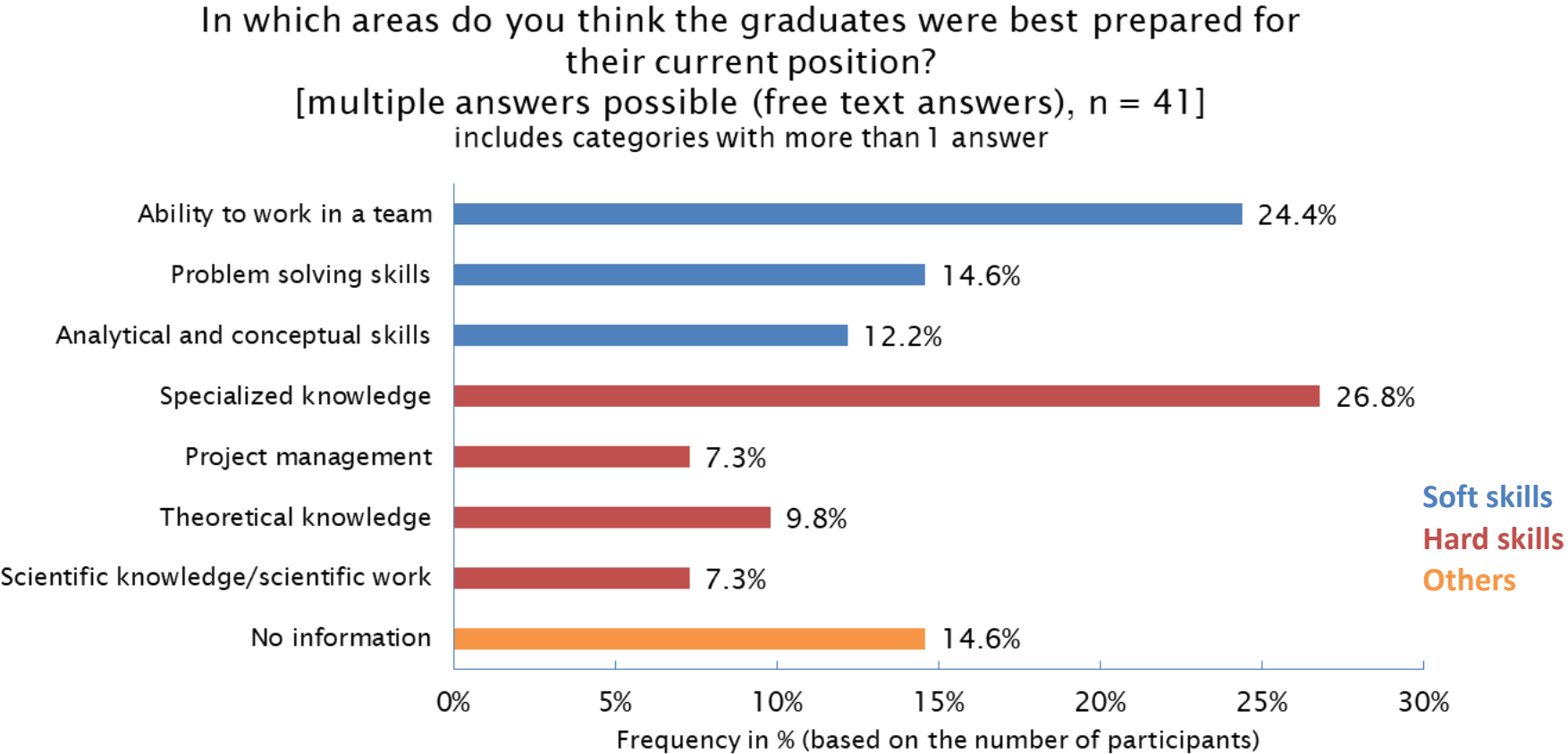- Intercultural work: 1 answer

* Multiple answers of one participant within one category are calculated as one answer in total for the category
** Identical free text answers are only listed as one example in the overview of free text answers

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**For all participants
(n = 41)**

- The following categories (shown with the number of answers* per category and free text responses** by the participants) were developed in "hard skills" and "others":

Hard skills

Specialized knowledge: 17 answers
- General knowledge of the subject
- Railway-specific topics
- Expertise in the railway system
- Subject-specific content
- Subject-specific topics
- Basics of mathematics, physics and rail transport. Basics of electrical engineering, reading circuit diagrams
- Organization and implementation of complex construction measures for the production or renewal of the rail infrastructure
- Production of rail transport services – rail infrastructure activities
- Specialized knowledge of transport
- Specific knowledge and processes of strength tests
- Technology ETCS approvals, locomotive technology
- Overarching railway processes, within the framework of resource and availability management
- Legal framework, interoperability
- Approval processes
- Digital skills
- Interdisciplinarity

Practical knowledge: 10 answers
- Practical knowledge
- Operational practice, connection between theory and practice
- significantly more practical relevance is necessary
- Practice transfer
- Practical relevance to rail freight transport
- Internships, practical experience during the studies
- Inadequate practical experience for all graduates
- Practical relevance
- Practical experience
- Practical expertise

System integration: 3 answers
- Integration of complex systems
- Systems thinking
- System engineering understanding

Process thinking: 2 answers
- Complex process thinking
- Planning processes

Language skills: 2 answers
- The written and spoken German language is mostly poor
- English skills

Project management: 2 answers
- Project management

Single answers:
- Research: 1 answer
- Project references: 1 answer
- Recognizing and delimiting cause and effect: 1 answer
- DHBW Business Administration + Business Informatics: 1 answer

Others

Single answers:
- Expectations regarding remuneration: 1 answer
- Different: 1 answer

No information: 4 answers
- No answer, space, dot, hyphen etc.

* Multiple answers of one participant within one category are calculated as one answer in total for the category
** Identical free text answers are only listed as one example in the overview of free text answers

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For all participants (n = 41)

In which areas do you think additional preparation is needed?
[multiple answers possible (free text answers), n = 41]
includes categories with more than 1 answer

Category	Frequency
Ability to work in a team	9.8%
Problem solving skills	4.9%
Independent work	12.2%
Communication skills	4.9%
Dealing with complexity	7.3%
Specialized knowledge	41.5%
Practical knowledge	24.4%
System integration	7.3%
Process thinking	4.9%
Language skills	4.9%
Project management	4.9%
No information	9.8%

Frequency in % (based on the number of participants)

Soft skills
Hard skills
Others
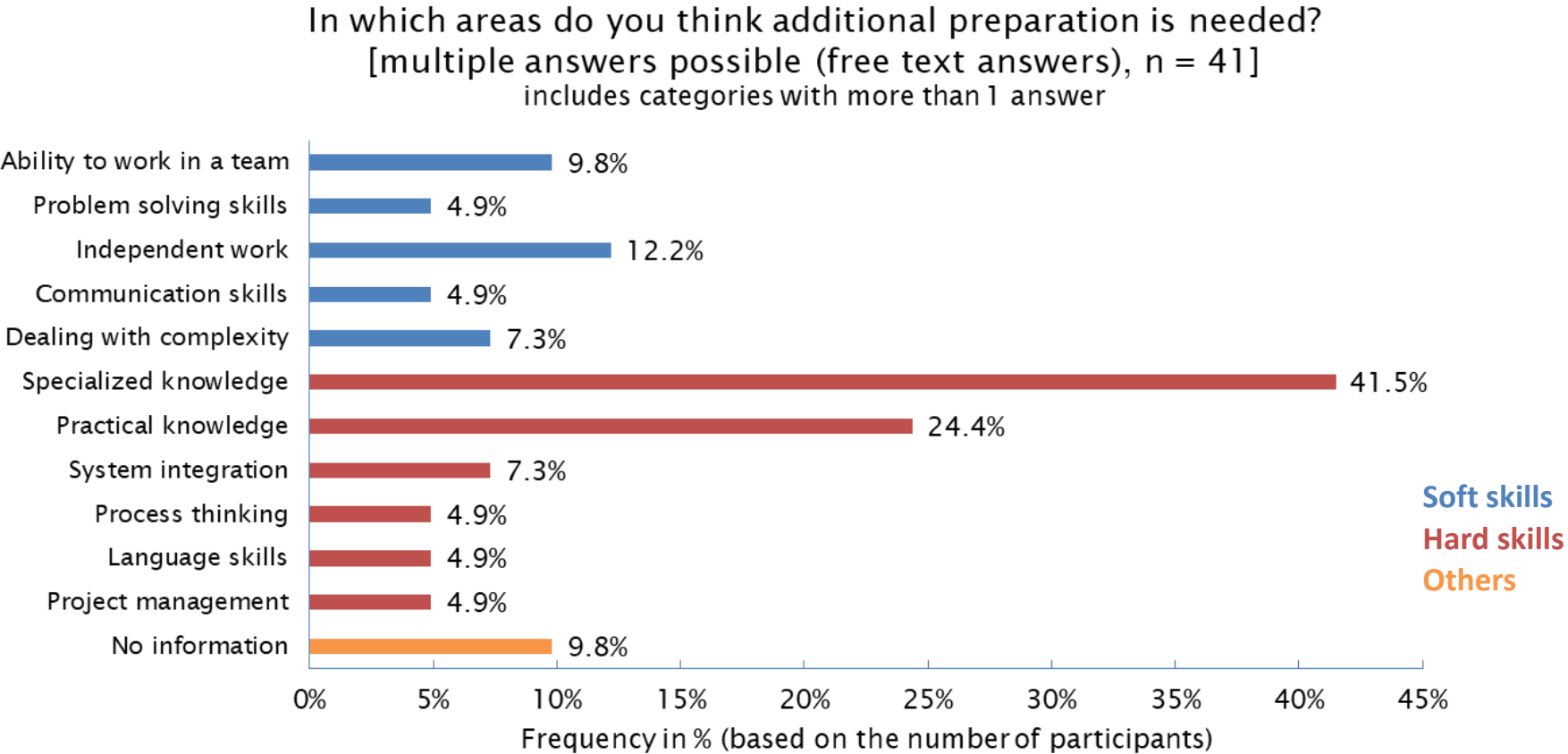
Soft skills in which the graduates need further preparation are, for example:
- Independent work
- Ability to work in a team

The following are mainly mentioned as hard skills:
- Specialized knowledge
- Practical knowledge

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Competency level of graduates

For all participants (n = 41)

How do you rate the level of competence of university graduates starting in your company?
(n = 41)

5; 12%   3; 7%

33; 81%

■ Excellent   ■ Sufficient   ■ Unsatisfactory
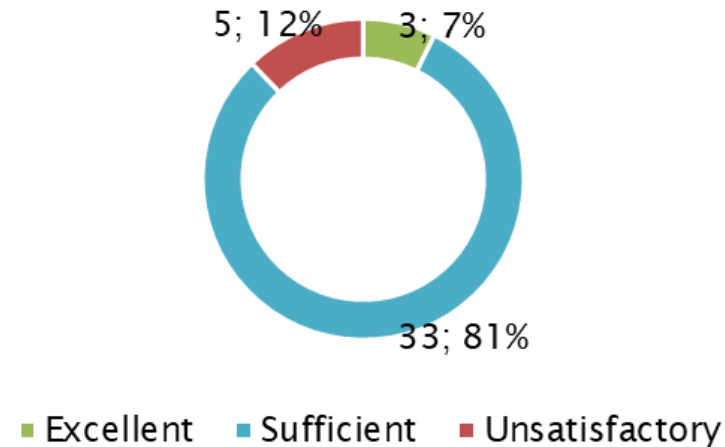
- 81% of the participants rate the level of competence of the university graduates as "sufficient"
- 12% consider the level of competence to be "unsatisfactory"
- Only 7% consider the level of competence to be "excellent"

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Graduates' ability to work in international contexts

For all participants (n = 41)

Are the skills of hired graduates sufficient to work in international contexts?
(n = 41)

12; 29%   13; 32%

16; 39%

■ Yes ■ No ■ Unnecessary
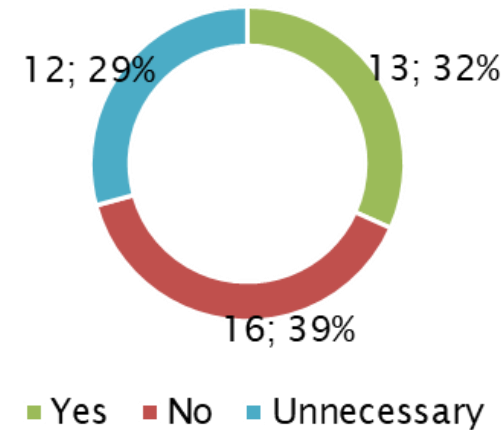
- For 39%, the graduates' skills are insufficient to work in international contexts
- 32% consider the skills to be sufficient
- For almost a third of the participants (29%), skills for working in international contexts are not required

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Foreign language skills of new employees

For all participants (n = 41)

Are the foreign language skills of newly hired employees sufficient with regard to the needs of your company?
(n = 41)

0; 0%
5; 12%
11; 27%
25; 61%

- Yes
- Rather yes
- Rather no
- No
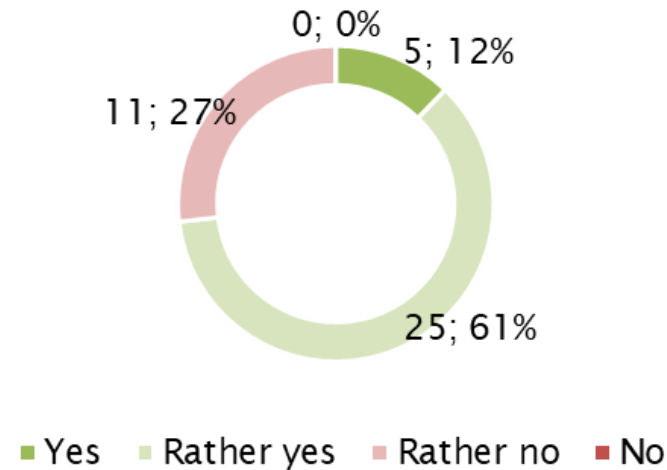
- 61% consider the foreign language skills of new employees to be rather sufficient
- 27% rate the foreign language skills as rather not sufficient
- The foreign language skills of the new employees are sufficient for 12% of the participants
- No participant is of the opinion that the foreign language skills are insufficient

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Comments and suggestions

For all participants

Do you have any comments or suggestions about the survey?

- Answers as free text
- 7 participants answered the question
- The following answers were given:
  - [Spaces]
  - When hired, the knowledge of a young person is hardly sufficient to be able to work internationally, but professional experience makes them engineers who can help develop systems for the international market. In this respect, I consider the question on the penultimate page to be answered only with yes / no, a bit 'too digital'.
  - We would also be happy to focus primarily on electric locomotives
  - No answer
  - I am missing special points in the survey that concern the expansion of the rail infrastructure
  - Course content must (also) be conveyed through internships and excursions. These should be a mandatory focus.
  - Survey is a good tool to get in touch with companies

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Appendix – Required Knowledge of Graduates per Category of Participants

Required knowledge of graduates

Infrastructure operator (n = 2)

Please rate the knowledge required for graduates applying for a position in your company in the following areas on a scale of 1-4.

- 2 participants in the survey belong to the category "infrastructure operator"
- Knowledge that is rated as "highly desirable" or "required" (see also the following slide) by the participants, based on the mean value:

Knowledge	1 = unnecessary	2 = partially required	3 = required	4 = highly desirable	No answer	Mean value	Rating
Reliability	0	0	1	1		3.50	highly desirable
Government regulations	0	0	2	0		3.00	
Legal framework of transport	0	0	2	0		3.00	
Transport modelling and simulations	0	0	2	0		3.00	
Demand forecasting	0	0	2	0		3.00	
Logistics technologies and transport chain management	0	0	2	0		3.00	
Interlocking	0	0	2	0		3.00	required
Route based signalling	0	0	2	0		3.00	
Resource management	0	0	2	0		3.00	
Security	0	0	2	0		3.00	
Safety	0	0	2	0		3.00	
Safety regulations	0	0	2	0		3.00	
Cost benefit analysis	0	0	2	0		3.00	

Required knowledge of graduates

Infrastructure operator (n = 2)

- The following knowledge areas are considered "required", "partially required" or "unnecessary"

Knowledge	1 = unnecessary	2 = partially required	3 = required	4 = highly desirable	No answer	Mean value	Rating
ITS (Intelligent transport system)	0	1	1	0		2.50	
Noise pollution	0	1	1	0		2.50	
Other knowledge of transport externalities	0	1	1	0		2.50	
Interoperability	0	1	1	0		2.50	
ERTMS	0	1	1	0		2.50	
ETCS	0	1	1	0		2.50	
Route assignment	0	1	1	0		2.50	required
Track capacity management	0	1	1	0		2.50	
Sustainability	0	1	1	0		2.50	
Railway costing	0	1	1	0		2.50	
Life cycle cost	0	1	1	0		2.50	
Infrastructure costs modelling	0	1	1	0		2.50	
Data analysis	0	1	1	0		2.50	
Level crossings	0	1	1	0		2.50	
Traffic control	1	0	1	0		2.00	
Air pollution	1	0	1	0		2.00	
Programming and software development	1	0	1	0		2.00	partially required
Timetable management	1	0	1	0		2.00	
Remote monitoring	1	0	1	0		2.00	
Magnetic levitation	1	0	0	0	1	1.00	unnecessary

Required knowledge of graduates

Passenger transport company (n = 7)

Please rate the knowledge required for graduates applying for a position in your company in the following areas on a scale of 1-4.

- 7 participants in the survey belong to the category "passenger transport company"
- Knowledge that is assessed as "required" (based on the mean value) is:

Knowledge	1 = unnecessary	2 = partially required	3 = required	4 = highly desirable	No answer	Mean value	Rating
Data analysis	0	2	4	1		2.86	
Security	1	2	2	2		2.71	
Safety	1	2	2	2		2.71	
Railway costing	0	2	5	0		2.71	
Life cycle cost	0	2	5	0		2.71	
Passenger management	0	2	5	0		2.71	
Legal framework of transport	1	2	3	1		2.57	required
Automatic train control	1	2	3	1		2.57	
Interlocking	2	1	2	2		2.57	
Track capacity management	2	0	4	1		2.57	
Resource management	2	0	4	1		2.57	
Availability	1	2	3	1		2.57	
Safety regulations	1	2	3	1		2.57	
Timetable management	0	4	2	1		2.57	

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Required knowledge of graduates

Passenger transport company (n = 7)

- The following knowledge areas are considered "partially required":

Knowledge	1 = unnecessary	2 = partially required	3 = required	4 = highly desirable	No answer	Mean value	Rating
Government regulations	0	4	3	0		2.43	
Route based signalling	1	3	2	1		2.43	
Sustainability	2	2	1	2		2.43	
Traffic control	3	0	3	1		2.29	
ETCS	2	2	2	1		2.29	
Speed based signalling	1	4	1	1		2.29	
Route assignment	1	4	1	1		2.29	
Transport modelling and simulations	2	3	1	1		2.14	
Logistics technologies and transport chain management	3	1	2	1		2.14	partially required
Programming and software development	1	4	2	0		2.14	
Magnetic levitation	3	1	2	1		2.14	
Demand forecasting	1	5	1	0		2.00	
Other knowledge of transport externalities	1	5	1	0		2.00	
Interoperability	1	5	1	0		2.00	
ITS (Intelligent transport system)	3	2	2	0		1.86	
Noise pollution	3	2	2	0		1.86	
ERTMS	2	4	1	0		1.86	
Remote monitoring	2	4	1	0		1.86	
Air pollution	3	3	1	0		1.71	

- None of the given knowledge is regarded as "highly desirable" or as "unnecessary" by all participants (based on the mean value)

Required knowledge of graduates

Freight transport company (n = 5)

Please rate the knowledge required for graduates applying for a position in your company in the following areas on a scale of 1-4.

- 5 participants in the survey belong to the category "freight transport company"
- Knowledge that is assessed as "required" is:

Knowledge	1 = unnecessary	2 = partially required	3 = required	4 = highly desirable	No answer	Mean value	Rating
Interoperability	1	0	2	2		3.00	
Life cycle cost	0	0	5	0		3.00	
Government regulations	0	2	2	1		2.80	
Sustainability	1	1	1	2		2.80	
Safety	1	1	1	2		2.80	
Data analysis	0	1	4	0		2.80	
Legal framework of transport	1	1	2	1		2.60	required
Logistics technologies and transport chain management	1	1	2	1		2.60	
ETCS	1	1	2	1		2.60	
Resource management	1	0	4	0		2.60	
Safety regulations	1	1	2	1		2.60	
Railway costing	0	3	1	1		2.60	

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Required knowledge of graduates

Freight transport company (n = 5)

- The following knowledge areas are assessed as "partially required":

Knowledge	1 = unnecessary	2 = partially required	3 = required	4 = highly desirable	No answer	Mean value	Rating
Interlocking	2	0	2	1		**2.40**	
Route assignment	2	0	2	1		**2.40**	
Availability	1	1	3	0		**2.40**	
Remote monitoring	0	3	2	0		**2.40**	
ITS (Intelligent transport system)	1	2	2	0		**2.20**	
Demand forecasting	1	2	2	0		**2.20**	
ERTMS	1	3	0	1		**2.20**	
Automatic train control	0	4	1	0		**2.20**	
Route based signalling	2	1	1	1		**2.20**	
Speed based signalling	2	1	1	1		**2.20**	
Track capacity management	2	0	3	0		**2.20**	partially required
Security	2	1	1	1		**2.20**	
Timetable management	2	0	3	0		**2.20**	
Traffic control	2	1	2	0		**2.00**	
Transport modelling and simulations	2	1	2	0		**2.00**	
Air pollution	1	3	1	0		**2.00**	
Noise pollution	1	3	1	0		**2.00**	
Other knowledge of transport externalities	1	3	1	0		**2.00**	
Freight management	2	1	2	0		**2.00**	
Magnetic levitation	3	0	2	0		**1.80**	
Programming and software development	2	3	0	0		**1.60**	

- The participants do not rate any of the knowledge as "highly desirable" or "unnecessary" (based on the mean value)

Required knowledge of graduates

Other administrative unit (n = 3)

Please rate the knowledge required for graduates applying for a position in your company in the following areas on a scale of 1-4.

- 4 participants in the survey belong to the category „other administrative unit", 3 of them answered this question
- Knowledge that the participants assess as "required" and "partially required" are:

Knowledge	1 = unnecessary	2 = partially required	3 = required	4 = highly desirable	No answer	Mean value	Rating
Government regulations	0	0	2	1		**3.33**	
Interoperability	0	1	1	1		**3.00**	
ETCS	1	0	0	2		**3.00**	
Data analysis	0	0	3	0		**3.00**	required
Legal framework of transport	0	1	2	0		**2.67**	
ERTMS	1	0	0	1	1	**2.50**	
Sustainability	0	1	1	0	1	**2.50**	
Life cycle cost	1	0	2	0		**2.33**	
Demand forecasting	1	0	1	0	1	**2.00**	
Other knowledge of transport externalities	1	1	1	0		**2.00**	
Resource management	0	1	0	0	2	**2.00**	
Safety	1	1	1	0		**2.00**	
Safety regulations	1	1	1	0		**2.00**	
Programming and software development	1	1	1	0		**2.00**	partially required
Passenger management	2	0	0	1		**2.00**	
Timetable management	1	1	1	0		**2.00**	
Logistics technologies and transport chain management	2	0	1	0		**1.67**	
Security	2	0	1	0		**1.67**	
Railway costing	2	0	1	0		**1.67**	

Required knowledge of graduates

Other administrative unit (n = 3)

- The following knowledge is assessed as "unnecessary":

Knowledge	1 = unnecessary	2 = partially required	3 = required	4 = highly desirable	No answer	Mean value	Rating
ITS (Intelligent transport system)	2	1	0	0		1.33	
Noise pollution	2	1	0	0		1.33	
Traffic control	3	0	0	0		1.00	
Air pollution	2	0	0	0	1	1.00	unnecessary
Interlocking	2	0	0	0	1	1.00	
Freight management	3	0	0	0		1.00	
Magnetic levitation	3	0	0	0		1.00	

- None of the given knowledge is rated as "highly desirable" by the participants (based on the mean value)
- In "other" one participant answered:
    - "Train control"
    - The participant regards knowledge of this topic as "highly desirable" (4.00)

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Required knowledge of graduates

Manufacturer of rail vehicles or rail vehicle equipment (n = 7)

Please rate the knowledge required for graduates applying for a position in your company in the following areas on a scale of 1-4.

- 7 participants in the survey belong to the category "manufacturer of rail vehicles or rail vehicle equipment"
- None of the given knowledge is considered "highly desirable" from the participants (based on the mean value)
- The following knowledge areas are rated as "required":

Knowledge	1 = unnecessary	2 = partially required	3 = required	4 = highly desirable	No answer	Mean value	Rating
Maintenance	1	0	2	3	1	**3.17**	
Data analysis	0	0	6	1		**3.14**	
ETCS	1	0	1	2	3	**3.00**	
Safety regulations	1	0	3	2	1	**3.00**	
Programming and software development	0	3	2	2		**2.86**	
Safety	0	2	3	1	1	**2.83**	
ERTMS	1	0	1	1	4	**2.67**	
Life cycle cost	0	2	4	0	1	**2.67**	required
Electromagnetic compatibility	1	1	3	1	1	**2.67**	
ITS (Intelligent transport system)	1	2	2	1	1	**2.50**	
Security	1	2	2	1	1	**2.50**	
Railway costing	0	3	3	0	1	**2.50**	
Electric drives	2	1	1	2	1	**2.50**	
Heating and ventilation	1	1	4	0	1	**2.50**	
Wheel-rail interface	1	2	2	1	1	**2.50**	

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Required knowledge of graduates

Manufacturer of rail vehicles or rail vehicle equipment (n = 7)

- Knowledge that is rated to be "partially required":

Knowledge	1 = unnecessary	2 = partially required	3 = required	4 = highly desirable	No answer	Mean value	Rating
Government regulations	1	2	1	1	2	**2.40**	
Interoperability	1	2	1	1	2	**2.40**	
Resource management	2	0	4	0	1	**2.33**	
Sustainability	1	2	3	0	1	**2.33**	
Brakes	2	1	2	1	1	**2.33**	
Wheel set	2	1	2	1	1	**2.33**	
Traction drives	1	1	2	0	3	**2.25**	
Legal framework of transport	1	3	0	1	2	**2.20**	
Fuel cells	3	0	2	1	1	**2.17**	
Distributed power	2	1	3	0	1	**2.17**	
Lighting	2	1	3	0	1	**2.17**	partially required
Logistics technologies and transport chain management	1	3	1	0	2	**2.00**	
Suspension	3	1	1	1	1	**2.00**	
Diesel drive	2	3	1	0	1	**1.83**	
Traffic control	3	2	1	0	1	**1.67**	
Air pollution	4	1	1	0	1	**1.50**	
Noise pollution	4	1	1	0	1	**1.50**	
Other knowledge of transport externalities	2	2	0	0	3	**1.50**	
Body construction	4	1	1	0	1	**1.50**	

Required knowledge of graduates

Manufacturer of rail vehicles or rail vehicle equipment (n = 7)

- Knowledge that is rated to be "unnecessary":

Knowledge	1 = unnecessary	2 = partially required	3 = required	4 = highly desirable	No answer	Mean value	Rating
Interlocking	3	2	0	0	2	**1.40**	
Gas turbine	4	2	0	0	1	**1.33**	unnecessary
Magnetic levitation	4	0	0	0	3	**1.00**	

- In "other" one participant answered:
  - "Railway system technology"
  - The participant regards knowledge of this topic as "highly desirable" (4.00)

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Required knowledge of graduates

Other manufacturing company of the railway industry (n = 6)

Please rate the knowledge required for graduates applying for a position in your company in the following areas on a scale of 1-4.

- 6 participants in the survey belong to the category "other manufacturing company of the railway industry"
- Knowledge that the participants rate as "highly desirable" and "required" (based on the mean value) are:

Knowledge	1 = unnecessary	2 = partially required	3 = required	4 = highly desirable	No answer	Mean value	Rating
Maintenance	0	0	0	5	1	4.00	highly desirable
Safety	0	1	2	3		3.33	
Safety regulations	0	1	2	3		3.33	
Security	0	1	2	2	1	3.20	
Data analysis	0	1	2	2	1	3.20	
Government regulations	1	1	1	3		3.00	
Sustainability	0	2	2	1	1	2.80	required
Electromagnetic compatibility	0	3	0	2	1	2.80	
Railway costing	0	3	2	1		2.67	
Life cycle cost	0	3	1	1	1	2.60	
Programming and software development	1	1	2	1	1	2.60	

Required knowledge of graduates

Other manufacturing company of the railway industry (n = 6)

- Participants consider the following knowledge areas to be "partially required" or "unnecessary":

Knowledge	1 = unnecessary	2 = partially required	3 = required	4 = highly desirable	No answer	Mean value	Rating
Resource management	0	3	2	0	1	2.40	
Legal framework of transport	2	2	0	2		2.33	
Logistics technologies and transport chain management	1	3	0	1	1	2.20	
Level crossings	3	0	1	1	1	2.00	
Traffic control	2	2	1	0	1	1.80	
Noise pollution	1	4	0	0	1	1.80	partially required
Remote monitoring	2	2	1	0	1	1.80	
ERTMS	2	0	1	0	3	1.67	
Air pollution	2	3	0	0	1	1.60	
Other knowledge of transport externalities	2	3	0	0	1	1.60	
ITS (Intelligent transport system)	2	2	0	0	2	1.50	
Interoperability	3	0	1	0	2	1.50	
ETCS	3	1	0	0	2	1.25	
Interlocking	3	1	0	0	2	1.25	unnecessary
Magnetic levitation	3	1	0	0	2	1.25	

- In "other" one participant answered:
  - "Construction site management for the creation of the infrastructure (overhead line, tracks)"
  - The participant regards knowledge of this topic as "highly desirable" (4.00)

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Required knowledge of graduates

Developer / manufacturer of control and safety technology (n = 3)

Please rate the knowledge required for graduates applying for a position in your company in the following areas on a scale of 1-4.

- 3 participants in the survey belong to the category "developer/manufacturer of control and safety technology in rail transport"
- The participants rate the following knowledge as "highly desirable" (based on the mean value):

Knowledge	1 = unnecessary	2 = partially required	3 = required	4 = highly desirable	No answer	Mean value	Rating
Programming and software development	0	0	1	2		**3.67**	highly desirable
Remote monitoring	0	0	1	2		**3.67**	

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Required knowledge of graduates

Developer / manufacturer of control and safety technology (n = 3)

- The participants rate the following skills as "required" or "partially required":

Knowledge	1 = unnecessary	2 = partially required	3 = required	4 = highly desirable	No answer	Mean value	Rating
Security	0	0	2	1		3.33	required
Safety	0	0	2	1		3.33	
Electromagnetic compatibility	0	0	2	1		3.33	
ITS (Intelligent transport system)	0	0	2	0	1	3.00	
ERTMS	1	0	0	2		3.00	
ETCS	1	0	0	2		3.00	
Speed based signalling	0	0	3	0		3.00	
Resource management	0	1	0	1	1	3.00	
Sustainability	0	1	1	1		3.00	
Safety regulations	0	1	1	1		3.00	
Data analysis	0	0	3	0		3.00	
Traffic control	0	1	2	0		2.67	
Interoperability	1	0	1	1		2.67	
Interlocking	1	0	1	1		2.67	
Life cycle cost	0	2	0	1		2.67	
Level crossings	0	1	2	0		2.67	
Government regulations	0	2	1	0		2.33	partially required
Legal framework of transport	0	2	1	0		2.33	
Logistics technologies and transport chain management	0	2	1	0		2.33	
Railway costing	1	1	0	1		2.33	
Magnetic levitation	0	2	0	0	1	2.00	

- None of the given knowledge is rated as "unnecessary" by all participants (based on the mean value)

Required knowledge of graduates

Development / supply of information in rail transport (n = 1)

Please rate the knowledge required for graduates applying for a position in your company in the following areas on a scale of 1-4.

- 2 participants in the survey belong to the category "development/supply of information in rail transport", 1 participant answered the question
- This participant regards the following knowledge as "highly desirable":

Knowledge	1 = unnecessary	2 = partially required	3 = required	4 = highly desirable	No answer	Mean value	Rating
ERTMS	0	0	0	1		4.00	
ETCS	0	0	0	1		4.00	
Resource management	0	0	0	1		4.00	
Security	0	0	0	1		4.00	highly desirable
Safety	0	0	0	1		4.00	
Safety regulations	0	0	0	1		4.00	
Programming and software development	0	0	0	1		4.00	

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Required knowledge of graduates

Development / supply of information in rail transport (n = 1)

- Knowledge that this participant rates as "required", "partially required" or "unnecessary" are:

Knowledge	1 = unnecessary	2 = partially required	3 = required	4 = highly desirable	No answer	Mean value	Rating
Interoperability	0	0	1	0		3.00	
Data analysis	0	0	1	0		3.00	
Passenger management	0	0	1	0		3.00	
Remote monitoring	0	0	1	0		3.00	required
Government regulations	0	1	0	0		2.00	
Legal framework of transport	0	1	0	0		2.00	
ITS (Intelligent transport system)	0	1	0	0		2.00	
Transport modelling and simulations	0	1	0	0		2.00	
Logistics technologies and transport chain management	0	1	0	0		2.00	
Interlocking	0	1	0	0		2.00	partially
Railway costing	0	1	0	0		2.00	required
Traffic control	1	0	0	0		1.00	
Magnetic levitation	1	0	0	0		1.00	unnecessary
Infrastructure costs modelling	0	0	0	0	1	0.00	no answer

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Required knowledge of graduates

Engineering / consulting company (n = 15)

Please rate the knowledge required for graduates applying for a position in your company in the following areas on a scale of 1-4.

- 16 participants in the survey belong to the category "engineering/consulting company", 15 of them answered the question
- The following knowledge is assessed as "required" based on the mean value:

Knowledge	1 = unnecessary	2 = partially required	3 = required	4 = highly desirable	No answer	Mean value	Rating
Interoperability	1	2	3	6	3	**3.17**	
Data analysis	1	3	5	5	1	**3.00**	
ETCS	4	1	1	8	1	**2.93**	
Security	2	3	3	6	1	**2.93**	
Safety	1	4	4	5	1	**2.93**	
Safety regulations	1	3	6	4	1	**2.93**	
Programming and software development	1	4	3	5	2	**2.92**	required
Maintenance	0	4	5	3	3	**2.92**	
ERTMS	4	1	3	6	1	**2.79**	
Interlocking	4	2	1	6	2	**2.69**	
Government regulations	2	6	3	4		**2.60**	
Passenger management	3	4	2	4	2	**2.54**	
Resource management	2	5	5	2	1	**2.50**	
Sustainability	2	4	7	1	1	**2.50**	

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Required knowledge of graduates

Engineering / consulting company (n = 15)

- Knowledge areas that are considered "partially required" or "unnecessary" are:

Knowledge	1 = unnecessary	2 = partially required	3 = required	4 = highly desirable	No answer	Mean value	Rating
Legal framework of transport	4	2	7	1	1	2.36	
Life cycle cost	2	6	6	0	1	2.29	
Infrastructure costs modelling	4	5	2	2	2	2.15	
Logistics technologies and transport chain management	4	5	4	1	1	2.14	
ITS (Intelligent transport system)	4	5	3	1	2	2.08	partially required
Transport modelling and simulations	5	4	2	2	2	2.08	
Other knowledge of transport externalities	3	5	4	0	3	2.08	
Railway costing	5	5	3	1	1	2.00	
Traffic control	5	5	2	0	3	1.75	
Noise pollution	6	5	2	0	2	1.69	
Air pollution	8	5	0	0	2	1.38	unnecessary
Magnetic levitation	9	3	0	0	3	1.25	

- None of the given knowledge is rated as "highly desirable" by the participants (based on the mean value)
- In "other" two answers are given:
  - "Revenue management, revenue sharing", the participant rates this knowledge as highly desirable (4.00)
  - "Statics, stability", this knowledge is rated as unnecessary (1.00) by the participant

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