



Evidencing correlation between skills and education for energy performance and quality

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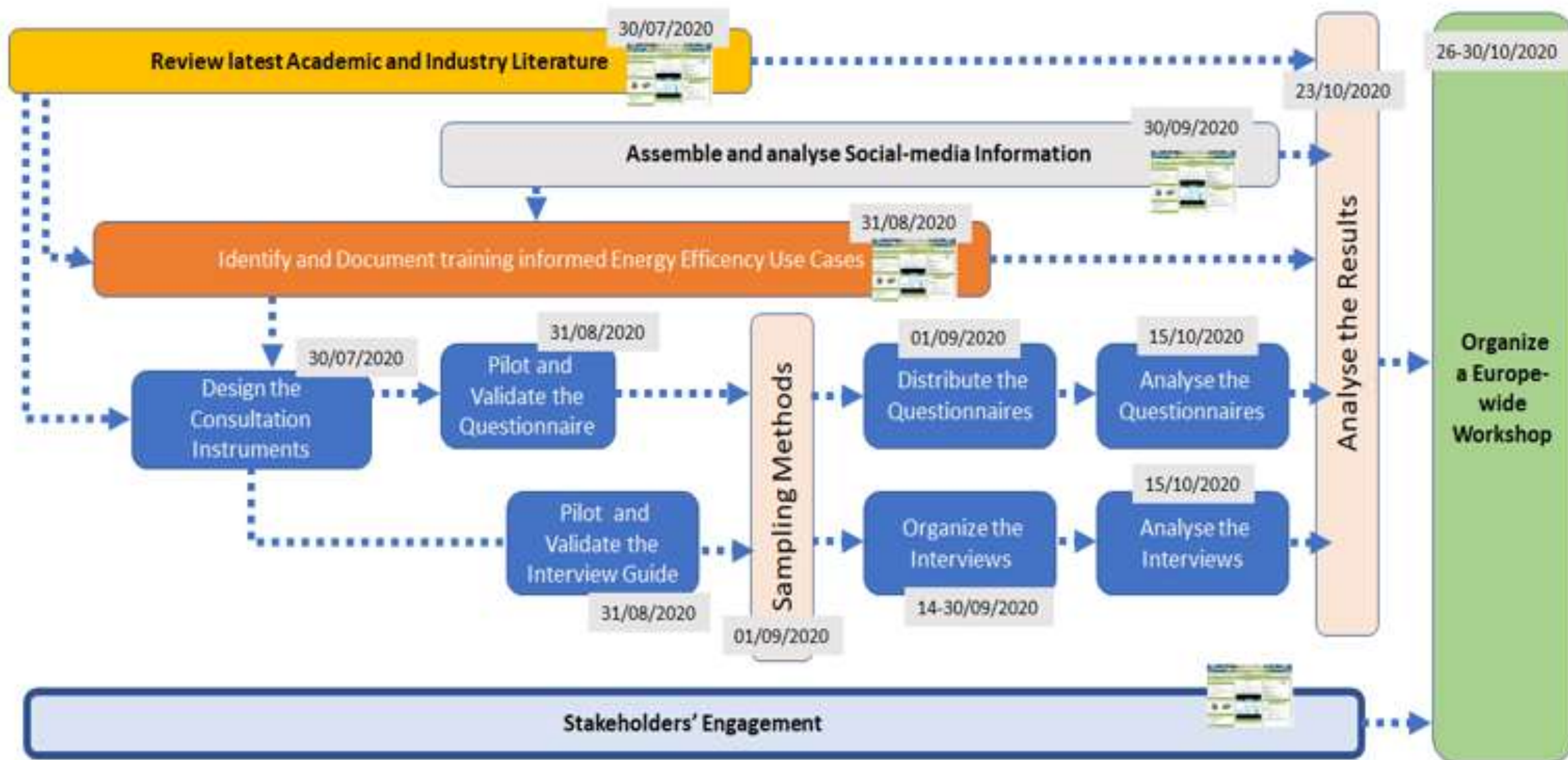


Research questions

These themes translate into the following research questions to **address the lack of demand for skilled workforce in energy efficiency**.

- a. What is the state of awareness, access to information and dissemination of knowledge for energy efficiency in the Construction sector?
- b. What is the level of demand for skilled workforce in energy efficiency?
- c. What is the state of the training programs for energy efficiency currently available in the industry (in terms of scope, quality, content, cost, etc.)?
- d. What is the state of the sector in terms of shared values and coordination of stakeholders across the supply chain for energy efficiency?

Science informed methodology



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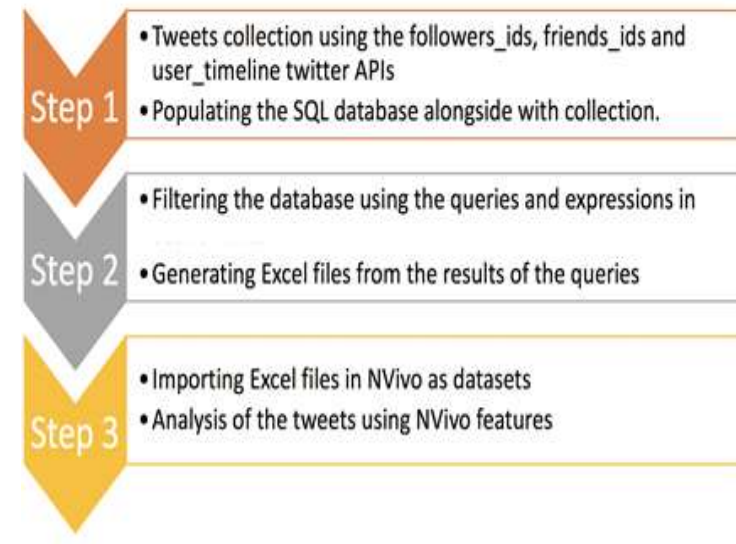
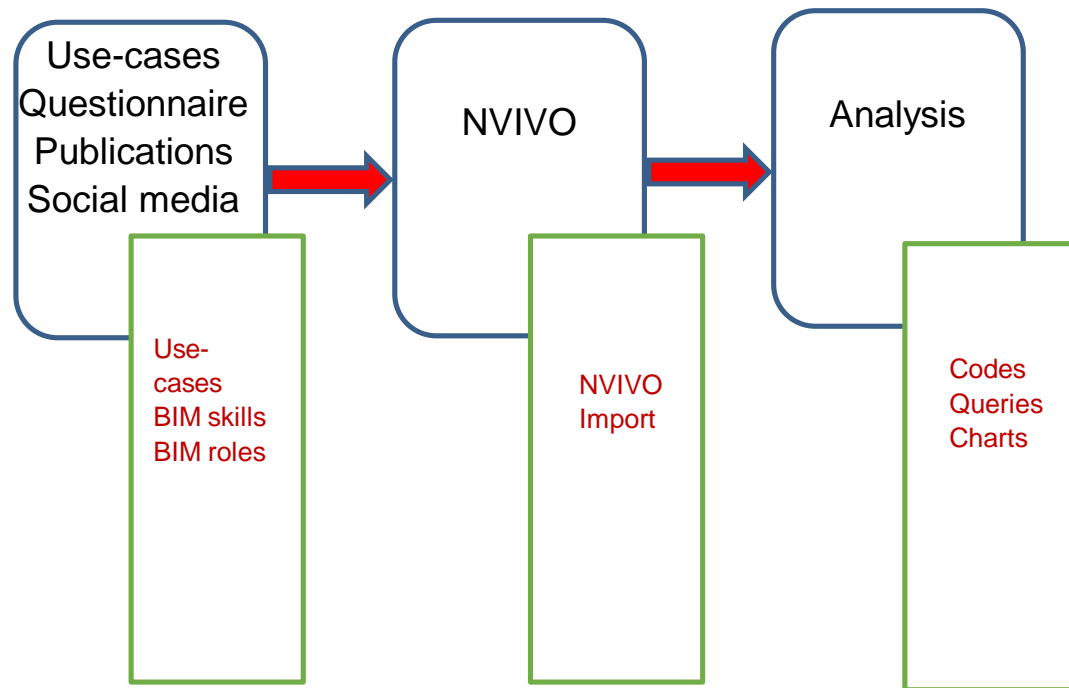
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BIM skills for energy via BIM EET Project

- **Role of BIM in achieving energy efficiency** in buildings across the whole value chain
- **BIM qualification and skills frameworks** available across Europe

The analysis phase in phases



Objective: Identification of skills and roles from best practice-use cases, scientific publications, interviews, standards and social media sources.

No.	Use cases/ Target discipline	Architecture design	Facility management	Structure engineer	Mechanical engineer	Other	Impacts
1	Reduce the Gap Between Predicted and Actual Energy Consumption in Buildings						Reduction of 25% energy compared to baseline figures.
2	Minimizing operational costs and carbon emissions through matching supply with demand of heat and electricity production.						Leading to a 32% increase in profit and 36% reduction in CO2 emissions.
3	Intelligent management and control of HVAC system						Up to 30% of Energy Saving Up to 30% Emission reduction
4	Friendly and Affordable Sustainable Urban Districts Retrofitting (FASUDIR) - Heinrich-Lubke housing area, Frankfurt, Germany						GWP reduction of 60%. Operational energy consumption reduction of 35%
5	Friendly and Affordable Sustainable Urban Districts Retrofitting (FASUDIR) - Budapest Residential District						Operational energy reduced by 35% and energy running costs reduced by 35%
6	An innovative integrated concept for monitoring and evaluating building energy performance (the gap between predicted and actual building energy performance is addressed by the project).						Achieve building energy performance
7	Parametric design of a shelter roof in urban context						Early BIM for parametric optimization through simulations
8	Building As A Service						Optimize energy performance in the application domain of non-residential buildings
9	Delivering highly energy efficient hospital centre						41% reduction in fabric loss heat, 29% reduction in carbon emissions, 15% reduction in overall energy usage
10	Shopping Center using around half the energy of a typical development						50 % energy savings , 50 % savings in water consumption
11	Design of energy-efficient library with high architectural goals						Energy optimization results impacted for the building and HVAC design
12	Use of Optimization tool to compare hundreds of concepts energy efficiency before actual design						Use of Optimization tool has the potential to save money and time while directing to more optimal energy efficiency solutions.

Relation between the BIM and impacts

Best practice use-cases and interview skills and roles

Table 2 Consolidated list of skills and roles from use-case studies

<i>Roles</i>	<i>Skills</i>
<i>Architect designer</i>	Optimal decision making
<i>Construction engineer</i>	Collaborative design open ICT platform
<i>Facility manager</i>	Operation energy running costs
<i>Mechanical engineer</i>	Operational energy demand
<i>Structure engineer</i>	Interaction between the project managers
<i>HVAC engineer</i>	Data management
<i>The worker in the ceramic sector</i>	Adapted to changing environment conditions
<i>BIM modeller</i>	Performance measuring, monitoring and optimisation
<i>Steel Contractor</i>	Integrated information management
<i>Electrical engineer</i>	Establish energy modelling
<i>Builder</i>	Achieve energy “LEED” certification
<i>Supply manager</i>	ICT skills
<i>Energy modeller</i>	Teamwork skills
<i>Energy simulation experts</i>	Understand BIM standards
<i>Operation engineers</i>	Understand energy efficiency principle
	BIM tools updates skills
	Searching and BIM development skills
<i>Architect</i>	Educating on BIM
<i>Project manager</i>	BIM training
<i>BIM instructor</i>	Practice Energy Modelling
<i>Trainer</i>	The link between different software
<i>Consultant of constructor</i>	Understanding of graphical information
<i>Energy expert</i>	Enhance the stakeholders’ skills of BIM for energy efficiency
<i>BIM manager</i>	Site meeting for the comprehension of BIM data and energy features implementation
<i>Planner and consultant of energy-efficient buildings</i>	Capability to use CAD programs and other EE software
<i>Real estate maintenance data management consultant</i>	Knowledge about the principle of EE & sustainable construction
<i>Structure engineer</i>	Formulating the model with EE simulation programs
<i>BIM coordinator</i>	Good communication between designers, client, supplier
<i>Facility manager</i>	Skills to separate the information needed
<i>Researcher and teacher in University</i>	Knowledge how to use BIM
<i>Contractor manager</i>	BIM training ability to implement BIM construction with energy space
<i>Site manager</i>	Collaborate with designers to manage the information from the model
<i>HVAC engineer</i>	Strategy management skills
<i>Civil engineer</i>	Managing and updating BIM data
	Data management skills
	Information management standards

Scientific publications skills and roles

Table 4 Consolidated list of skills and roles from scientific publications

<i>Roles</i>	<i>Skills</i>
<i>Facilitator of sustainable BIM manager</i>	Simulation programs
<i>BIM modeller</i>	BIM education
<i>Facility manager</i>	Assess respondents' perception of BIM competence and requisite skills
<i>Energy manager</i>	Knowledge of BIM standards
<i>Training and informing consultation professionals about BIM</i>	Applying theoretical knowledge and eventually facilitating the entry into the labour market
<i>BIM consult</i>	Developing contractual specifying owner's BIM requirements
<i>Structure engineers</i>	Training should be developed in BIM for energy efficiency
<i>Regulators</i>	Knowledge about BIM standards
<i>HVAC engineers</i>	Update knowledge about BIM developments
	An imbalance between the demand and supply of skilled labour in the construction sector
<i>Technical manager</i>	Focus on soft skills like collaboration and communication, negotiation, teamwork, leadership and conflict management.
<i>Contract manager</i>	Knowledge of building commissioning and building commissioning strategies
<i>Finance manager</i>	BIM model review – Automatic model check
<i>Maintenance manager</i>	Drawing skill with BIM tools
<i>Quality assurance manager</i>	Practices in facilitating information exchange to meet stakeholders' business needs in BIM execution
<i>Facility administration</i>	Perspective with LCA and LCC applications
<i>Sale manager</i>	Increase the awareness of energy consumption
<i>Production manager</i>	Increase the awareness of building regulations and how they will continue to evolve over time

Consolidated list of requirements

NO.	Parameters	Requirements
1	The skills they require to handle BIM data for the purpose of energy efficiency	<p>Designer: Formulating the model with EE simulation programs, Maintaining data of different variation and solutions, Good communication between designers, client, and supplier.</p> <p>Blue collar worker: Simulate use cases scenarios for the design, Communication with client and contractors to ensure best practice met.</p> <p>Contractors: Knowledge how to use BIM, BIM training ability to implement BIM construction with energy space, Collaborate with designer to manage the information from the model (See Table 17)</p>
2	The skills are lacking at the moment for using BIM for Energy Efficiency	Link between different software-tools, Understanding to find good solutions to get to fine level of EE, Understanding what the impacts of using BIM for EE (See Table 18)
3	The particular ways to enhance the stakeholders' skills for using the BIM for Energy Efficiency	<p>Blue collar workers: Training and field meetings to explain the specific plans.</p> <p>Designers/Engineers: Energy, BIM and data management training and educating, Understand the essence of simulation and to apply the result in practice (See Table 19, 20, 21, and 22)</p>
4	The training in BIM for Energy Efficiency by organisation	Teaching software programs; BIM for EE, Continuous learning: issue with standardization, Skills of BIM coordinators and BIM manager should be defined. Contractors: Educating and training understand the needs. Facility management teams: Ability to extract and update information from BIM model(See Table 23)
5	The common barriers to use BIM for Energy Efficiency	Lack of understanding the use and potential of BIM, Different software-tools, Lake of expertise that able to use this difficult programs (See Table 25)
6	Recommendations to enhance using the BIM for Energy Efficiency	Assessment performance evaluation and appropriate training mechanisms, The useful tools should be utilized as early stage of the project, Incentivise the adoption of BIM for EE (See Table 26)

Frequency determination

$$TF(T) = \frac{\text{number of times the term } t \text{ appears}}{\text{total number of terms of the same type as } t} \quad (1)$$

, where t is either a skill or a role and the *type of t* can be either a skill or a role. This has facilitated the classification of skills and roles with a view to understand the importance and relevance of skills and roles in the construction industry.

Importance determination

$$Importance(skill) = \frac{1}{n} \sum_{n=1}^n (\text{no. of occurrences}(\text{association}(\text{skill} + \text{role})))$$

, where n is the number of different associations between that skill and different roles.

$$Importance(role) = \frac{1}{n} \sum_{n=1}^n (\text{no. of occurrences}(\text{association}(\text{role} + \text{skill})))$$

, where n is the number of different associations between that role and different skills.

Correlation determination

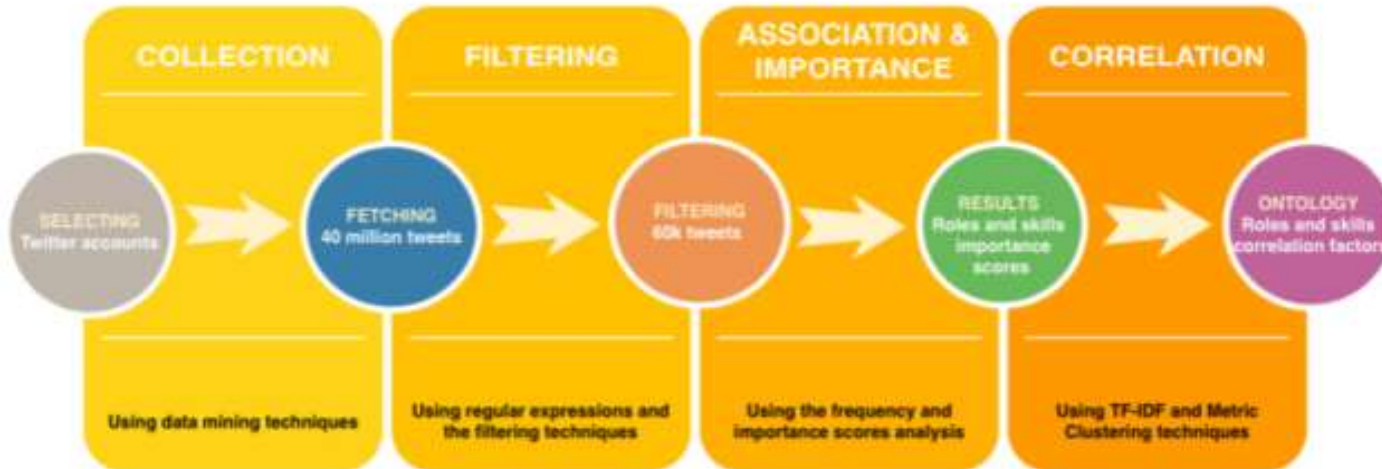
$$C_{u,v} = \sum_{k_i \in V(S_u)} \sum_{k_j \in V(S_v)} \frac{1}{r(k_i, k_j)}$$

The distance $r(k_i, k_j)$ between two keywords k_i and k_j is given by the number of words between them in the same tweet. $V(S_u)$ and $V(S_v)$ represent the sets of keywords that have S_u and S_v as their respective stems. In order to simplify the correlation factor given in Equation 4, it was decided not to take into account the different syntactic variations of concepts within the Twitter text, and instead use Equation 5, where $r(k_u, k_v)$ represents the minimum distance (in terms of the number of separating words) between concepts k_u and k_v in any single tweet.

$$C_{u,v} = \frac{1}{\text{Min}[r(k_u, k_v)]}$$

Datamining

- TOTAL: We have fetched a total of 15 million tweets with text.
- + ((contractor\manager\designer\engineer\client)\skills\)+ (\energy| \construction)
- + ((\BIM\construction\energy)\skills\)+ (\need| \require)
- + ((\BIM\construction\energy)\roles\)+ (\need| \require)
- + ((\BIM\construction\energy)\actors\)+ (\skills| \competencies)
- + ((\BIM\construction\energy)\knowledge\)+ (\requirements| \require)
- + ((\BIM\construction\energy)\skills\)+ (\need| \require)
- + ((\BIM\construction\energy)\competencies\)+ (\need| \require)
- + ((\skills\competencies\knowledge\expertise)\BIM\)+ (\energy| \construction)



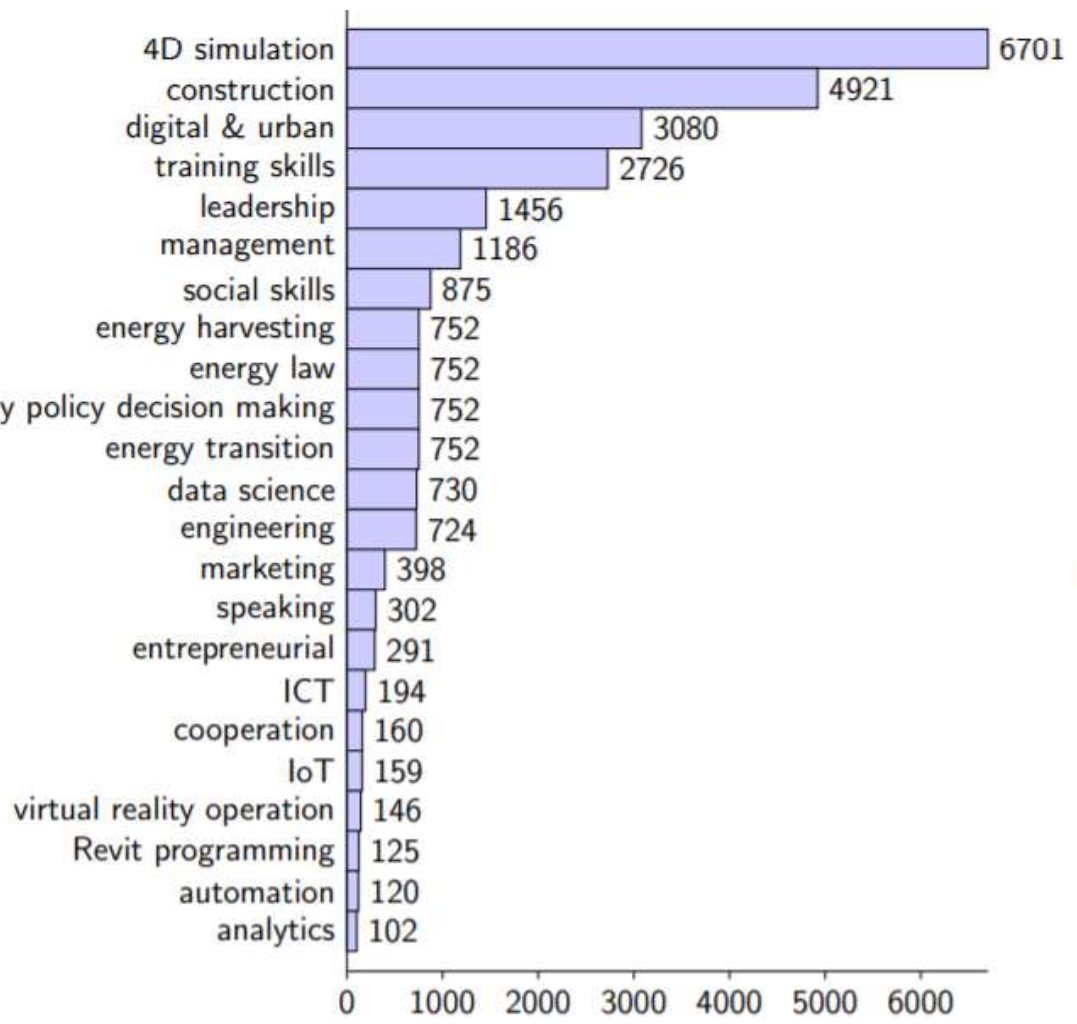
Algorithm 1 Roles and skills correlation + combination matrix algorithm

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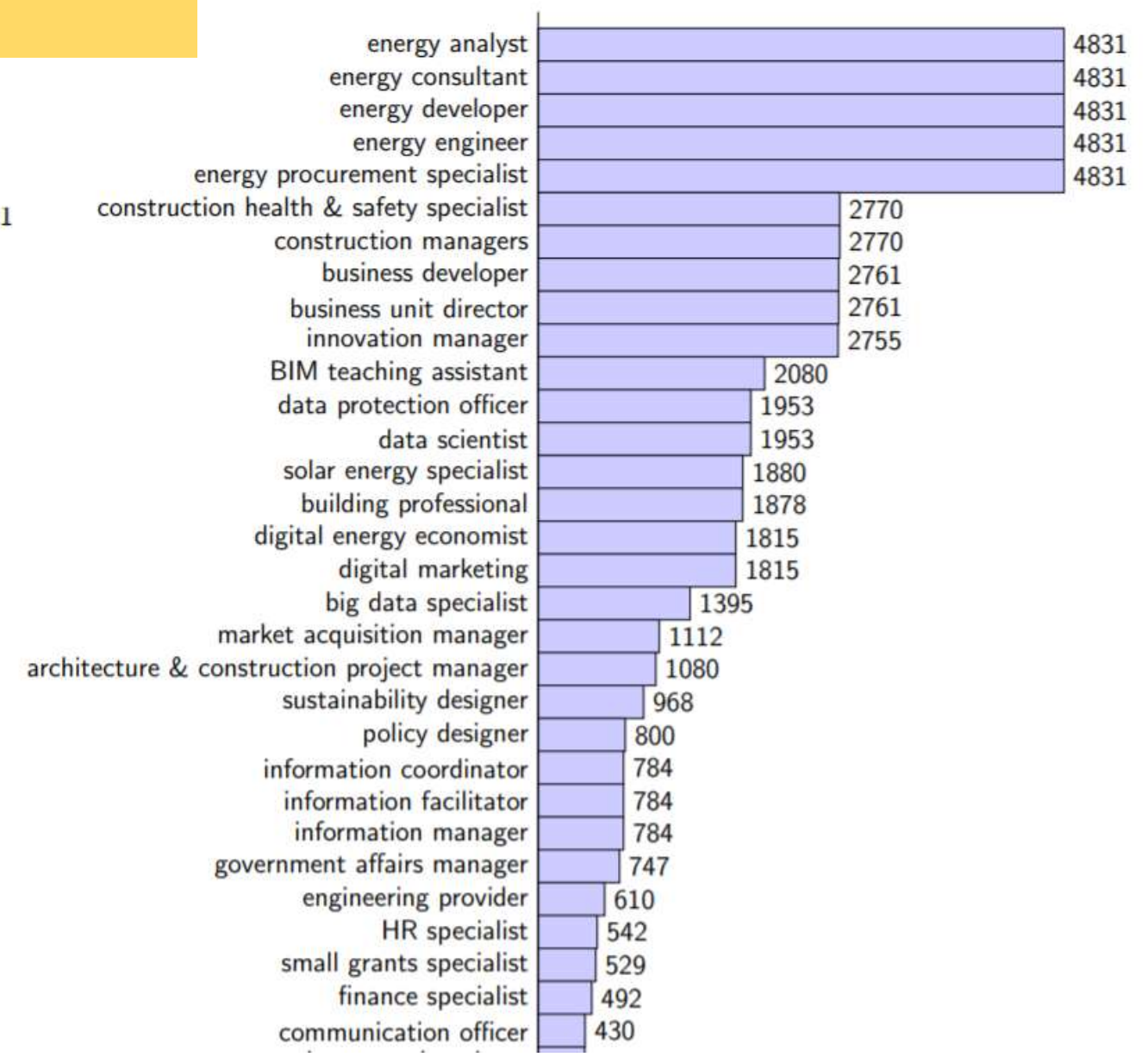
1: userList = SELECT DISTINCT FROM users
2: INITIALISE combinationList, roleSkillCombinationMatrix, skillRoleCombinationMatrix
3: for each user in userList do
4:   INITIALISE currentUserRoleList
5:   for each role do
6:     ADD role TO currentUserRoleList
7:   end for
8:   INITIALISE currentUserSkillList
9:   for each skill do
10:    ADD skill TO currentUserSkillList
11:  end for
12:  for each role do
13:    for each skill do
14:      if (skill IN currentUserSkillList) AND (role IN currentUserRoleList) then
15:        ADD PAIR OF role AND skill TO combinationList
16:      end if
17:    end for
18:  end for
19: end for
20: for each combination in combinationList do
    role do
    IN combination then
    | role TO roleSkillCombinationMatrix
    killCombinationCountMatrix[role][skill from combination] += 1

    skill do
    IN combination then
    | skill TO skillRoleCombinationCountMatrix
    roleCombinationCountMatrix[skill][role from combination] += 1
  
```

Skills and roles selection

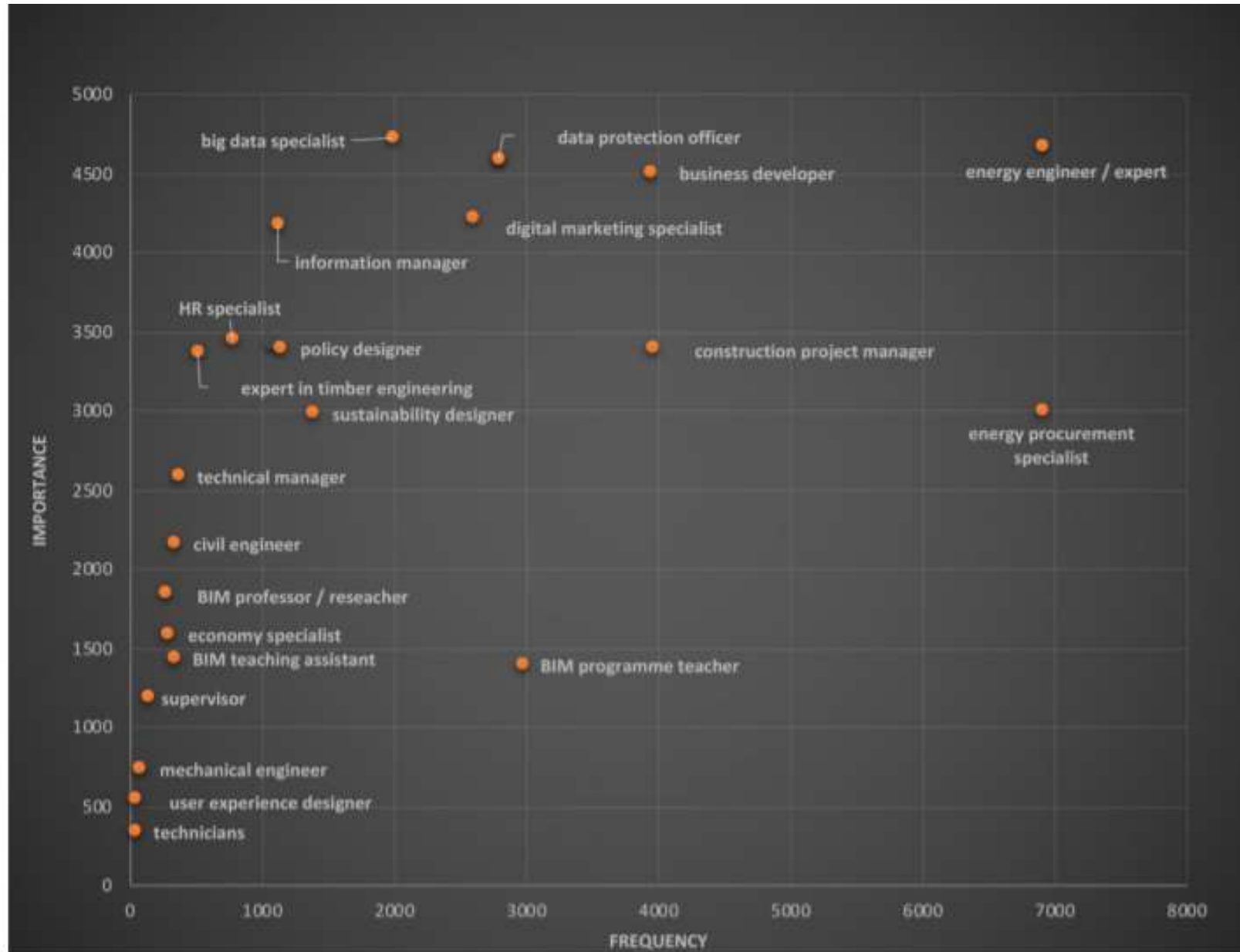


SKILLS

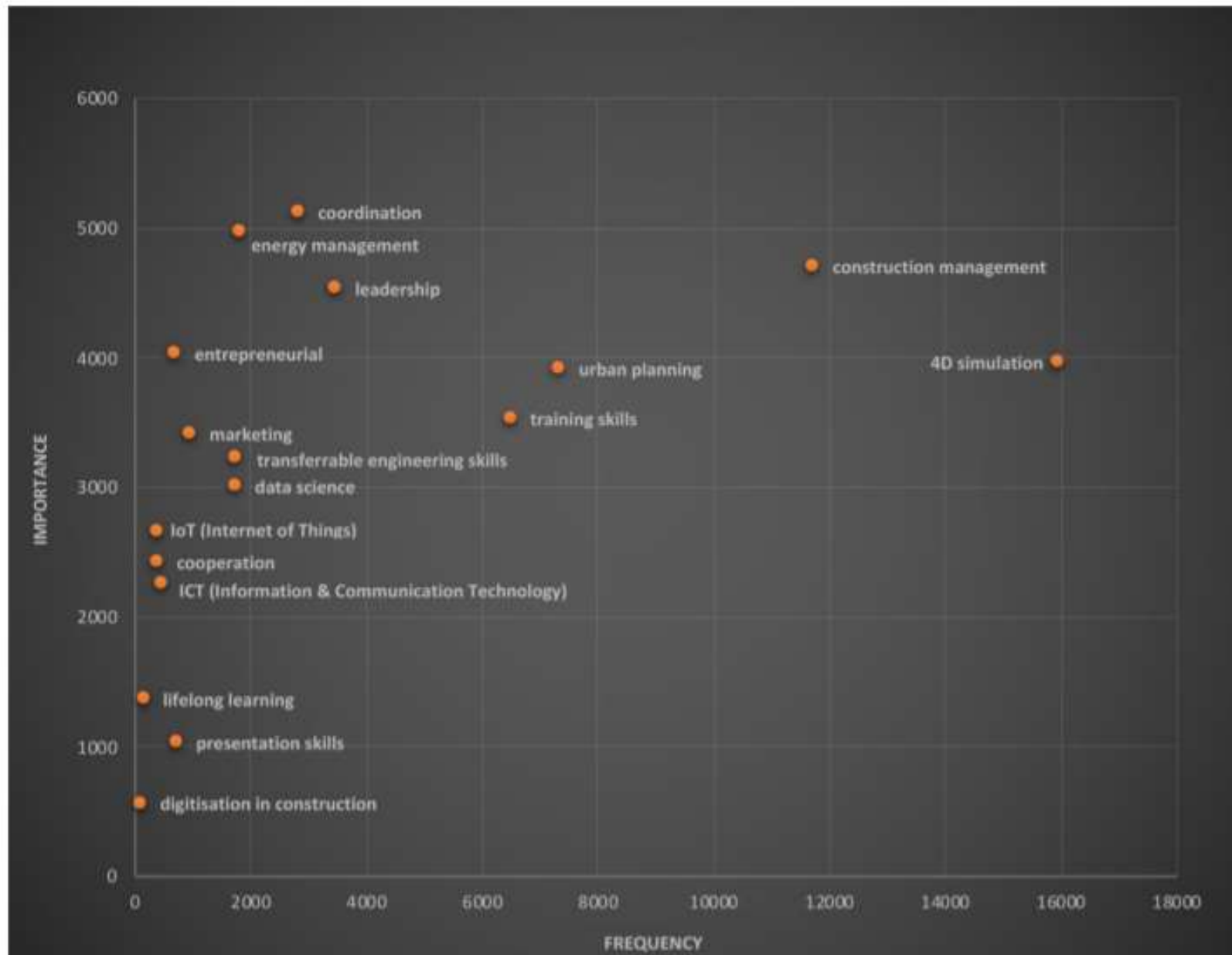


ROLES

Skills classification and correlation

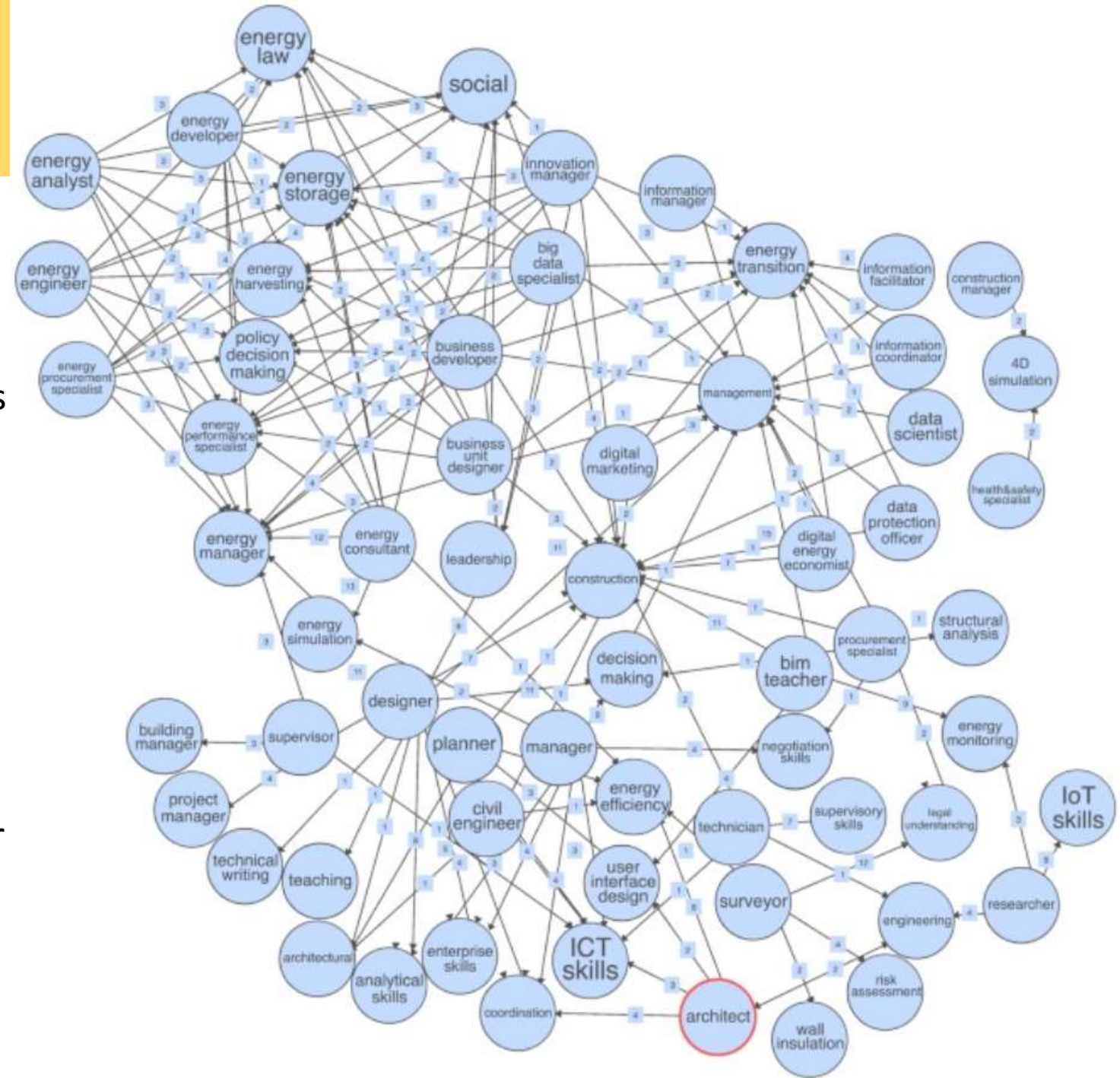


Roles classification and correlation



Ontological dependencies of BIM roles and skills

- Degree of correlation between skills and roles
- Clusters of transition to energy sustainability
- Multi-disciplinary skills and training requirements
- Cluster influence in the industry
- Under-developed skills and roles in the sector



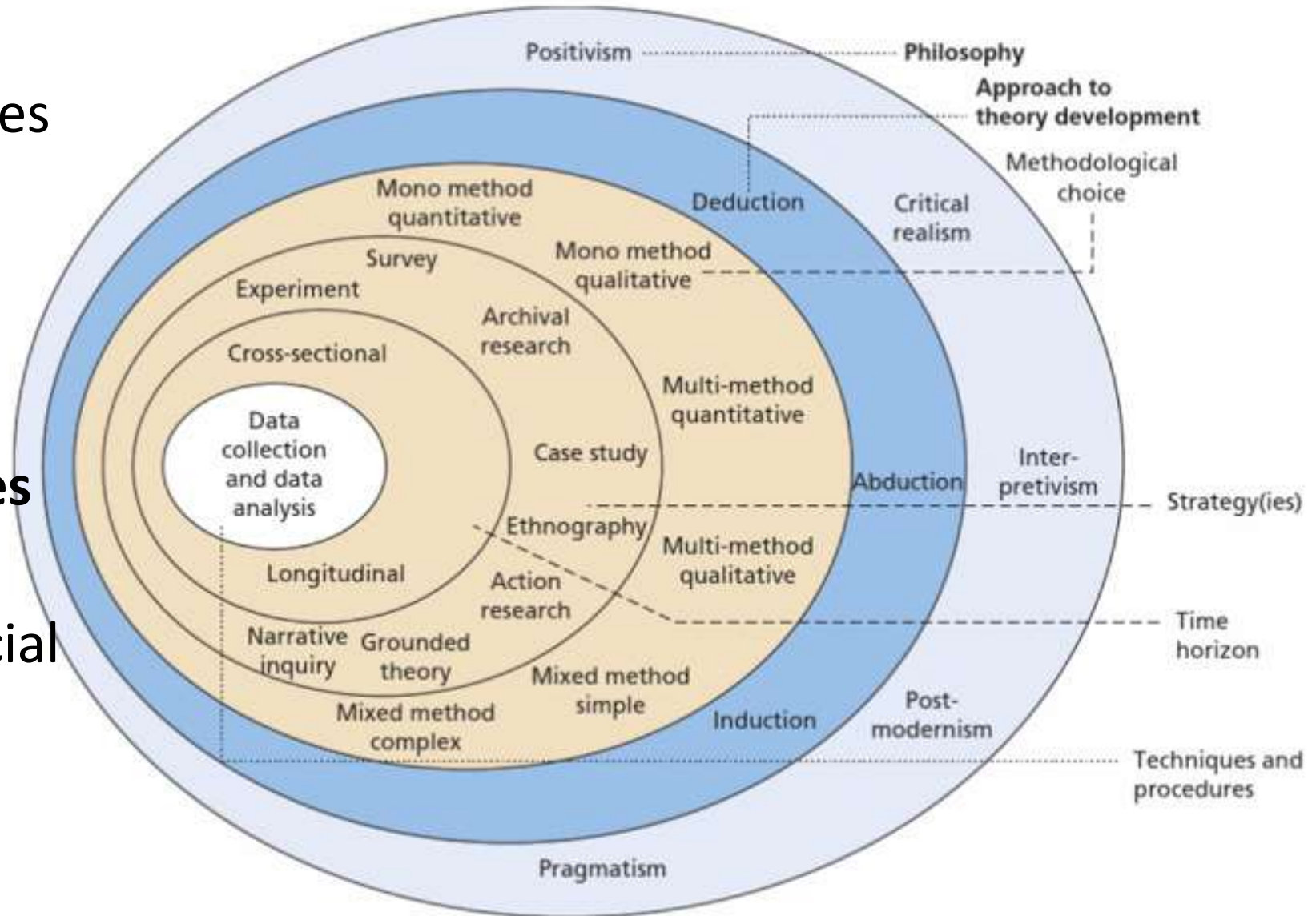


Energy skills via INSTRUCT project

- **Evidencing the correlation between training and energy efficiency**
- **Identifying Europe wide strategic actions to stimulate demand for energy efficiency skills**

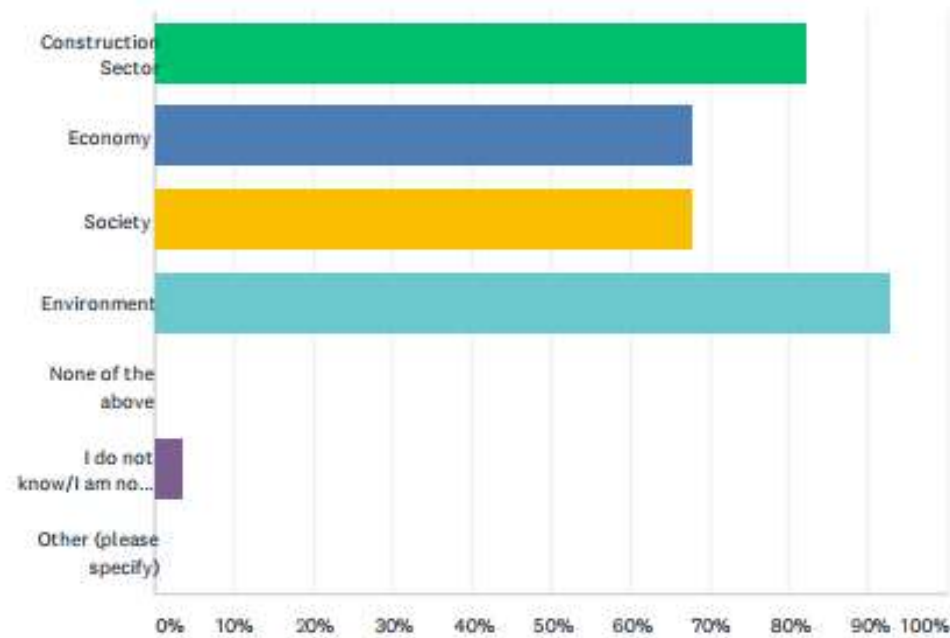
Research driven approach:

- **32 questionnaire** responses – SurveyMonkey
- **27 interviews** – Nvivo
- **70 Best practice use-cases**
- **15 mil. datasets** from social media



Q17 What areas, in your opinion, are affected positively by training for energy efficiency?(Please choose as many boxes as you think is appropriate)

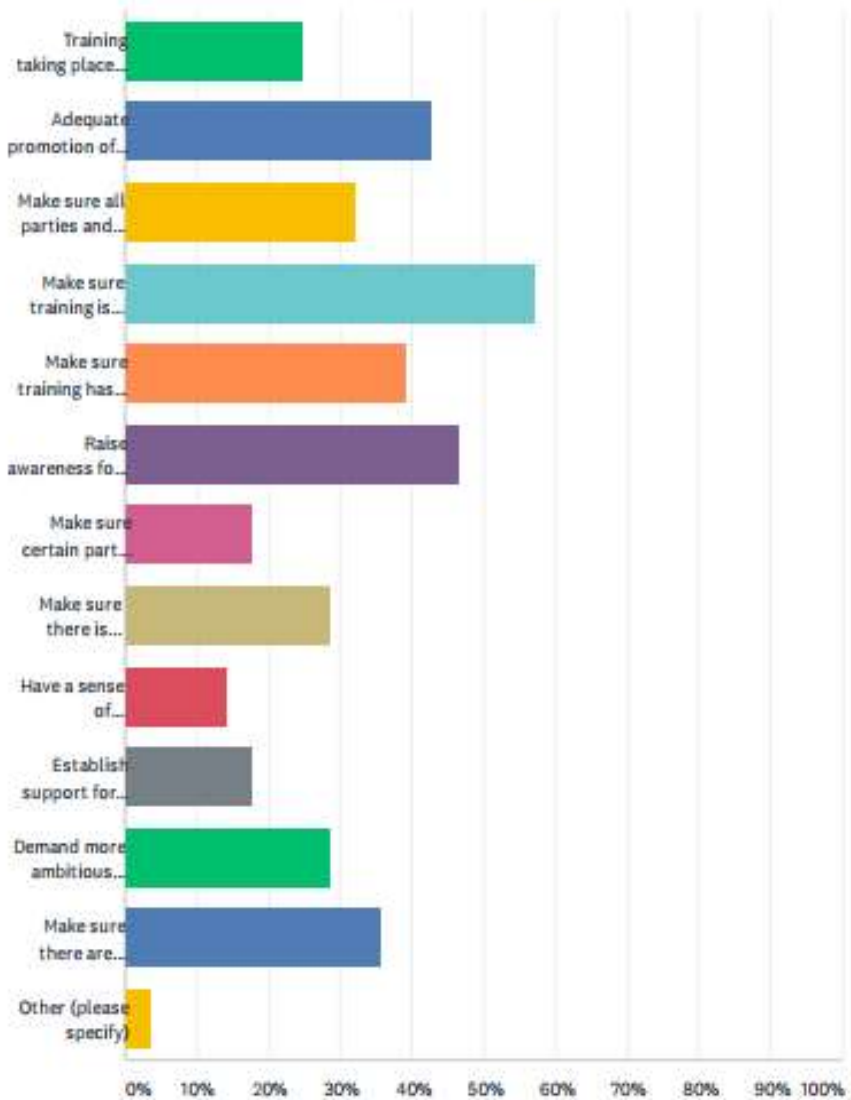
Answered: 28 Skipped: 4



ANSWER CHOICES	RESPONSES	
Construction Sector	82.14%	23
Economy	67.86%	19
Society	67.86%	19
Environment	92.86%	26
None of the above	0.00%	0
I do not know/I am not sure	3.57%	1
Other (please specify)	0.00%	0
Total Respondents: 28		

Q15 What are your recommendations to enhance training & skill development programs in your organisation? (Please choose as many boxes as you think is appropriate)

Answered: 28 Skipped: 4

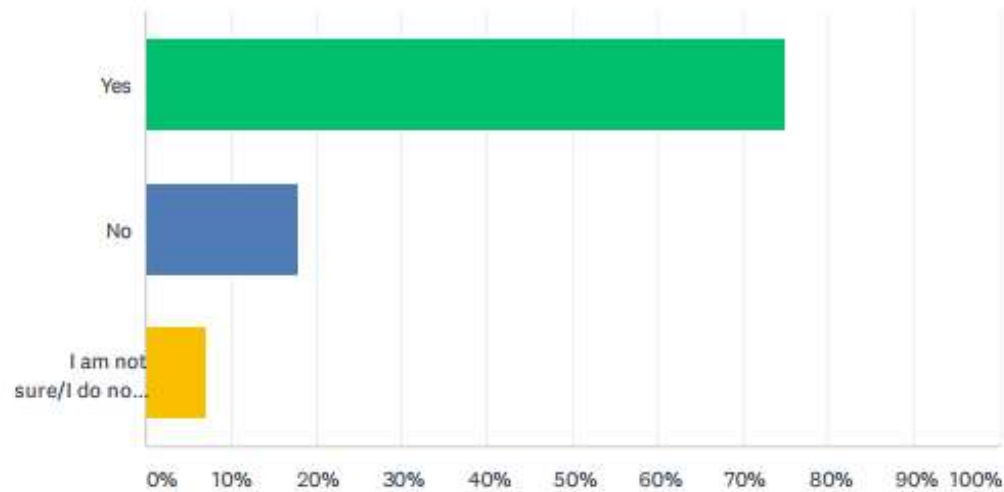


ANSWER CHOICES	RESPONSES
Training taking place in specific periods	25.00% 7
Adequate promotion of training	42.86% 12
Make sure all parties and stakeholders involved are integrated in the process of developing training programs, from the start	32.14% 9
Make sure training is flexible and adjusts to the needs of those who undertake it	57.14% 16
Make sure training has a significant practical contribution for those involved	39.29% 11
Raise awareness for the need for training in energy efficiency	46.43% 13
Make sure certain parts of training are made core elements of curricula	17.86% 5
Make sure there is recognition/qualifications for the training undertaken	28.57% 8
Have a sense of responsibility for the future impact of the training	14.29% 4
Establish support for funding initiatives that support training	17.86% 5
Demand more ambitious results	28.57% 8
Make sure there are mandatory courses for construction workers	35.71% 10
Other (please specify)	3.57% 1
Total Respondents: 28	

1. Not sure

Q20 Have you been involved with knowledge and experience sharing for energy efficiency in the construction sector?

Answered: 28 Skipped: 4

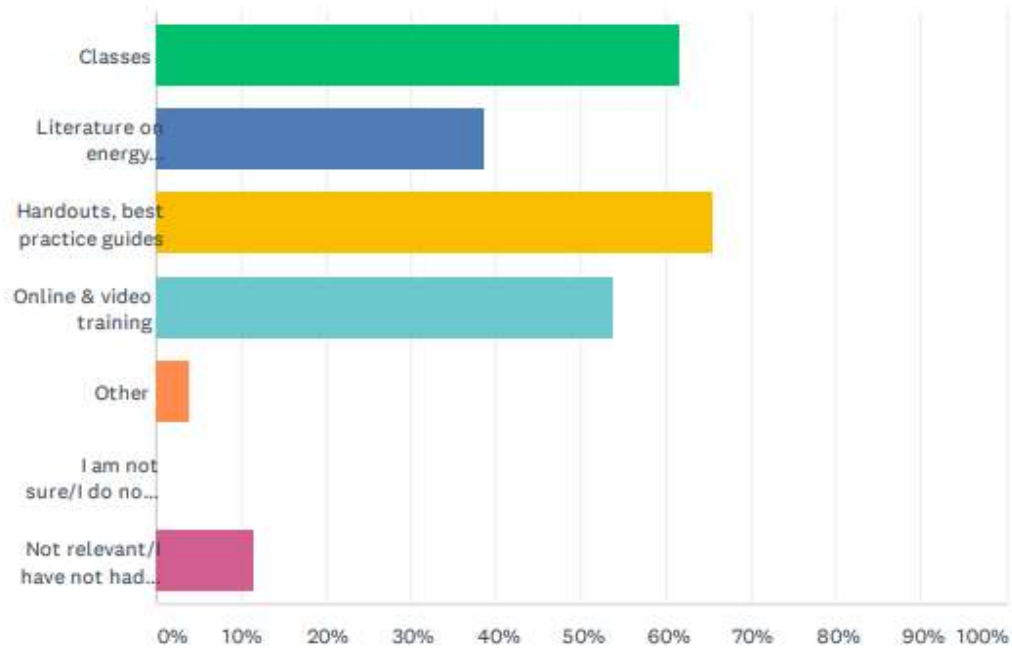


ANSWER CHOICES	RESPONSES	
Yes	75.00%	21
No	17.86%	5
I am not sure/I do not know	7.14%	2
TOTAL		28

1. "Research and innovation programmes"
 2. "Build up skills"
 3. "Keeping training about energy efficient construction at a construction company"
 4. "Short CPDs on energy renovation, including renovation of traditionally built buildings"
 5. "Involved as a trainer"
 6. "BUILD Up Skills Qualibuild, Train-to-Nzeb, VET4LEC, Construction Blueprint, BIMzeED, developing NZEB and BIM modules for VET and HEI"
 7. "Developing courses"
 8. "We were part of the projects Train-to-nZEB, BUILD UP Skills Enerpro. Currently part of the projects nZEB Roadshow and BUSLeague"
 9. "BuildUp skills"
 10. "12 years ago involved with championing energy efficiency in commercial buildings"
 11. "Training of trainers, designers and construction managers"
- Overall, the majority of respondents (75%) have been involved with knowledge and experience sharing in the construction sector, which shows a high level of knowledge among the respondents with regards to the subject of inquiry at hand.

Q24 What type of training material was used in the training program for energy efficiency in the construction sector that you have been involved with?(Please choose as many boxes as you think are appropriate)

Answered: 26 Skipped: 6



ANSWER CHOICES	RESPONSES
Classes	61.54% 16
Literature on energy efficiency	38.46% 10
Handouts, best practice guides	65.38% 17
Online & video training	53.85% 14
Other	3.85% 1
I am not sure/I do not know	0.00% 0
Not relevant/I have not had experience with training	11.54% 3
Total Respondents: 26	

Q4. What barriers can you identify in the field of training for energy efficiency, in the construction sector?

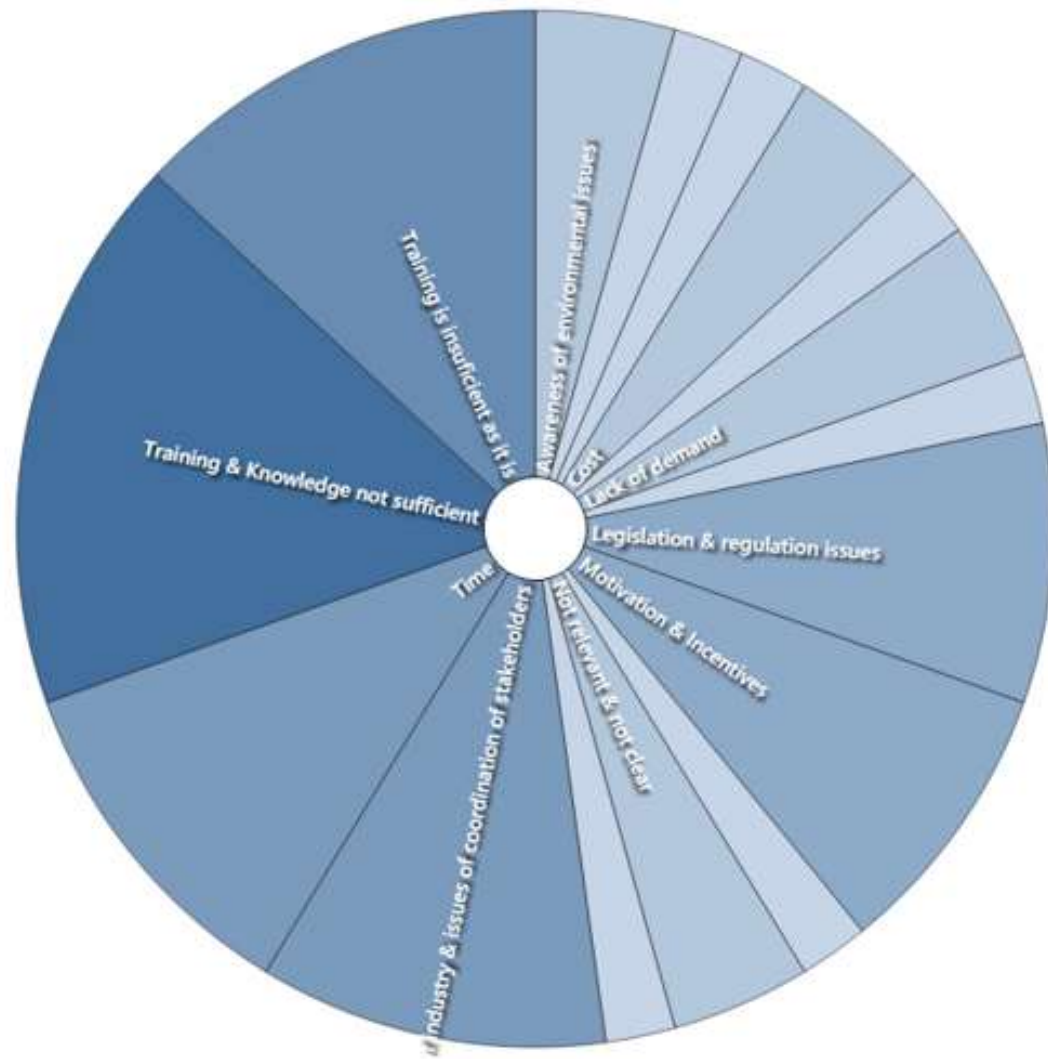
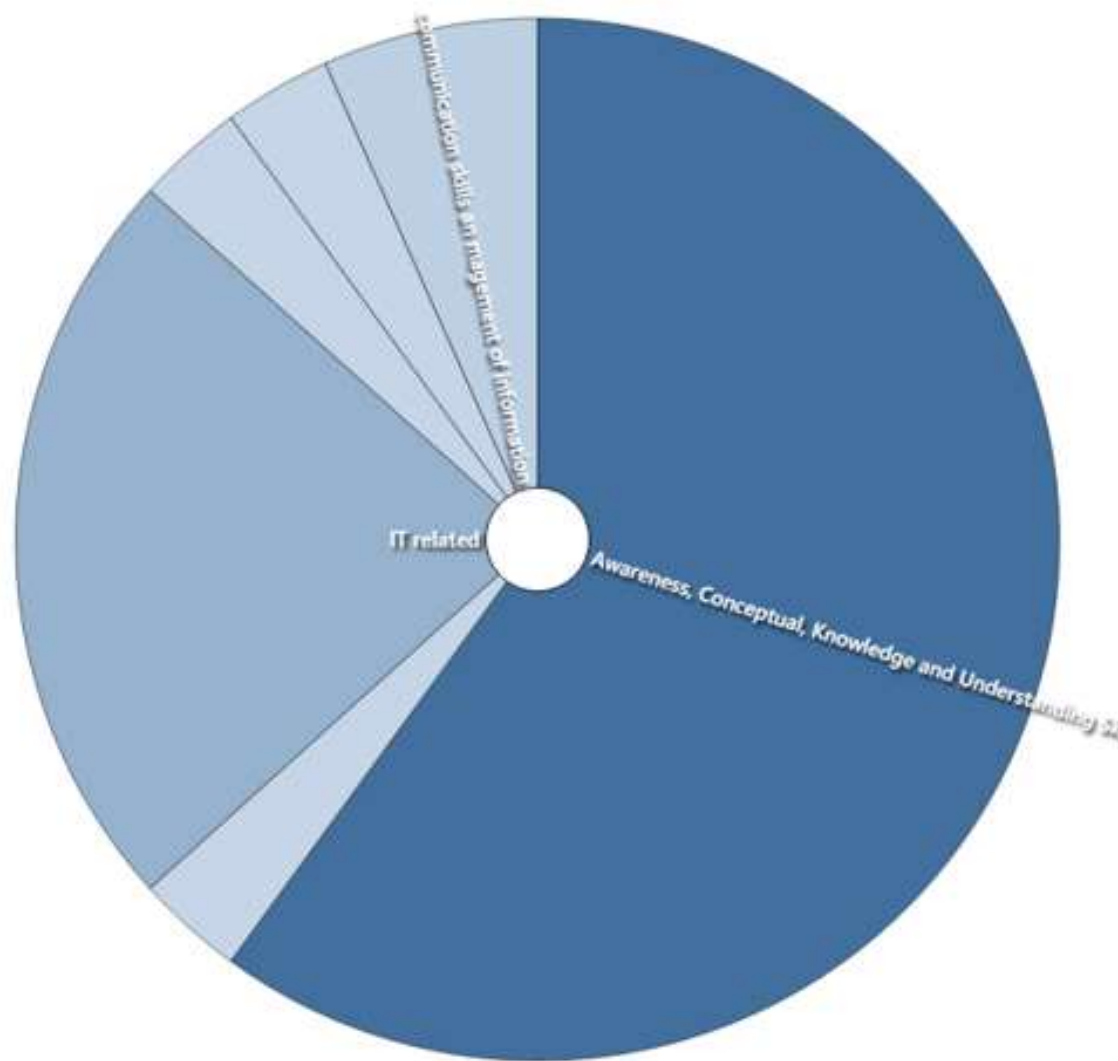


Diagram 2: Distribution of barriers, Q4

Barriers	Count
Barriers	27
Awareness of environmental issues	2
Clients not paying for energy efficiency	1
Communication issues	1
Cost	2
Difficult access to training	1
Lack of demand	2
Lack of interest	1
Legislation & regulation issues	4
Motivation & Incentives	4
No barriers	1
Not relevant & not clear	2
Perception of training for energy efficienc	1
State of industry & issues of coordination	5
Time	5
Training & Knowledge not sufficient	8
Training is insufficient as it is	6

Chart 4: Detailed account of responses to Q4 and barriers

Q12. Could you please describe the skills that are needed in the new energy efficiency technologies, in your field?

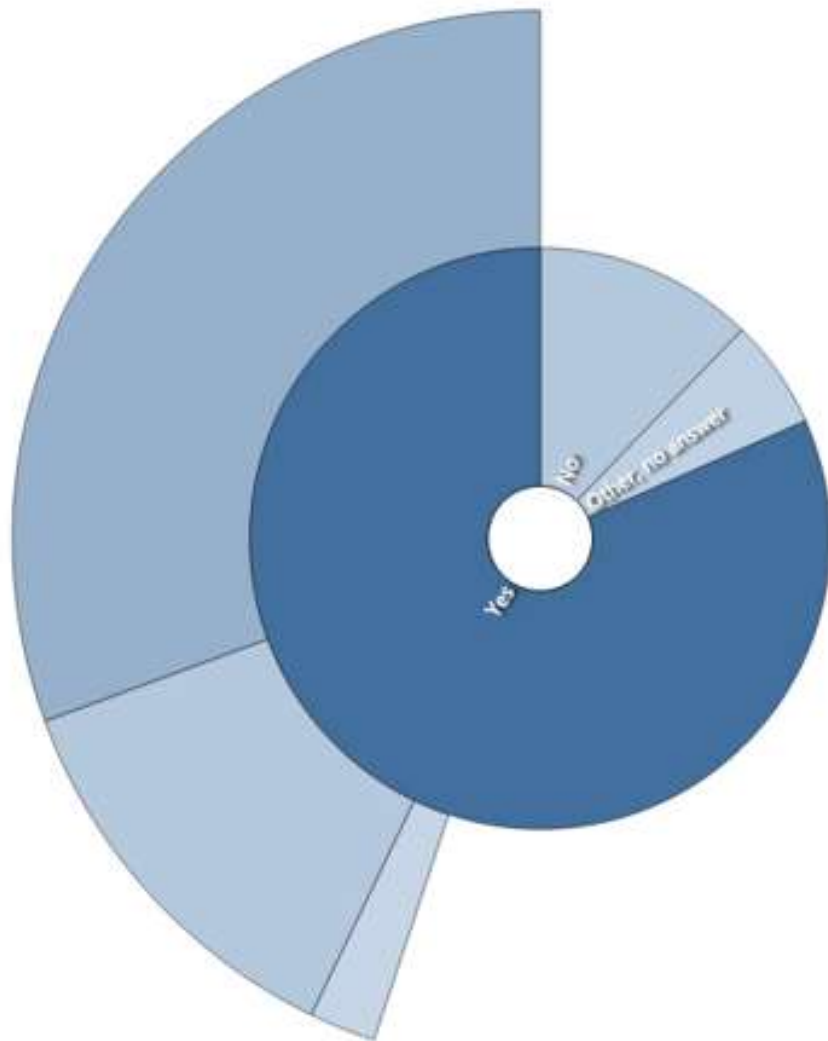


● Awareness, Conceptual, Knowledge and Understanding Skills	18
● Commissioning issues	1
● IT related	7
● No answer, not related, other	1
● Operation, maintanance and technology	1
● Soft Skills, communication skills an magement of information	2

Chart 9: Detailed account of responses to Q12

Diagram 8: Distribution of responses to Q12

Q16. Does completing training result in any formal (e.g. accredited) qualification? Do these qualifications increase employability?

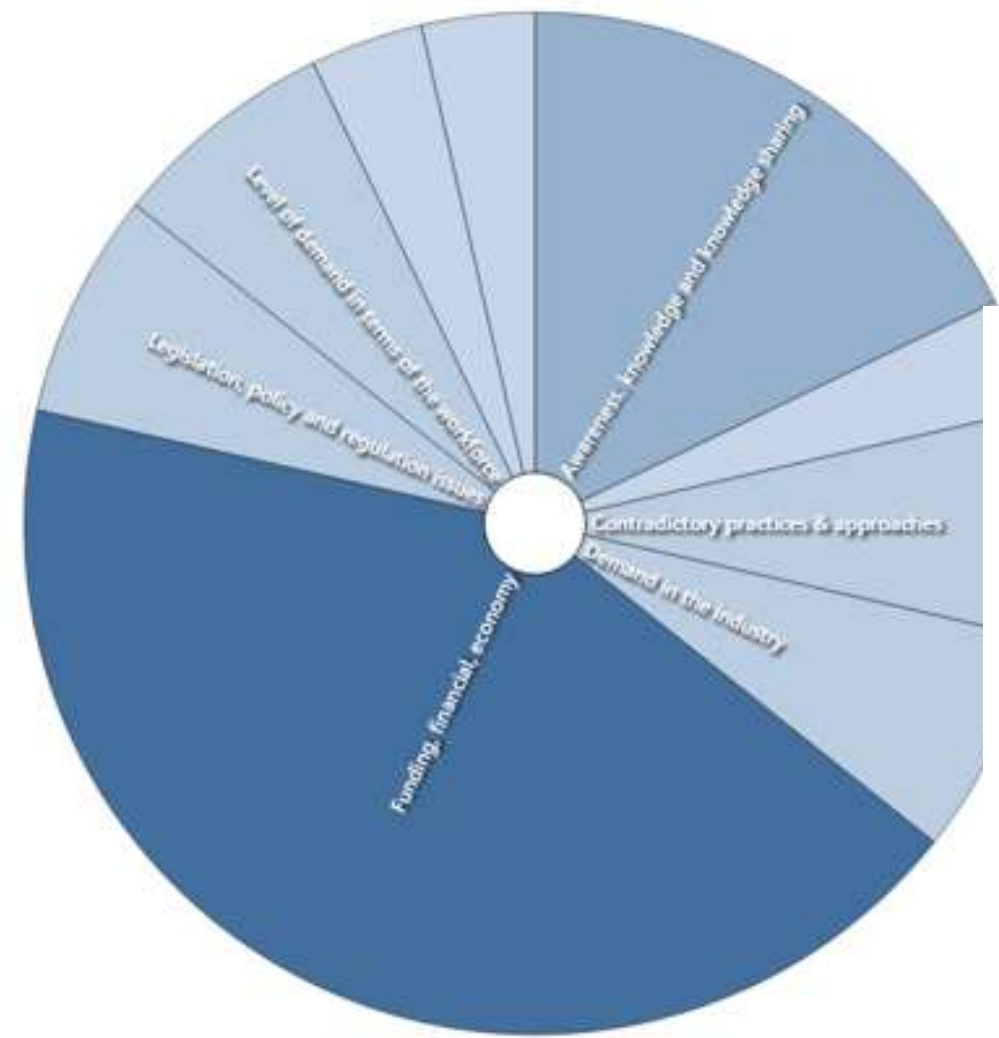


Qualification	26
No	6
Other, no answer	3
Yes	18
Other	1
This qualification does not increase employability	6
This qualification increases employability	15

Chart 13: Detailed account of responses to Q16

Diagram 12: Distribution of responses to Q16

Q19. What market challenges can you identify, concerning demand & economic changes? Are there any strategies that have been identified as successful in dealing with these challenges?



● Awareness, knowledge and knowledge sharing	5
● Client demands	1
● Contradictory practices & approaches	2
● Demand in the industry	2
● Funding, financial, economy	12
● Legislation, policy and regulation issues	2
● Level of demand in terms of the workforce	2
● Resistance in construction industry	1
● Time	1

Chart 16: Detailed account of responses to Q19

Diagram 15: Distribution of responses to Q19

Take away message from the analysis

- The analysis has evidenced the importance of socio-organisational aspects in construction skills
- The need to adopt a continuous improvement approach **to change in the current and ongoing energy training implementation landscape.**
- These correlations are dynamic and will change to reflect the continuous evolution of roles and skills that reflect the incremental adoption, and improvement of energy skills in the industry.
- Adopting modern communication technologies to deliver energy education in the construction sector.

Conclusions

- We have implemented and applied a **qualitative and quantitative analysis** method to identify skills and roles that evolve and change frequently.
- **Capturing the dynamic side of energy transition based on a demand driven approach.**
- We have extracted knowledge from use-cases, interviews, scientific publication and social media.
- We have used a **community platform collaboration** with social networks as a reliable source on knowledge to inform the development of training and education for energy skills.

Questions

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Open Access Article

Promoting Energy Efficiency in the Built Environment through Adapted BIM Training and Education

by  Ali Alhamami ^{1,2,*} ,  Ioan Petri ¹  ,  Yacine Rezgui ¹  and  Sylvain Kubicki ³  

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