Developing a Training and Educational Programme for Learning Energy-efficient Building Renovation

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Abstract: The building construction industry has a significant potential to develop and apply energy efficient solutions, and hence contribute to address climate and environmental concerns. Energy efficient solutions are applied not only in new buildings, but also in refurbishment / renovation of existing buildings. Energy efficient building renovation has become one of the notable aspects in the building construction industry in Europe. There are several challenges connected to energy efficient renovation of existing buildings. European Commission acknowledges the challenges and emphasizes the need to replicate best practices and learn from lessons. This paper is connected to an EU-project called "REZBUILD" (https://rezbuildproject.eu/), which focuses on developing decision and planning support for accomplishing near zero-emission in refurbishment of dwellings. One of the main intentions of the project is to spread the usage of the solutions / concepts that are created in the project. This spreading can be seen as a dissemination and a knowledge sharing effort. The study that is associated with this paper contributes to this effort by describing development of a training and educational programme to facilitate acquisition of skills by industrialists and research infrastructures for implementing REZBUILD solutions / concepts in a real environment. The paper presents an overall guiding framework to provide an understanding of the wider context of the skill-gap and address the skill-gap in the construction industry. In this regard, an action plan for skill development at company, industry and government levels is used. And then, the paper provides a brief description of four major kinds of skills that are needed in the construction industry. Finally, it describes a structure of a training and educational programme. This structure includes, among other things, suggestions for contents of such a programme and some relevant aspects that are to be taken into consideration. The paper is based on narrative literature study.

Keywords: Refurbishment, Training, Skill, Building construction, Learning

1. Introduction

"Refurbished and sustainable buildings in the EU will help pave the way for a decarbonised and clean energy system, since buildings are one of the largest sources of energy consumption in Europe, responsible for over a third of EU emissions. But only 1% of buildings undergo energy-efficient renovation every year, so effective action is crucial to making Europe climate-neutral (net zero emissions) by 2050. Currently, roughly 75% of buildings in the EU are not energy efficient, yet 85-95% of today's buildings will still be in use in 2050" (https://ec.europa.eu/energy/topics/energy-efficiency/energy-efficient-buildings/renovation-wave_en).

The above description mentioned by the European Commission emphasizes the importance of refurbishment / renovation of both public and private buildings. The European Commission also points out the importance of replicating / sharing effective new solutions that are developed, to address this issue (European Commission, 2015). Research and development (R&D) projects aim to make their contribution in this regard.

This paper is connected to an EU-project called "REZBUILD" (https://rezbuildproject.eu/), which focuses on developing decision and planning support for accomplishing near zero-emission in refurbishment of dwellings. One of the main intentions of the project is to spread the usage of the solutions / concepts that are created in the project. This spreading can be seen as a dissemination and a knowledge sharing effort. The study that is associated with this paper contributes to this effort by describing development of a training and educational programme to facilitate acquisition of skills by industrialists and research infrastructures for implementing REZBUILD solutions / concepts in a real environment.

Some of the important solutions / concepts that are developed in the REZBUILD project are: 3D printing facades, BIPV (building integrated photovoltaics) integration, Super thermal insulation materials, HVAC (Heating, ventilation, and air conditioning) systems by radiant floor, Solar heat pump solution (Solar assisted heat pump – SAHP) and APM (Agile project management) tool.

The paper first describes the research method. It then presents an overall guiding framework to understand the wider context of the skill-gap and address the skill-gap in the construction industry. In this regard, an action plan for skill development at company, industry and government levels is used. And then, the paper provides a brief description of four major kinds of skills that are needed in the construction industry. Having (1) the REZBUILD solutions / concepts, (2) the overall guiding framework (the action plan), and (3) the major kinds of skills as three building blocks, an attempt is made to design a structure of a training and educational programme. This structure includes, among other things, suggestions for contents of such a programme and some relevant aspects that are to be taken into consideration.

2. Research method

This paper is based on a narrative literature review (NLR). NLR takes into consideration various studies of a topic, and allows the reviewer to gain an understanding of various views associated with the topic, and to make a holistic interpretation of the studies by using his / her experience as well as existing theories and models (Campbell Collaboration, 2001; Kirkevold, 1997). Jahan et al. (2016) say that NLR does not necessarily require to report more rigorous aspects that characterise structured literature review – aspects such as research methodology, search term, database that was used, and inclusion as well as exclusion criteria.

3. Relevant theories

Reflection is one of the pivotal ingredients of a learning process. When describing reflection-in-action, Schön (1998) mentions that when professionals find unexpected results of their actions, then they reflect on their action. Their "reflection tends to focus interactively on the outcomes of action, the action itself, and the intuitive knowing implicit in the action" (ibid., page 56). Learning can occur in several ways. Argyris & Schön (1996) describes single-loop learning and double-loop learning. Single-loop learning focuses on modifying the existing knowledge within the realm of the underlying assumptions, frameworks and norms, and double-loop learning that deals with creating new knowledge by questioning / going beyond existing assumptions and norms. From learning, knowledge is developed. Schein (1973) presents three components of professional knowledge: (1) an underlying basic knowledge that is fundamental for developing the relevant practice (2) an applied knowledge that is used to solve day-to-day problems (3) Skills and attitudes related to actual work done for clients by using the basic and applied knowledge.

4. Addressing skill-gap – An action plan

World Economic Forum (2018a) presents an action plan for developing skills that are needed in the construction / infrastructure and urban development industry. This action plan also provides a bigger context as well as an overall guideline for designing a structure of a training and educational programme that can facilitate the acquisition of skills by industrialists and research infrastructures for implementing REZBUILD solutions / concepts in a real environment.

The action plan that are presented by World Economic Forum (2018a) has three levels. Figure 1 illustrates the action plan at the three levels.

We will look at some of the elements in the action plan that are closely related to the topic of this paper. For more detail on each element at each of the three levels, please refer World Economic Forum (2018a).
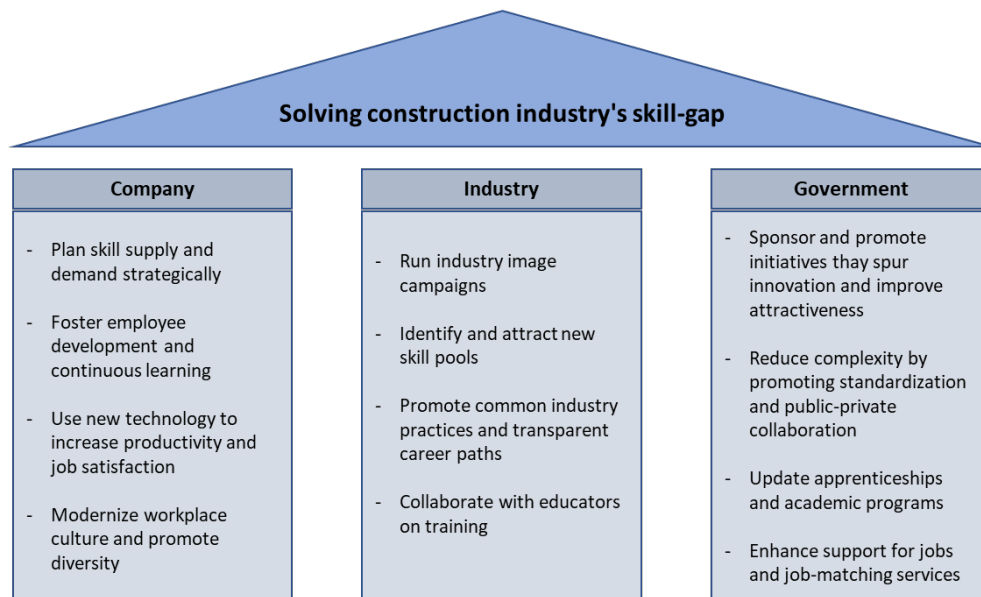
Figure 1: Strategies / action plans to address the skill-gap (World Economic Forum, 2018a)

4.1 Company-level measures

Companies should provide opportunities for their employees to learn and develop. This would make the company a desirable place to work not only for the potential recruits but also for the current employees to acquire new skills that are needed. Learning opportunities can be provided through many ways; for example, through continuing (adult) education at recognized institutions, institutionalizing knowledge sharing, and establishing career programmes that recognize learning and development achievements.

Since the construction industry has been historically viewed as relatively more conservative workplace, there is a need to rebrand it as an industry that characterises purpose-driven thinking, increased flexibility (flexible work-patterns), forward-looking culture, a dynamic performance appraisal practices and agile ways of working. This task will be approached, organised and conducted from a strategic perspective in order to ensure desired outcomes. In addition, construction companies can improve productivity and job satisfaction by adopting technologies, for example, prefabrication, sensors, and mobile collaboration tools.

4.2 Industry-level measures

It is important to work on the image of the construction industry, since the industry is not at the same level compared to other industries. A survey conducted by YouGov shows that two-thirds of the respondents of the survey would never consider a career in the construction industry (UK Construction Week, 2017; World Economic Forum, 2018a). Various efforts can be taken to promote a better image of the construction industry - For example, Build UK and the Construction Industry Training Board (CITB) established a collaboration to start an image campaign. The campaign is called Inspiring Construction (https://builduk.org/priorities/recruiting-training-retaining-talent/inspiring-construction/). The aim here is to attract potential jobseekers to the construction industry by providing relevant and motivating information to them. The construction industry can focus on promoting new technologies that the industry is adopting (for example, 3D printing, augmented reality and virtualization) to students at schools.

New focus areas have gained much attention in the construction industry in the recent years. Two of them are sustainability (energy efficient solutions, near zero carbon emission, etc.) and digitalization. The new focus areas call for / demand skill development in the industry. The World Economic Forum (2018a) says that there is no corporate educators or academia have kept pace with the demand to date. Therefore, it is necessary that the construction industry has to collaborate with universities, professional colleges and vocational training providers to develop relevant curricula for existing and future employees. This issue can be addressed in three dimensions (World Economic Forum, 2018a):

- The first dimension is to identify the skills-gap to have a clear understanding of what skills are needed and how many workers possess those skills. An example that can be mentioned here is an effort taken by two German institutions called, the Federal Institute for Vocational Education and Training (BIBB) and

Institute for Employment Research (IAB). These institutions regularly conduct research to find out supply and demand for workforce skills to provide leading industry and education providers with information about the labour market and professional education trends.

- The second dimension is that the construction industry should provide feedback to the academia / educators on how current curricula satisfy meet the industry's needs. This feedback helps the educators to design and shape future training, both in vocational educational training (VET) programmes and in higher education. In the German Dual VET system, businesses, the government and the society take part in the BIBB committee, which makes sure that the real-world work requirements are a part of the education and training programmes.
- The third dimension is collaboration between the construction industry and higher educational institutions. The collaboration can manifest as R&D or pilot projects.

4.3 Government-level

Juricic et al. (2021) point out in the conclusion of their study on "Review of the construction labour demand and Shortages in the EU", that skill and occupational requirements change over time and are affected by changes such as technological changes. Therefore, updating apprenticeships and academics programmes play an important role in developing skills for current and potential workers in the construction industry to meet existing and emerging demands and conditions. The update can be done in the following steps:

- Find out the skills that the construction industry needs
- Compare it with the contents of the apprenticeships and academic training programmes
- Based on this comparison, determine what new courses are needed
- According to this result, update the educational / training programmes

Updating apprenticeships and academic programmes could pave the way to promote life-long learning which in turn can contribute to increase productivity and competitive advantage. When organizations become learning organizations, then they can achieve and retain competitive advantage (Senge, 2006).

One of the approaches to apprenticeship programmes, which is similar to the existing system in Germany, is to combine on-the-job training with theoretical learning at vocational school. Universities can be encouraged by governments to teach new courses in digital technologies, soft skills (such as communication, leadership, stakeholder management, etc.) and general skills (such as project management, foundational engineering and programming, etc.). This could enable students to become eligible for different types of jobs in the industry.

Soft skills and practical knowledge emerge through practice. Higher extent of practice will lead to acquire soft skills and practical knowledge. On way to achieve this, is hands-on learning. For example, University of Chichester in UK is building an engineering and digital technology park with a project-oriented engineering workshop. This park incorporates a fabrication laboratory, 3D printers and hands-on learning spaces. The intention of building this park is to educate and train students to address business challenges that are emerging in engineering and technology.

There are specialized programmes that provide support to governments to update academic programmes – for example, UNEVOC (World Economic Forum, 2018a). It is a UNESCO centre for technical and vocational education and training (TVET). This centre provides help to the member states of UNESCO in developing and improving TVET systems and implementing skills-development policies and programmes. These policies and programmes are relevant, accessible to all and have a long time span (lifelong).

5. A categorisation of needed skills

The action plan that was described in Chapter 4 can be applied as an overall guiding framework or a foundation to develop a training and educational programme for learning the REZBUILD solutions / concepts. These programmes, which are aimed at developing skills, will be more effective, if they also reflect on and represent the kinds of skills that are needed in the construction / infrastructure and urban development industry. In this regard, we can look at the following categories of future skills that are mentioned by Construction Leadership Council (2019, page 3).

- Digital skills: Development of more widespread digital skills to underpin future, collaboration and productivity improvements within the sector. This must be coupled with 'digital leadership', meaning

that executives and managers across clients, contractors, consultants and the supply chain are committed to resourcing and delivering their projects digitally.

- Technical skills: An increase in technical skills to enable deployment of Smart Construction methods during all stages of a project lifecycle: project initiation, design delivery and operation. This will allow projects to be developed with manufactured products in mind from project inception; rather than designing traditionally and converting the design later.
- Collaborative skills: Development of the necessary collaborative skills to enable individuals to work effectively across teams to plan and to communicate and deliver digitally-enabled Smart Construction projects. As projects become more complex and demanding, the industry will be required to work more closely together than ever before. The transactional and isolated behaviours of the past counteract progress in an increasingly complex and interconnected industry.
- Traditional skills: Maintaining and enhancing traditional skills. These skills will remain in demand as they already face skills shortages and they are essential in maintaining and extending our existing built environment.

The categories of skills reflect and have several connections with the action plan presented in Chapter 3, for example focus on digital skills.

6. Designing a structure of a training and educational programme

Designing a structure of a training and educational programme includes both examples of the content of such a programme, and some important aspects that are to be taken into consideration.

6.1 Content of a training and educational programme

A training and educational programme can take several forms. Scope (to what extent the topics are covered in a training and educational programme), and duration of the programme can vary according to the situation – for instance, according to the need and possibility. We will present one such form as an example based on the description that we have seen so far. This example takes a holistic / systemic view; that is, the programme provides not only the knowledge on the REZBUILD solutions per se, but also topics related to them so that the learner could obtain a holistic understanding that would strengthen his or her skill development. The training and educational programme that we suggest has seven parts. They are:

1. Sustainable construction
2. Energy efficiency
3. Standards, labelling, certifications and policy instruments
4. Current and emerging technologies
5. REZBUILD solutions / concepts
6. Project management
7. Soft skills

These seven parts can be categorized into three categories:

- Background knowledge: The first four parts (Part 1, 2, 3, and 4) could provide background knowledge that is needed to understand the implementation of REZBUILD solutions / concepts better and reap greater benefits of implementing them.
- REZBUILD solutions / concepts: Part 5 deals with the REZBUILD solutions / concepts.
- Methods for effective implementation: The last two parts (Part 6 and 7) are about means or methods for implementing the solutions / concepts efficiently in a real environment. Refurbishment efforts that include the application of the REZBUILD solutions can be seen as projects. By applying project management techniques and skills (for example, organizing and time management) can be helpful to accomplish the desired results in an efficient manner. Generally speaking, implementation of such projects and REZBUILD solutions / concepts in industrial and research infrastructure settings involves several people. Dealing with and managing people effectively require soft skills such as communication, leadership, etc. As a part of the training and educational programme, project management and soft skills ensure accomplishing the desired results of the implementation of the REZBUILD solutions / concepts effectively.

Now, we will see possible contents of these seven parts that constitute a training and educational programme. This description is developed with the help of information and inspiration from other relevant deliverables from

the REZBUILD project, Building up green skills of trainers from the construction industry (Eco-Trainer in the construction industry, 2018), discussions with professionals, academics and researchers, and our own work experiences.

- *Sustainable construction*, as a starting point, can encompass a general description of sustainability in the construction industry – including refurbishment projects and activities – addressing what it is, why there is focus on sustainability in the construction industry, how it is accomplished, etc.; a fundamental description of sustainable construction techniques (for example, passive solar design); a general description of relevant traditional construction topics and techniques, incorporating relevant aspects of bioclimatic design and construction such as climate, ventilation, thermal comfort; and a general description of new technologies applied for the sustainable refurbishment of buildings (for example, insulation and related measures to reduce the energy consumption of buildings).

- *Energy efficiency* can focus on providing more detail knowledge on energy efficient insulation (walls, roofs, windows and ceilings), and heating and cooling systems.

- *Standards, labels, certifications and policy instruments* can provide information on regulations / categorisations that one has to refer to when refurbishing dwellings, as well as policy instruments that provide supporting governmental mechanisms for refurbishment efforts.

- *Current and emerging technologies* can address not only relevant building construction technologies, but also how the technologies affect the construction industry, what companies and the industry can do to deal effectively with opportunities and threats that the technologies bring forth, and how to do it at the strategic, tactical and operational levels. In addition, this part can also include a general description and basics of the digital technologies, for example, Building information modelling (BIM), computer-aided design (CAD), 3D printing, laser scanning, and virtual reality (VR) and augmented reality (AR).

- *REZBUILD solutions / concepts* are the solutions / concepts that are developed in the REZBUILD project include; for instance, 3D printing facades, BIPV (building integrated photovoltaics) integration, Super thermal insulation materials, HVAC (Heating, ventilation, and air conditioning) systems by radiant floor, Solar heat pump solution (Solar assisted heat pump – SAHP) and APM (Agile project management) tool. In the learning session, each solution / concept can be addressed in the following manner:

- Presentation and description of the solution / concept: Characteristics of the solution / concept, rationale behind developing it, requirements for implementing it, a description of how to implement it effectively, information on factors that are to be considered when implanting it, expected and potential impact of it.

- Sharing of experiences (best practices and lessons learned, tips and guidance): Presentation and description of how the solution has been implemented in the three REZBUILD demo-sites and other places.

- *Project management* can include topics related to practical project management from project start to project completion / delivery. Some of the relevant topics that can be taken into consideration are, organizing and project work-structure, contracts, time planning, cost estimation, budgeting, resource allocation, work scheduling, coordinating, communication, collaboration, stakeholder management, uncertainty management, change management, work culture, project delivery, reflection and learning. Reflection and learning can contribute to improve future refurbishment projects – for instance, saving time and cost, and ensuring a better quality.

- *Soft skills* can include the following elements:

- Fundamental principles of organizational behaviour, organisational culture, and social aspects of organization

- Tools, methods and approaches for handling aspects related to organisational behaviour, organisational culture, and the social dimension of the organization effectively

- Special focus can be given to key soft skills, for instance, communication, collaboration, negotiation, conflict management and leadership

6.2 Some relevant aspects to consider

The training and educational programme (physical and / or online participation) can be designed and implemented in various ways and forms depending on the need, availability of resources and other existing conditions. Several aspects are relevant to be considered when the training and educational programme is being planned. Some of them are:

- Level of skills: The level of skills that potential learners have, can determine how the programme can be designed – that is, duration of the programme, choice of topics, the extent to which the topics are

covered, etc. Various skill-levels also point out the necessity to focus on criteria for selecting / admitting potential learner to the programme.

- Learning setting: This is about deciding whether the learning process will be a stand-alone programme or an integral part of a larger learning setting / programme at an educational institution.
- Cost related issues: This is about determining the cost of conducting the programme and learners' participation fee (if any).
- Approving learners' participation: This is about determining the form of approving learners' participation in the programme (following a credit system from an established educational entity or providing certificates for participation, etc.).
- Completion and evaluation of the programme: A learner's completion of the programme can be approved based on either the learner's participation and/or an exam at the end of the programme, depending on the existing conditions of the situation. If the programme becomes a part of a curriculum at an educational institution, then there is a high probability for exams. These exams can be written exams that should be taken within a designated time interval, oral exams, practical exams, in the form of delivering reports at the end of the programme, or some combination of all these alternatives.
- Feedback on the programme: The students / learners who participate in the programme can give their feedback on the programme after they complete it. A questionnaire can be used in this regard. They can also provide information later regarding how this programme has helped them to improve their work / projects. This kind of feedback can be used to reflect and evaluate the programme continuously in order to find possibilities for improvement. This continuous improvement could also lead to identify emerging technologies and learning trends, and include them in the training and educational programme over time. This could attract many people – specially, young people – to learn and try out new, innovative solutions and concepts.
- Duration of the programme: As we have seen in the discussion so far, time period for conducting a training and educational programme (how much time that should be used in each part of the content, etc.) can vary according to the situation and condition, and hence it is difficult to present a specific structure (time-plan, etc.) for a programme.

7. Discussion and concluding remarks

Engaging in an effort to shape the future of construction, World Economic Forum (2018b) says that one of the key reasons for lack of innovation in the construction industry (as compared to other industries) is an ongoing industry-wide shortage of qualified, skilled workers. It points out that this skill-gap will also lead to stagnate productivity (for example, hindering the adoption of new digital technologies) and negative effects on the economy, society and the environment. In order to close the skill-gap and acquire the skills needed to accelerate the adoption of promising new technologies and concepts, there is a need to improve workers' skills, attract new, talented professionals to the industry and promote new technology.

When major actors from the construction industry and ministers of several countries dealt with the issue of transforming the industry in the World Economic Forum Annual Meeting in 2018, they mentioned three most important efforts to address the skill-gap in the construction industry (World Economic Forum, 2018b):
1. Attract new talent and build up required skills
2. Integrate and collaborate across the value chain
3. Adopt advanced technologies at large scale

This description suggests the relevance of adopting REZBUILD solutions in future renovation efforts and of disseminating REZBUILD solutions through training and educational programmes. By sharing its knowledge, the REZBUILD project can contribute to create a greater impact on the construction industry. In this regard, we can think of REZBUILD's contribution to following / materialising the action plan (that we have seen in Chapter 4) and strengthening the four kinds of skills (Chapter 5).

Having (1) the REZBUILD solutions / concepts, (2) the overall guiding framework (the action plan), and (3) the major kinds of skills as three building blocks, we attempted to design a structure of a training and educational programme – a programme that can facilitate the acquisition of skills by industrialists and research infrastructures for implementing REZBUILD solutions / concepts in a real environment. Figure 2 illustrates it.
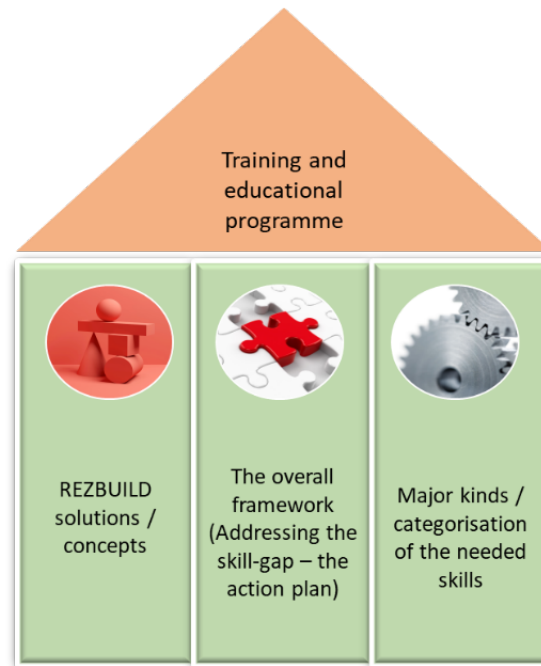
Figure 2: Developing a training and educational programme

It should be noted that the structure of the training and educational programme (for instance, the extent to which the topics are covered in the training and educational programme and duration of the programme) can vary according to the situation. Therefore, what we have presented in Chapter 4, 5 and 6 can be considered as a suggestion that can guide one to develop a training and educational programme according to the current conditions (need, possibility, etc.). This can be considered as a limitation of this paper.

One of the essential factors of learning processes in a training and educational programme is reflection. Reflection on a new knowledge with respect to the current practice can lead the learner to figure out how (or to what extent) the new knowledge can be applied in practice. Schön (1998, page 61) says, "A practitioner's reflection can serve as a corrective to over-learning. Through reflection, he can surface and criticize the tacit understandings that have grown up around the repetitive experiences of a specialized practice, and can make new sense of the situations of uncertainty or uniqueness which he may allow himself to experience". Hence, reflection can lead not only to single-loop learning, but also double-loop learning (Argyris & Schön, 1996). REZBUILD solutions, such as 3D printing, can be considered as an impetus for or a result of double-loop learning.

The training and educational programme presented in this paper reflects – at least to a certain extent – the three components of professional knowledge that Schein (1973) describes:
- Basic knowledge: Part 1, 2, 3 and 4 (of the programme)
- Applied knowledge: Part 5
- Skills and attitudes: Part 6 and 7

Detail of the parts of the programme are mentioned in Chapter 6.

With its solutions / concepts, the REZBUILD project aims to demonstrate, among other things, primary energy reduction, reduction of installation time in comparison with a traditional refurbishment work, and a rapid feedback period. Conducting a training and educational programme will contribute to share and spread the REZBUILD solutions / concepts to others and increase energy efficient refurbishment of buildings.

Further research can focus on implementation of the programme in various contexts, and identify possibilities for improving the content and the implementation of the programme.

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dissemination of results must indicate that it reflects only the author's view and that the Commission is not responsible for any use that may be made of the information it contains.

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