From BIM to TIM

Competences required for the digital future in tunnelling

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ABSTRACT: Digitalisation in tunnelling enables better transparency and plannability of major projects over the entire life cycle. Change towards digitalisation within the tunnel industry is only feasible with appropriate technology and qualified employees. The Tunnel Information Modelling (TIM) method already provides the technological contribution towards digitalisation. But the human factor in the digitalisation process has been neglected so far and therefore will be explored in this master thesis. The focus is set on the competencies of the employees and to explore these the following research question will be answered: Which competencies are required for the application of Tunnel Information Modelling?

While an extensive literature review has brought up many results and theories in the field of operational and digital competences in underground mining, most of them focus specifically on the fields of geotechnical engineering, structural engineering and tunnelling methods. There are barely any literature and research results on the required competencies in tunnelling, especially in digital competence in this industry. Therefore, this work cannot be based on already existing hypotheses, but on the experience and opinion of experts in tunnelling through qualitative research. A total of eight interviews were conducted including eleven experts, varying from both clients and contractors in infrastructure and underground construction.

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KEYWORDS: BIM, TIM, competence, expert interview, qualitative content analysis, underground construction, digitalisation

1 INTRODUCTION

Major infrastructure and underground construction projects have a reputation for not being able to meet projected project goals. [1] A study by the European Court of Auditors shows that major projects in the infrastructure sector have significant cost increases as well as time delays for completion. The considerable deviations in terms of time and cost lead to conflicts, both with builders and population. The lack of transparency in the use of subsidies and the complexity of major projects make it difficult for many to understand and accept deviations. In this context, a digital working method can be a valuable contribution to achieve a reliable cost and time schedule. [2]

The term Tunnel Information Modelling (TIM) was introduced by the endowed professorship of the University of Innsbruck. The focus is on the development of a digital twin, which holistically and interdisciplinary represents underground structures. The digital twin combines three required submodels: the building, ground and construction site model. [3, 4] Therefore, employees who are able to apply the TIM method due to their qualifications and skills are required in tunnelling to fully exploit the potential of the digitalisation.

The aim of the Master's thesis was to identify the required competence for the digital future in tunnelling. The systematic literature search revealed that existing literature very much deals with new competence requirements that arise due to digitalisation, but does not address the specifics of the tunnelling industry. In addition, the focus of BIM and TIM publications is often on the requirements of the digital partial models, the specific use cases, the aspects of contract award, contract law, data management, and hardly pays any attention to the resulting changes in the professional qualifications and working methods of the employees. It also neglects the identification of future skills needed in digital tunnelling and the development of defined strategies for building up these skills within the framework of training and further education opportunities. This research gap led to the research question:

Which competencies are required for the application of Tunnel Information Modelling?

2 THEORY

Due to the focus on digitalisation skills in tunnelling, the OECD's 21st century skills model and the concept of digital literacy served as the basis for the analysis of the required skills. In order to meet the challenges of the digital age, 21st century skills are crucial. In general, these skills include collaboration, communication, digital literacy, problem solving, critical thinking, creativity and productivity. It can be observed that these skills are closely related to current economic and social developments as well as changes in the labour market. The two models were included in the identification of the required competences for TIM and further adapted to fit the specific requirements in tunnel construction. [5, 6]

In addition, the competence-based model according to Erpenbeck and Rosenstiel served as the basis for the research. Competency-based models are a descriptive tool that identifies the competencies needed in an organisation and are a crucial factor in adapting education and training to the needs of the labour market. They allow not only the assessment of an individual's strengths and weaknesses, but also the evaluation of the overall human potential and the highlighting of areas that need further development. They serve as a basis for education and training. [7]

3 METHOD

Qualitative research was based on the research results and competence theories. The data collection method chosen was qualitative guided interviews with experts from the tunnelling industry. The variety of the chosen experts ensure that the opinions of clients and contractors in infrastructure and underground construction are represented. Since the answer to the research question results exclusively from the relevant content-related statements and interpretations of the experts, the selective transcription system was used to transcribe the interviews. Subsequently, the transcripts of the scientific research work were evaluated by means of qualitative content analysis according to Mayring. [8]

4 ANALYSIS AND DISCUSSION

For a structured evaluation, relevant statements and text passages of the expert interviews were bundled in a topic-oriented manner, assigned to the appropriate field and integrated into the associated categories and subcategories.

The framework analysis from the initial situation and the literature has revealed two thematic areas.

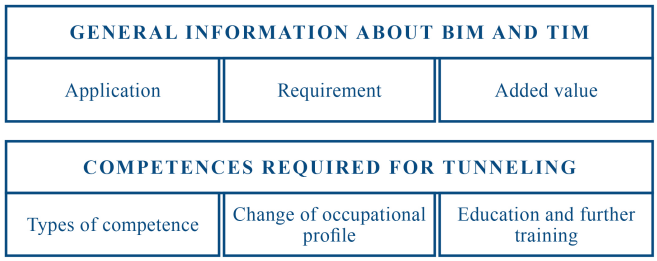

Fig. 4-1: Thematic fields and categories of the qualitative research

The categories were formed inductively, i.e. categories were created on the basis of the text material. In addition, deductive categories were added, which were already given by the interview guide. The statements resulted in further subdivisions of the respective categories, which were combined into subcategories.

The creation and definition of all categories and their subcategories was documented in detail in the form of an evaluation table. The evaluation table is divided into the two thematic fields and contains all text passages from the transcripts that were assigned to the categories and the corresponding subcategories.

All of the interviewed experts are convinced that the method of TIM and its implementation will be an inevitable topic for future tunnel construction. All experts consider the new digital working methods to be future oriented for tunnelling and are anxious to act in spirit of this methodology. Some of the companies surveyed already (partially) apply TIM in their projects, but mostly in a supportive manner and not to its full potential. The application often takes place on a voluntary basis in order to gain experience with the TIM method. The DAUB already has developed recommendations for BIM in underground construction, but the lack of binding standardisation, guidelines and regulations means that it cannot be applied universally. [9]

The experts' statements regarding the required competence also predominantly match with the specialist literature. What was surprising here was the emphasis on the attitude of employees in the course of digitalisation. Openness to new methods has a direct influence on methodological competence. But social competence is also necessary in order to optimally facilitate the exchange of information between the project participants. Digital working methods in underground construction also create new job profiles that can be taught in higher education institutions and technical colleges. But until these new training and courses are established, competence development is only done on-the-job and in internal and external training courses.

5 CONCLUSION

Five types of competences could be identified as essential: Technical, methodological and social competence, digital and data competence, relevant values and attitudes. The specific competence descriptions of the respective categories with regard to employees in tunnel construction can now be researched and defined in more detail in further studies in close cooperation with clients and contractors.

By considering the increasing application of new digital working methods in underground mining, this research work contributes to the identification of relevant and necessary competence requirements. Especially considering the necessary competences in a digital context, starting points were created for further theoretical development of the topic. In addition, the description of the types of competences provides orientation for practice and offers the possibility to develop targeted competence development measures.

6 OUTLOOK

The findings of this research indicate that future competence-based research should focus on generalising and extending the results by considering other perspectives.

Future studies should consider the view of the trainers and the approaches of the Ministry of Education in order to verify and supplement the identified competences. Some questions remain open as to how the required competences are acquired and which measures and formats turn out to be useful and suitable for competence development and therefore subsequently become established. A further study may make it possible to identify critical gaps as well as opportunities in the education system and requirements for on-the-job training.

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