

Engineering skill requirements to cope with the local and global challenges of the future

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The paper discusses how the working environment of civil engineers has changed throughout the years, and how curricula need to be adapted towards these changes.

Global challenges

In the 21st century, adequate habitat and functioning infrastructure are critical for global societal and economic stability. In addition, growing urbanisation and environmental pollution cause challenges to societies. With increasing velocity, humanity faces that the current way of living is not sustainable. Thus, habitat, infrastructure, urbanisation, environment and sustainability are definitively among the most striking challenges of the 21st century.

By consulting, planning, building, maintaining, exploiting and processing of global resources, civil engineers contribute significantly to the existence of these challenges. This is a high responsibility, but due

to the heavy involvement, together with adjacent disciplines such as architecture, geosciences, chemistry, physics, environmental sciences and economics, civil engineers also hold the key to mitigate these challenges and provide a brighter global future (Fig. 1).

Solutions towards greener, more sustainable and economically viable materials do exist (e.g. [1]), and there is ongoing research on how greener technologies can contribute to better livelihood and economic growth (e.g. [2]), but their level of implementation is limited, a major reason for which is that these approaches require more fundamental understanding rather than standard application.

Global challenges of the 21st Century

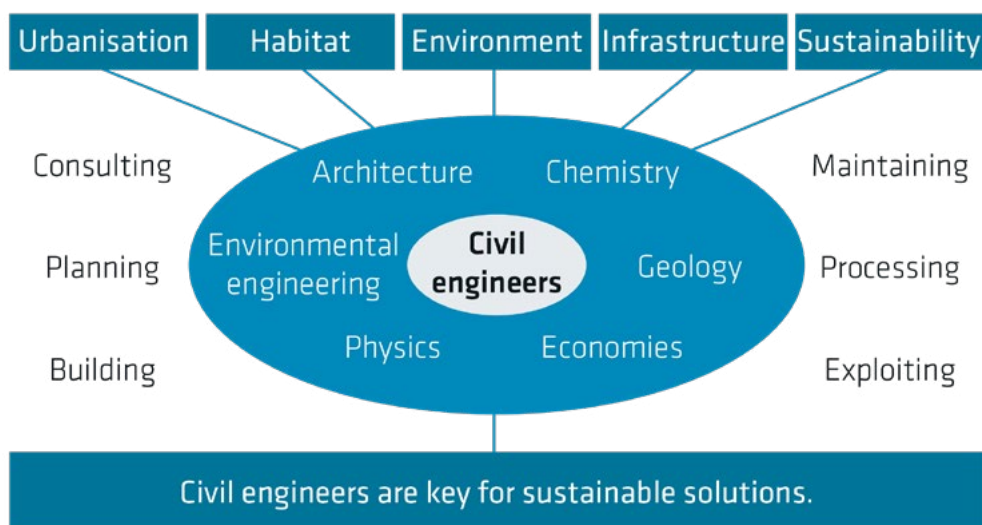


Fig. 1: The role of civil engineers in global challenges

Gap between curricula and real-life requirements

Civil engineering education has traditionally been focused strongly on fundamental mathematics and physics. This may have historical reasons, as the major responsibility of civil engineers in the past was to deliver a reliable, robust and sound calculation, which required a high level of mathematic understanding and reliable calculation skills. Today, with computational tools, the possibilities to calculate and model have increased significantly, but at the same time today no engineer needs to use paper and pen to solve complex equations any more (Fig. 2). Hence, while fundamental understanding of mathematics is definitively still required for civil engineers today, the

reliability of the operations can be provided by computational tools.

While the skill to conduct mathematical operations has lower significance today than in the past, the importance to understand materials has significantly increased [3]. In the beginning of the 20th century, construction materials were limited to concrete, steel, timber and masonry, all of them exhibiting limited ranges of performance specifications. Today there is a vast number of materials with a wide range of mechanical and physical properties.

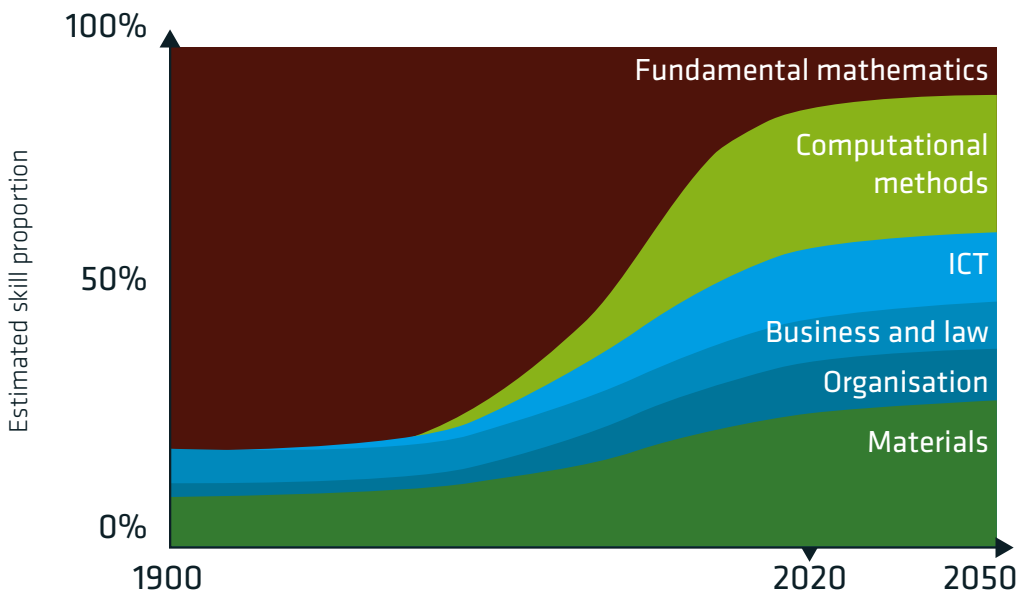


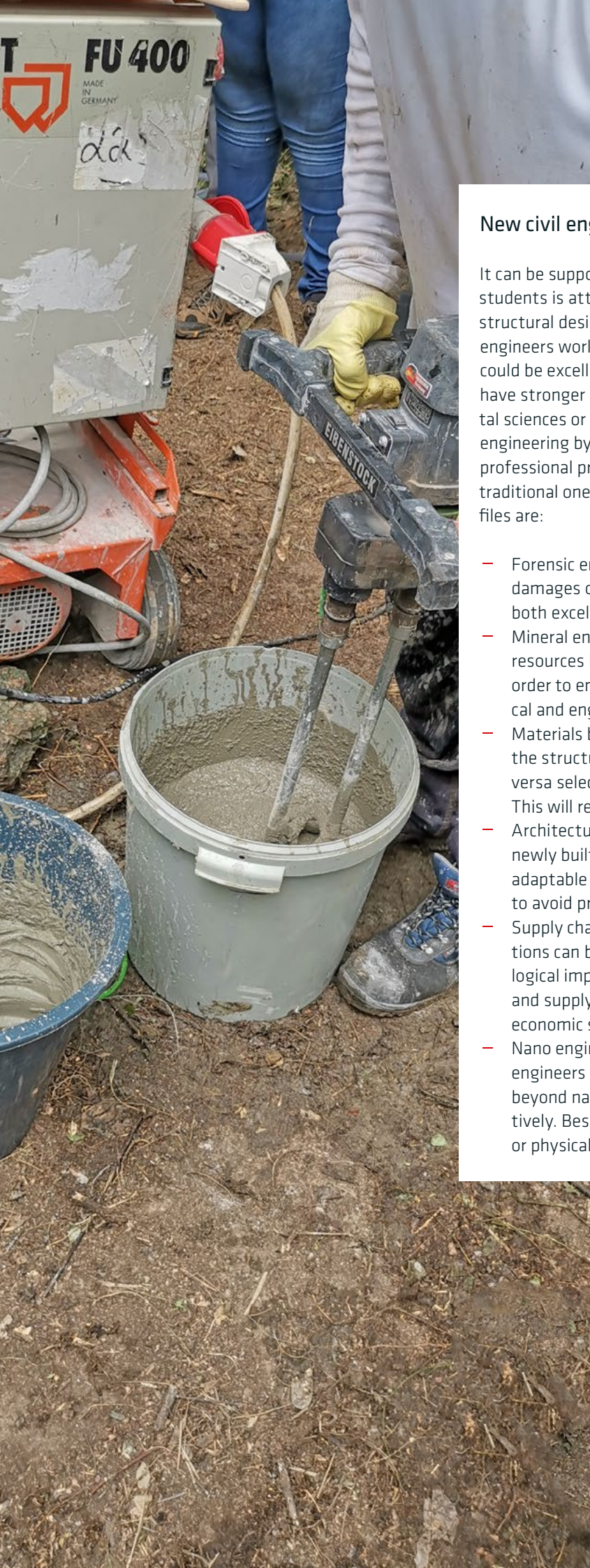
Fig. 2: Skill requirements for civil engineers throughout the last century

Future skill requirements for civil engineers

The working environment for civil engineers has dramatically changed. Specialist knowledge is more and more important, while at the same time individual specialist knowledge alone cannot tackle the challenge of rapidly changing boundary frameworks, more complex challenges, and breakthrough innovation. Furthermore, the working environment has become more global, more digital, more communicative. Therefore, future curricula have to put stronger focus on skills that were formerly often neglected.

Some relevant skills that have to be put more into the focus of educations are:

- Comprehension of the broader context of local problems
- Assemblage of specialist knowledge
- Interdisciplinarity
- Generalising and/or modelling with great awareness of the thresholds
- Language skills and cultural sensitivity
- Communication skills



New civil engineering profiles

It can be supposed that the largest part of the undergraduate students is attracted by traditional civil engineer profiles such as structural designer or site manager, although a majority of civil engineers works in different areas later. Some students, who could be excellent civil engineers in their professional life, but have stronger interest in natural sciences, culture, environmental sciences or geosciences may be deterred from studying civil engineering by the traditional profiles, not knowing that the professional profiles of civil engineers can vary greatly from the traditional ones. Some examples of possible future relevant profiles are:

- Forensic engineers assess structures before or after severe damages occur and develop remedial actions. They require both excellent structural and materials skills.
- Mineral engineers compensate lack of single raw materials resources by blending a large variety of altering materials, in order to ensure steady final materials properties. Mineralogical and engineering knowledge will be required.
- Materials based structural designers who iteratively optimise the structure according to the materials properties and vice versa select materials according to the structural necessity. This will require excellent mechanical and materials skills.
- Architectural engineers take care that structures that are newly built will maintain utilisable, aesthetically pleasing and adaptable to any technological and societal necessity in order to avoid premature demolition of functioning structures.
- Supply chain engineers ensure that the adaption of innovations can be made possible with lowest economic and ecological impact due to evaluation of locally available resources and supply chain optimisation. Besides materials knowledge, economic skill will be required.
- Nano engineered meta materials engineers or bionic civil engineers develop materials and structural concepts that go beyond natural products or are inspired by nature, respectively. Besides engineering skills, a high level of chemical and/or physical skill will be important.

Summary and outlook

The professional profiles of civil engineers have dramatically changed. More scientific skill in the education of engineering can become a booster for an economic, ecologic and societal upward spiral (Fig. 3). Hence, in the light of climatic changes, societal challenges and resource scarcity, contemporary civil engineering education adapted to the challenges of today and in the future may not only be a useful option but possibly a must.

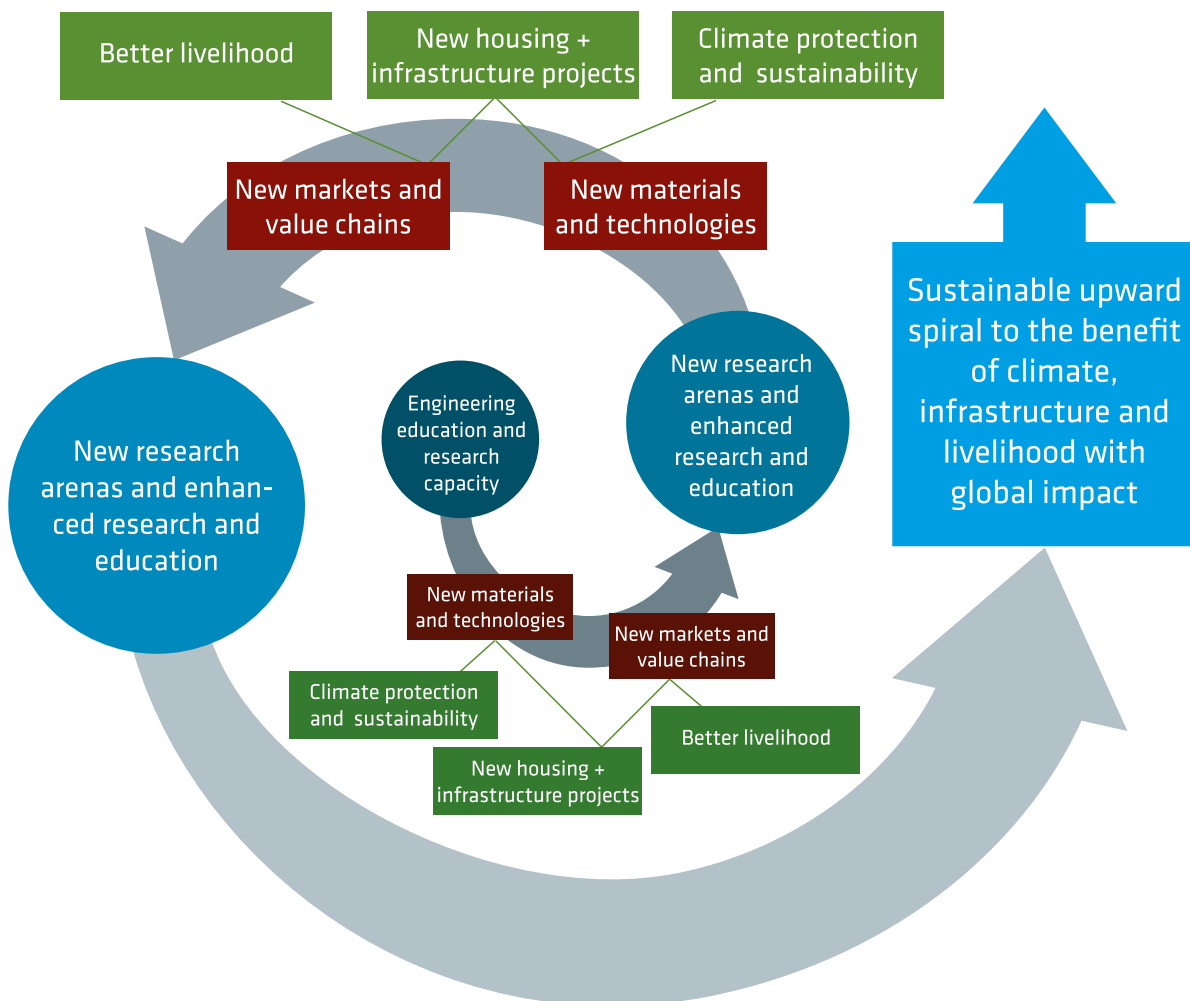


Fig. 3: How engineering research capacity can facilitate positive global developments

References

- [1] K. Scrivener et al., "Eco-efficient cements: Potential, economically viable solutions for a low-CO₂ cement-based materials industry", UN environment, Paris, 2017, <https://wedocs.unep.org/handle/20.500.11822/25281>
- [2] W. Schmidt et al., "Materials and technology solutions to tackle the challenges in daily concrete construction for housing and infrastructure in sub-Saharan Africa", AJSTID, 2017, <https://doi.org/10.1080/20421338.2017.1380582>
- [3] W. Schmidt et al., "Education for sustainable use of cement based materials", CCR, 2017, <http://dx.doi.org/10.1016/j.cemconres.2017.08.009>