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Dr. Boglárka Eisinger Balassa
Prof. Dr. Zoltán Baracskai

Abstract

In this paper we are exploring the learning processes of engineering students with focus on engineers who will take up jobs in SMEs. The students are 'shallows' and the SMEs cannot afford highly specialized 'deep' engineers. Building off a previous study conducted with school children, we explore the pedagogical implications of educating engineers who can cater for the knowledge needs of these SMEs.

In the age of shallow knowledge (Carr, 2010) we do not make value judgement regarding whether shallow knowledge is good or bad, whether it is better or worse than deep knowledge valued in the previous era, or whether it will be good or bad in the future. Our starting point is that shallow knowledge does exist and it characterizes students today. This raises questions regarding contextualization, as fragments of knowledge that originate from different contexts come together forming 'wide' knowledge, as opposed to 'deep' knowledge. The notion of wide knowledge makes it possible to consider that shallow knowledge is not necessarily ignorance, as wide knowledge of a very large scope can account for as 'large amount' of knowledge as highly specialized deep knowledge. However, sophisticated thinking is traditionally associated with deep knowledge, so the question rises if there can be sophisticated thinking in shallow knowledge if it amounts to a sufficiently large volume.

This paper is part of a project which seeks to understand the supply of expertise for SMEs. SMEs have never been able to afford highly specialized professionals with deep knowledge; therefore, they need professionals with shallow but wide knowledge. However, no shallow knowledge can cover everything, therefore we seek to understand the required knowledge portfolio and the way of developing shallow professionals who can deliver them. Our starting point is the presumption that SMEs with greater and fresher knowledge are more competitive than those with lesser and older, and thus likely outdated, knowledge. Here we do not question this presumption – we do acknowledge that it is hypothetical but anecdotal evidence as well as systematic thinking suggest that it makes sense. If we accept this presumption, then

a problem emerges: the teachers can only teach what they know and their knowledge of the praxis (applied professional knowledge) is limited and more or less outdated, depending on how fast the field is changing.

In this paper we focus on one part of this problem, on educating engineers of tomorrow. As we believe that we cannot know today what we should teach engineering students tomorrow that they will need the day after tomorrow, we adopt a different starting point. We take into consideration the shallow mindset of the students of engineering and focus on finding and/or creating teaching methods that they work for such students. Importantly, we do not look at shallow students as not being interested in anything. To the contrary, they are interested in everything, a little bit. This may involve technology, but with Sir Ken Robinson we believe that great technology does not substitute great teachers in delivering great education: great teachers and great technology together make great education. An unsystematic survey of potential employers supports what we suspected: the employers do not really care about the content that the students learn during their education. *What* they need to know the employers will teach them once graduates are hired. What any graduate needs is sometimes called 'transferable skills' (domain-independent knowledge, something that can be applied in a variety of different contexts), these include communicating, presenting, working in teams, but most of all being able to learn. In addition to this engineer need to have a good relationship with technology, it should not be people who are afraid of machines, who are uncomfortable with gadgets, etc.

Furthermore, it is not known what kind of mindset will be needed in the future. It cannot be known today what kind of engineers will be available at labour market or what kind of engineers the market will demand. We propose that the main problem is the method used in social science related practice. So, an SME may be looking for engineers, which profession is rooted in hard sciences and can qualify as applied science, however, educating engineers has its pedagogy and didactics, which belong under the umbrella of human and social studies. Similarly decisions about accepting students and selecting the graduated engineers for particular jobs are parts of human and social studies, not to mention their career progress which may involve taking on managerial duties. So even if engineering is closely linked to hard sciences, educating, hiring, managing engineers cannot be handled without knowledge that is embedded in human and social studies.

This research builds on a previous research project, in which we explored how children learn during play. As our engineering students will not have outdated knowledge from the discipline at the beginning of their studies, they are in many ways similar to those children. We will use the same method to conduct our research in this project as in the one looking into children's learning during play. We develop a qualitative model building a knowledge-based expert system (KBS). This tool belongs under the umbrella of artificial intelligence. In KBSs knowledge is represented in the form of 'if… then' rules. In this project we use the modelling capability of the KBS to establish relationships between the attributes of the students' learning processes. The learning process that we describe as our findings are likely to be ephemeral. There may be a different process in place tomorrow and new learning processes that we cannot imagine today may emerge tomorrow. Therefore the 'meta-level' of our findings is far more important than the direct findings. By this we mean that we developed a meta-model of model development and framed it as a method. Therefore, if new learning processes evolve, we can still use the same meta-method to study these learning processes, to identify their attributes and to establish the 'if… then' relationships between them.