von Michael E. Caspersen

Informatics as a Foundation for Empowered Citizens

Information technology is a technology unlike any other humankind has invented. All other technologies stretch our physical ability by enabling us to move faster from one place to another, to generate energy, to develop life-saving medicine, to refine food production, and so forth. Information technology is crucial for all modern technologies, but the essential unique quality of information technology is that it stretches our cognitive ability.

There is a remarkable development at universities, where computational methods are embraced by researchers and educators in all disciplines. The development began many years ago, first in the natural sciences where Nobel Laureate Ken Wilson in 1975 described computing as the third scientific method complementing theory and experiment (Denning, 2009). It is now fundamental for all disciplines (Djorgovski, 2005, p. 6):

Applied computer science is now playing the role, which mathematics did from the 17th through 20th centuries: Providing an orderly, formal framework and explanatory apparatus for other sciences.

Figure 1 illustrates the fundamental nature of reading, writing, mathematics, and informatics.

Already in 1967, Danish Turing Laureate Peter Naur wrote about the importance of including informatics in general education (Naur, 1967, pp. 14-15; Naur, 1992, p. 176):

To conceive the proper place of informatics in the curriculum, it is natural to compare with subjects of similar character. One will then realise, that languages and mathematics are the closest analogies. Common for the three is also their character as tools for many other subjects.

More than half a century after Naur's plea, informatics is finally becoming a school subject. Internationally there is a quite fast emerging breeze in the direction of making informatics part of national curricula and part of general education for all. This trend reflects the growing recognition that informatics is an important foundational competence along with „the three Rs": reading, writing, and arithmetic/mathematics (Caspersen et al., 2019).

THE EUROPEAN COUNCIL RECOMMENDATIONS ON INFORMATICS

In 2023, the Council of the European Union adopted a set of recommendations on enabling factors for high-quality, accessible, and inclusive digital education, and a set of recommendations for improving the provision of digital skills (ACM, 2023).

The recommendations are rich and diverse (digital education is many things). Regarding informatics, Member States are

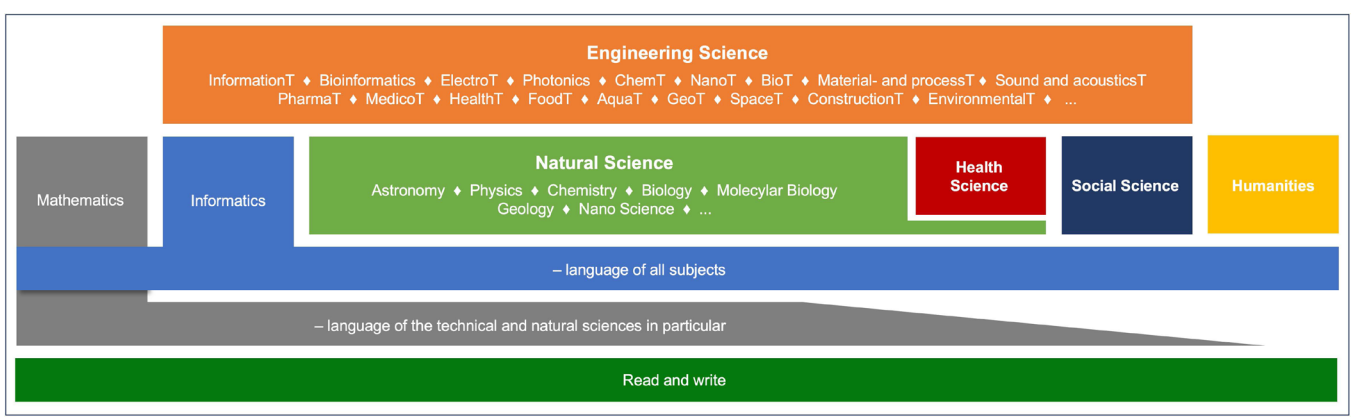

Fig. 1

committed to

- improve measures to recruit and educate teachers with expertise in the areas of informatics in primary and secondary education, and to
- foster the provision of high-quality informatics education from the start of compulsory education with clear learning objectives, dedicated time, quality and accessible learning resources, and structured assessment of learning outcomes.

In short: Member States are committed to provide Informatics as a fundamental discipline in general education.

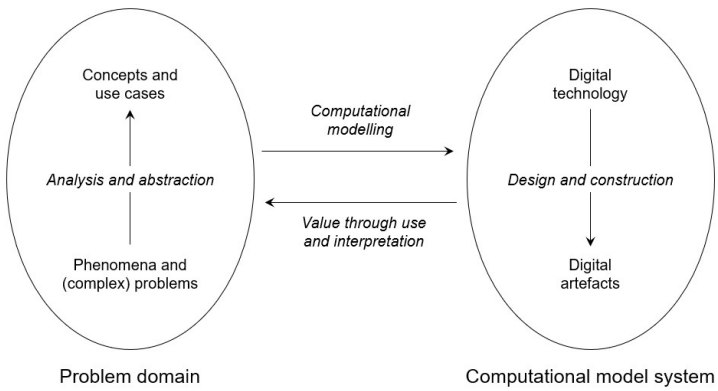

Fig. 2

Currently, the Commission continues to support the development and has recently established a Commission Expert Group to develop guidelines for teachers on high-quality informatics to be published by the end of 2025.

THE BIPARTITE NATURE OF COMPUTING

Informatics curricula in general tend to prioritise technical content (computing systems, networks and the Internet, data and analysis, algorithms and programming) – perhaps adding an element of impact of computing.

The Danish curriculum for general education for both primary, lower and upper secondary school acknowledges the bipartite nature of all computations directed at purposes in the real world – the problem domain and the computational model system – as well as the relation between the two: representation and interpretation (see Fig. 2).

The real or an imaginary world is populated with phenomena and activities, which – through analysis and abstraction – can be understood in terms of concepts and use cases; through computational modelling, these can be prioritised, structured and modelled for computational representation. Through design and construction using digital technology, new digital artefacts can be developed to manipulate and transform these representations into something, which hopefully provides value through interpretation and use back in the real world (Madsen et al., 1993, chapter 18).

The equal inclusion of problem domain and interpretation, complementing computational model system and representation, is rather unique and embodies the Danish curriculum's perspective on digital humanism.

THE DANISH INFORMATICS CURRICULUM FOR GENERAL EDUCATION

Various flavours of informatics have been a topic in Danish upper secondary schools for more than fifty years (Caspersen & Nowack, 2013). The contemporary Danish informatics curriculum consists of four competence areas (Caspersen, 2021):

- Digital empowerment
- Digital design and design processes
- Computational thinking and modelling
- Technological knowledge and skills

An overview of the four competence areas is provided in Fig. 3.

The four competence areas constitute a holistic approach to informatics, here described in terms of the model in Fig. 2. Approximately, the four competence areas map 1-1 to the four processes in the model (Fig. 4).

Not only do the four competence areas constitute a nice, full circle. They also mutually strengthen each other. Analytic competences provided by Digital empowerment will strengthen the three other competence areas. And vice versa: if you know how to build digital artefacts, your critical and constructive analysis can become much richer and deeper.

EMBRACING UNCERTAINTY – THE REPRESENTATIONAL AND THE INTERPRETATIONAL CHALLENGE

However, the focus is not only on the two parts of "the bipartite system" – problem domain and solution domain – but also

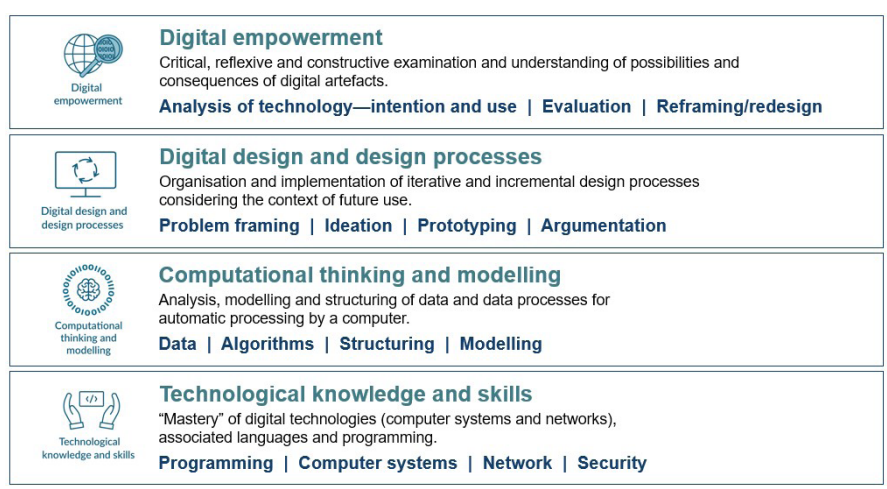

Fig. 3

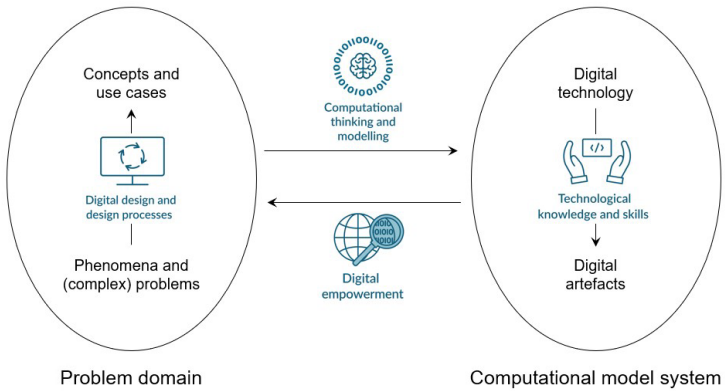

Fig. 4

on the relations between the two parts: representation and interpretation.

Most aspects of the physical world, which we attempt to capture and represent in computational models and artefacts, are blurred, uncertain, and non-deterministic. On the other hand, the computational models we construct, are fundamentally strict, certain, and deterministic.

The challenge has two faces. One is the representational challenge: How can we model the blurred, uncertain, and computational artefacts? The other is the interpretational challenge: How do we avoid to constrain and eventually de-humanise our understanding of phenomena and concepts in the real world when our world-view is increasingly defined through the lenses of strict, certain, and deterministic computational models and artefacts?

The representational challenge is addressed by the competence area Computational thinking and modelling (data, pretational challenge is addressed by the competence area Digital empowerment, which represents the ability to analyse and evaluate digital artefacts with a focus on intention and use through a critical, reflexive and constructive examination and understanding of consequences and possibilities of a digital artefact. This competence area is for digital artefacts what literature analysis is for novels, but with the additional liberating component of reframing and redesign – realising that digital artefacts are human-made and could have been designed differently if other perspectives had been applied.

These are essential issues on our way forward into an increasingly digital society in all aspects. It is imperative that informatics becomes a fundamental and general discipline in school to ensure that future generations become educated and empowered to contribute to the development of their digital environment and to realise our technological advancement to ensure the evolution of a safe, secure, environmentally conscious and just society.

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Michael E. Caspersen is Director of It-vest – networking universities and Honorary Professor at the Department of Computer Science, Aarhus University, Denmark.