Preprint

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From the *is* to the *ought*[1]

Genesis

Originally a coding theorist, I was trained in a tradition of mathematics and logic-deductive proof, within informatics (i.e. mathematical computer science). Trying to escape the narrow niche of mathematical coding theory, I explored areas believed to have more industrial potential, first applications of coding theory to multimedia security, and later to multimedia security using machine learning, thus widening my scope by gradually exploring adjacent fields.

In 2011 I took up a post in computer engineering at a small regional higher education college. Aiming for more industrial relevance, I have then explored a wide range of (mostly) cross-disciplinary fields, including assistive technology in health care, design of maritime technology, and biomechatronics.

These topics require a different epistemology. We are no longer looking for results that are true in any absolute sense, but rather results which are *good* within a given human context. The collaboration with industrial designers in maritime technology was particularly fruitful; design being a discipline which is very aware of the differences between what *is* and what *ought* to be. This inspired me to read design methodologists like Simon and Schön[2].

After years of diversification, I am still torn between different areas and methods of research, but it is time to consolidate. Spreading thin is good for idea generation, but epistemological confidence requires focus and depth, and this is required for my own peace of mind. Even so I have two clearly distinct activities. One is returning to my mathematical roots, attempting to apply machine learning to problems in astrophysics. The other is building on an amalgamation of SoTL

[1] This is a preprint of my contribution to *Scholarship of Teaching and Learning und disziplinäre Forschung; Eine komplexe Bezeihung* by Carla Bohndick, Robert Kordts, Jonas Leschke, and Nere Vöing, published by Springer Verlag 2025.

[2] I compared Schön's and Simon's approaches in a paper in *Design Studies* 2022 (volume 79): «Where Schön and Simon agree: The rationality of design. Their original main works are: Herbert A. Simon: *Sciences of the Artificial* (1969/1996) and Donald A. Schön: *The Reflective Practitioner* (1983).

and the challenges from the design project, studying the nature of knowing and learning in terms of educational philosophy and epistemology.

Exodus

Returning to teaching in 2013 after a year of research and paternity leave, I started with a fresh mind and a radical attitude. Two years earlier, I had several times experienced having to repeat lectures because *every* attending student had missed the previous session and consequently lacked the expected background. Therefore I decided to publish every lecture except the welcome session only as an online video. The class time would be reserved for exercises and supervision. I only later learnt that this is called *flipped classroom* and that there are scholarly approaches to educational development and intervention.

I had mixed experiences from this early project, largely echoing those of Njål Foldnes[3], and in the end I concluded that mathematics is a soft and conversational subject[4]. The methodical computation of solutions is less important than the use of concepts to make sense of real problems in conversation. After teaching a small class (≤ 20 students) for three years, I wanted extend the ideas to a larger class and took on an elementary mathematics module for business students (~ 70 students attending).

To facilitate conversation I used a quiz system (JazzQuiz[5]) for both diagnostic tests, rhetoric questions following the suggestions from Eric Mazur[6]. questions from the students, and feedback on the teaching format. JazzQuiz was designed for improvisation, with no need to prepare questions in advance.

At the start of the project, the premise was that the syllabus was given, and the challenge was to make the students absorb it. The premise turned out to be false. Interaction in JazzQuiz gave a lot of insight into how the students think about mathematics and how they perceive the learning objectives. The majority of students did not think of mathematics as vehicle of thought but merely as a set of procedures to be carried out without thinking. They strove to copy the teacher[7], rather than develop themselves as critical thinkers.

Reforming the module to encourage mathematical thinking over mechanical com-

[3] I had the opportunity to read several preprints of Njål's work as well as discussing them with him in person. The pilot study, where he still used individual practice exercises, did not have a significant effect on learning. It was when he introduced collaborative student activities that he saw a major improvement. In final publication, he focused on experimental validation of the end result, at the expense of some of the experience that was important for me; see Njål Foldnes. «The flipped classroom and cooperative learning: Evidence from a randomised experiment.» *Active Learning in Higher Education* 17.1 (2016): 39-49.

[4] Hans Georg Schaathun «Matematikk er eit pratefag og andre røynsler frå eit omvendt klasserom» *UDIT 2015*

[5] We developed JazzQuiz as a Moodle plugin, available from the Moodle Plugin Directory

[6] Mazur, Eric. "Farewell, lecture?." *Science* 323.5910 (2009): 50-51.

[7] The distinction between copying the teacher and creative imitation is discussed by Peter Kemp *Verdensborgeren* (2013) and Donald Schön *Educating the reflective practitioner* (1987), among others.

putation was a lengthy process, changing both practice problems and assessment, with emphasis on real world problems relevant to the degree programme. The research method was based on a research diary, recording everyday observations from class as well as minutes from the reference groups which is the standard module evaluation instrument at NTNU.

This project has totally transformed my approach to teaching. I no longer assume that I know what the students need to learn when I plan a taught module. I give the students more freedom to learn[8] and actively encourage them not to copy my solution approaches, but always reinterpret the subject in light of the problem at hand. This is manifest in the assessment format, where I use a *viva voce* following an idea from Kristina Edström's keynote at *MNT-Konferansen 2015*. The students have the first seven minutes to present the highlights of their learning and explain why it is important and relevant to them. The principal grading criterion is that the student have achieved some functional understanding which is *their own*.

Consolidation

A priori SoTL has little or nothing in common with mathematics. Mathematics is concerned with the logic deduction of true propositions. SoTL is concerned with practical reasoning about what *ought to be*. This dilemma has haunted many disciplines at least since David Hume's formulation of the is-ought problem. In the 20th century many discipline were forced into the same scientific method[9]. There is no immediate solution, and to me this is a research problem so important that it has forced me to pick up new research directions in the humanities.

It so happens that I ran into the same is-ought problem concurrently in research and in teaching. Like education, industrial research in computer science leads to wicked[10] problems where we have to consider what is good in the particular situation. At the time of the SoTL project, I was also working with industrial designers on software and data models for field studies, and I had to make sense of the designers' approach to truth and knowledge. Many small encounters worked together to bring me to a new understanding[11].

While many different research directions could have followed from my experience, I was pushed into research on epistemology and theories of knowledge. My current pet research question is, *what can students learn that artificial intelligence do does not do better?*

This single question is obviously an interesting one both within SoTL, as probably the most urgent challenge of the year, and within my original discipline of

[8]Carl R. Rogers *Freedom to Learn* (1969) and third edition with H. Jerome Freiberg (1994).

[9]Schön's *The Reflective Practitioner* (1983) gives one of the most concise discussions of this issue.

[10]The concept of wicked problems is due to Rittel, H., & Webber, M. (1973). Dilemmas in a general theory of planning. *Policy Sciences*, 4 , 155–169.

[11] *Understanding* is seen in the terms of Gadamer, H.-G. (1960). *Wahrheit und Methode*. Tübingen.

informatics, as well as my interest in epistemology and design methodology. While useful insight can be discerned with the empirical methods of social sciences and the logic-deductive methods of algorithm theory and mathematics, as well as the statistical methods used to assess machine learning performance, I consider the main challenges to be in philosophy of mind and design methodology, and particularly hermeneutics. Knowledge has no value in itself. What matters is our understanding of the knowledge and the meaning it has to us as human beings.

To me, SoTL and research comes together in their end goals. Most fundable research and certainly education aim to make a better world. We research technology to enable desired changes, and we develop knowledge to know what such changes entail, thus enabling rational choice. Students get an education to find a better place in the world, and to contribute to its continued change. How we make this change is not as important as why we make it and what the change means to us, and therefore approaches to find meaning is fundamental to all we do.

Instead of employing methods from in mathematics and informatics SoTL, I have taken up entirely new disciplines and methods, prompted partly by experience from SoTL and partly other research. Within computer science, I have shifted from the mathematical study of what is possible to the designerly study of what is *needed*. Methodologically, this is a shift from necessary to contingent reason[12]. So far, too many disciplines have neglected contingent reason[13], and I am still struggling to improve my approach in this respect.

[12]The dichotomy of necessary and contingent reason was made by Aristotle *Ethics* (Book 6), and later, in a modern context, by Herbert Simon *Sciences of the Artificial* (1969/96).

[13]Goldman, S. L. (2004). Why we need a philosophy of engineering: a work in progress. Interdisciplinary Science Reviews, 29 , 163–176.