The Impact of Technology on Thinking, Learning, and Teaching Differently

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Abstract

Purpose – Drawing on the traditions of autoethnography and reflective practice, this paper explores the experiences and reflections of one of the longest serving foreign academics in China's Sino-foreign Higher Education (SfHE) system. He started out at UIC (United International College, a collaboration between Beijing Normal University and Hong Kong Baptist University). After UIC, he moved to another SfHE institution, UNNC (University of Nottingham Ningbo China), where he currently serves. The paper examines early deficit views of non-specialism, contrasting with the more recent embrace of interdisciplinarity and problem-solving focused (rather than discipline-focused) approaches. Some principles from a recent approach to software testing, Metamorphic Testing, are explored as an example (and a further lens) for re-examining traditional ways of thinking, learning, and teaching.

Design/methodology/approach – The paper is structured around reflections on various aspects of life for an academic in the context of SfHE in Mainland China. Reflective practice, guided by authoethnography, and critical analyses of relevant literature form the main methodologies. The paper also includes (and addresses) informal and focus-group discussions surrounding attitudes to non-specialism, in both traditional research-led higher education (HE) and Liberal Arts HE, contrasting with the more recent embrace of interdisciplinarity being seen in SfHE.

Findings – The author's multidisciplinary background provides a foundation to explore and identify parallels across disparate disciplines. Insights from one discipline, through this parallel view, can provide support and inspiration for others. Solutions from one discipline can provide starting points for solutions in others: the specific example of action research in English as a second language (ESL) teacher training compared with software engineering's *Kaizen* is used to illustrate this parallel and opportunity. Experiences from Metamorphic Testing provide insight into opportunities to think (and teach and learn) differently.

Originality/value/implications – This is the first explicit use of Metamorphic Testing principles to suggest alternative perspectives for teaching and learning. The COVID-19 pandemic, and its impact on education, led to many disruptions and innovations. A small silver lining of the terrible situation has been the development of new ways to deliver education and engage learners. This paper provides new ideas for further imagination, and re-imagination, of HE.

Keywords: Autoethnography, COVID-19, Metamorphic Exploration/Testing (MET), Open Education Resources (OERs), Professional Development.
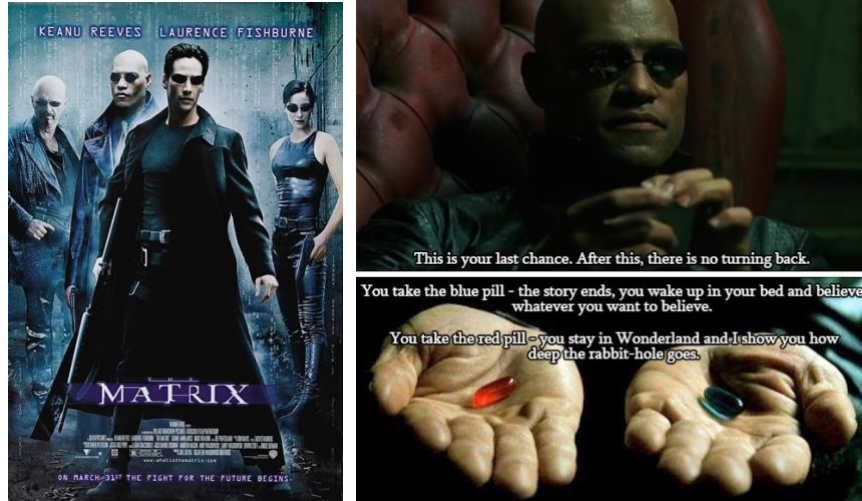
1   Introduction

Fig. 1. (a) The Matrix[1]   (b) The Red and Blue Pills[2]

I have very clear memories of how my world views got thrown out of sync when I watched The Matrix (Wachowski & Wachowski, 1999) — when I took that red pill, and tried to see how deep the rabbit hole went. It was the first time a movie, a science-fiction movie at that, had caused me to really question reality, and what I had come to understand as "how the world works." I have often tried to recapture that first experience, but have never really succeeded.

This paper has grown out of an opportunity I had recently, at the invitation of a former colleague, to examine how I have found technology to have impacted on the way that we learn and teach, and even how we think. That reflective examination (Schön, 1987), guided by authoethnography (Duncan, 2004; Ellis, 2004; Maréchal, 2009) has allowed me to explore some of my formative experiences as a teacher, and rethink how teaching and learning (T&L) may evolve.

The COVID-19 pandemic (Lau et al., 2020; Alvarez, Argente, & Lippi, 2020; Khlaif & Kouraichi, 2021) has caused enormous disruption and suffering. Although there have been silver linings (Towey & Pike, 2021), including higher education (HE) innovations and positive adaptations (Gill et al., 2020; N.D.), overall, the disruptions have mostly been negative (Towey, 2021). One thing that has struck me from the COVID experiences is how we have had to challenge pre-pandemic assumptions about how education and the student experience (ESE) are best supported, in some cases adopting technologies and techniques that we might never have considered before (Gill et al., 2020; N.D.).

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[1] https://www.imdb.com/title/tt0133093/mediaviewer/rm525547776/

[2] https://gointothestory.blcklst.com/great-scene-the-matrix-5e656d03c5cb

This paper, drawing from over twenty years of HE experience, includes my reflections on how technology and interdisciplinarity have shaped how I think and learn, and, as a teacher, how I teach. It also includes some ideas for how, especially in the post-COVID context, we, as educators, can reimagine our approaches to T&L.

2 Context

2.1 Sino-foreign Higher Education

HE in the People's Republic of China (PRC) has been defined as that education conducted after completion of senior middle-school (Xie, Towey, & Jing, 2014). PRC HE has undergone several reforms, including projects to enhance provision quality, such as: Project 985, Project 211, and the C9 League (CEC; Lixu, 2004; Sainsbury, 2009; THE, 2011). PRC HE has also opened up to foreign input, attempting to address both quality and quantity of provision. This has included Sino-foreign HEIs (SfHEIs), which are institutions created through partnerships between a Chinese and a foreign institution. The University of Nottingham, in collaboration with the Wan Li Education Group, established the first SfHEI in 2004: University of Nottingham Ningbo China (UNNC). By 2019, according to Ma et al. (2019), there were nine SfHEIs in operation, most of which involved a 985 or 211 project university as the Chinese host.

SfHEIs represented an innovative solution to the PRC need to provide more HE opportunities, and, as well as thus being innovations, they are also often themselves hosts to innovative projects and thinking (Towey, 2014).

2.2 A Bit about Me

I am a professor of computer science (CS) at UNNC, and have been here since 2013. Before UNNC, I served at another SfHEI, the Beijing Normal University—Hong Kong Baptist University: United International College (UIC). At UIC, a liberal arts college, in addition to CS, I also taught classes related to linguistics, education, and performance drama. I first became involved with UIC in 2005, while still living in Hong Kong.

I have described my background as being somewhat that of an "academic mongrel" (Towey, 2014b; 2021). I hold qualifications in CS, linguistics, and education; I have had industrial CS experience in several countries; teaching experience in kindergarten, primary, secondary, and postgraduate levels; and have held a number of administration and leadership roles in both UIC and UNNC.

3 Challenges of Interdisciplinarity

The famous Hong Kong martial artist Bruce Lee is credited with a number of philosophical and motivational sayings. One of these has often resonated with me: "I fear not the man who has practiced 10,000 kicks once, but I fear the man who has practiced one kick 10,000 times"[3]. As a former martial arts practitioner, the need to work hard to achieve mastery of a technique was always clear. Even now, whether that technique be a kick or a pedagogical tool, I agree with the necessary associated

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[3] https://www.brainyquote.com/quotes/bruce_lee_413509

apprenticeship effort. However, there was a time when I also interpreted his words as meaning to focus on a specific discipline, and not to be interdisciplinary.

When I was first planning to enter university, my target undergraduate degree courses were interdisciplinary. I was warned that such a path may leave me a "Jack of all trades, but master of none"[4], but I was sure that I would be happier doing so than locking into a single discipline. I was lucky: at that time in Irish HE, many interdisciplinary degrees were being offered (Towey, 2014b), and the one I selected, a triple-major in CS, linguistics, and languages (CSLL)[5], was immensely enjoyable. That CSLL degree led to a 3-year CS job in Japan, which eventually led a PhD, again in CS, in Hong Kong. Reflecting on these experiences, I believe that, rather than hinder me, the interdisciplinarity throughout these stages has helped. Nevertheless, I have also witnessed, and experienced, challenges from interdisciplinarity.

It has seemed to me that interdisciplinarity brings with it more workload. When I taught (simultaneously) in several departments, the admin tasks, especially meetings, were multiplied by the number of units I was in. Academically, it has always seemed like there are so many more things to learn, to keep abreast of, and to master, than if working only within a single discipline.

Earlier in my career, too, I encountered outright academic snobbery: the academic "thoroughbreds" looked down on the pedigree-lacking academic mongrel. The often-siloed traditional academic units that I encountered seldom appreciated, much less respected, "other" disciplines.

Coming again to Bruce Lee: Although I had once (mis-)interpreted his 10,000 kicks comment to mean focusing on a single discipline, a little deeper study of Master Lee reveals his actual practice of always seeking to better his martial arts skills. He did this by studying many different martial arts and taking elements from each to form his own style, Jeet Kune Do (Lee, 1975). Another famous quote attributed to Lee that exemplifies this is: "Absorb what is useful. Discard what is not. Add what is uniquely your own."[6]

4   Kaizen

Bruce Lee's attitude to martial arts resonates with me for a second reason: software engineering (SE).

SE was, arguably, founded in the 1960s[7], as a call to apply the perceived rigour and methodologies of traditional engineering processes to the development of software (Dijkstra, 1972). Thirty years later, Agile approaches[8] started becoming popular, and are now the most widely-used approaches. The Agile movement has caused a fundamental change in how SE is perceived, with emphasis now on the role of feedback and iteration. Unlike the original manufacturing-process metaphor underlying traditional SE, the new metaphor is about *prototyping* — expecting that the product will

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[4] https://www.languagecouncils.sg/goodenglish/resources/idioms/jack-of-all-trades-master-of-none

[5] https://www.scss.tcd.ie/undergraduate/computer-science-language/

[6] https://www.goodreads.com/quotes/9087407-absorb-what-is-useful-discard-what-is-not-add-what

[7] https://inf.ethz.ch/personal/wirth/Miscellaneous/IEEE-Annals.pdf

[8] http://www.agilealliance.org/the-alliance/what-is-agile/

need input and feedback from multiple stakeholders; iteration; and refinement. Figure 2 outlines a typical Agile approach to development.
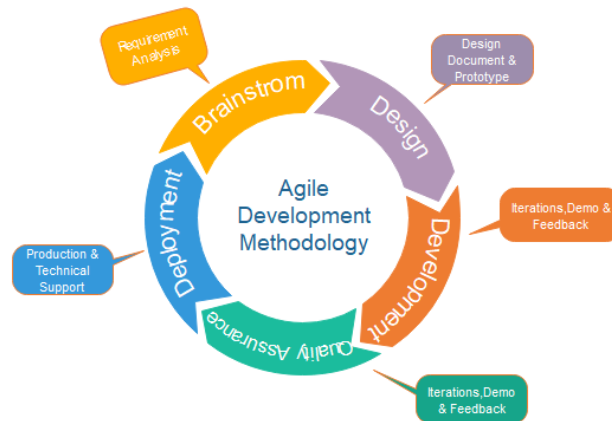

Fig. 2. Outline of Agile Software Development Methodology[9]

A key aspect of what we know about SE is this: We employ best practices, but we also recognize that SE is an experiential discipline (Kolb, 1984), and that the more experience we get, the better we become. We do not claim that our current approaches and methods are perfect. We monitor how we use them, and constantly consider how we might improve. This idea of always trying to improve is embodied in the phrase Kaizen (Imai, 1986).

For me, an important part of SE is that it is based on problem solving. Engineering, in many ways, is about identifying problems and challenges, and then addressing them. When an engineer is solving a problem, he doesn't need to do an inventory of the provenance of his skills and tools — "here are my CS skills"; "this is my language skill"; "here are some maths skills and tools"; etc. — he just needs to identify and deploy the correct ones. This, too, resonates with another Bruce Lee saying[10]:

> Be Water, My Friend.
> Empty your mind.
> Be formless, shapeless, like water.
> You put water into a cup, it becomes the cup.
> You put water into a bottle, it becomes the bottle.
> You put it into a teapot, it becomes the teapot.
> Now water can flow or it can crash.
> Be water, my friend.

5   Sages, Guides, Meddlers, and Partners

We have seen, I believe, application of the Kaizen (Imai, 1986) philosophy to the evolution of education, especially the evolution of the teacher-student relationship. I

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[9]   https://www.javatpoint.com/software-engineering-agile-model

[10]   https://brucelee.com/podcast-blog/2016/7/20/2-be-water-my-friend

believe that, much like Adam Smith's invisible hand (Smith, 2010), the most successful classroom approaches have moved how we view our relationship with our students to the current perspective.

The changes in teachers' roles have often been discussed, with phrases like "sage on the stage" evolving to the "guide on the side" and eventually into the "meddler in the middle" (King, 1993; McWilliam, 2009). I have had the good fortune to be able to count "partner" as one of the most important relationships I have had with my students, both postgraduate and undergraduate. This has been explicit in initiatives like "Students as Partners" (Mercer-Mapstone et al., 2017; Sturman et al., 2018) and "students as change agents" (Dunne & Zandstra, 2011), but also implicit in my classrooms, and especially in some of what I now consider my happiest collaborations with students, including: the TESL Angels, student teaching assistants (STAs), and other student volunteer work at UIC; and the SE team projects and student mentorship programme (SMP) at UNNC.

5.1   Students as Partners at UIC

A key element in many of the SfHEIs' early histories was the need to engage with and overcome unforeseen challenges. This required an agile mentality among both the staff and students at these institutions (Towey, Walker, & and Ng, 2019). This also, I believe, created an environment that allowed for the best in people, again, both staff and students, to come forth.

One of my earliest happy memories as a teacher at UIC was in the second year of the TESL (teaching English as a second language) degree programme. A number of the most senior students (then in their 2nd year of studies) approached me with a proposal. They had identified groups of people in the local community, including cleaners, security guards, and migrant families. They saw many of these people having difficulties communicating with the non-Chinese-speaking foreign teachers, and wanted to help. As they explained at the time: they were learning how to be English teachers; they had already developed some skills; they had seen people in need in their community; they thought that they could apply their skills to help these people. "Deploy us," they said. And deploy them, we did. We eventually called this group of students the TESL Angels, partly as a wordplay on the pronunciation of "TESL" and the Chinese word for angel, 天使 [tianshi]. Over the years, that initiative grew to help a great deal of people, and the students matured, graduated, and many have gone on to have very successful careers as teachers.

Around the time that the TESL Angels was first created, in the 2007-2008 academic year, a new challenge being faced by many organisations was that of bringing foreign staff into the PRC: The 2008 Beijing Olympics had resulted in much more difficulties obtaining visas and getting relevant staff to UIC (AFP, 2008; Baker, 2008). A very popular and impactful aspect of the UIC student experience at the time was what we then referred to as the team of foreign teaching assistants (FTAs). These were usually young, newly-graduated, foreign nationals who provided a lot of academic and pastoral support on campus. Their absence from campus would be a major blow to both the staff and students. The TESL students, who would normally be amongst those who spend a lot of time with the FTAs, again came forward, offering to help. This resulted in another new initiative, the "student teaching assistant" (STA) programme, where these TESL

students became STAs, supporting the teaching work of UIC staff in ways that the FTAs would normally have done.

These partnerships and experiences, seeing my students take ownership and responsibility for solving problems that they hadn't created (but that they could address), remain amongst the most inspiring of my career.

5.2 Students as Partners at UNNC

When I moved from UIC to UNNC, in 2013, I arrived with an eagerness and enthusiasm to bring some of the UIC experience to UNNC. This resulted in some missteps in my first year, but by my second year, things were going much better (Towey, 2015). In that second year, the UNNC SE team projects were first held.

The team projects are part of a year-long class where students are grouped into teams of about five to seven people, paired with a member of staff as advisor/supervisor, and given a real-world project to address using their SE skills. I have been the convenor (administrator) for this class since its second year. Some of the teams I have been involved with became, as intended, partners with me in addressing the project. Some of the research and SE work have resulted in outstanding outcomes, both as software artefacts and as published work (Foster et al., 2018). These outcomes would not, I believe, have been possible without the partnership collaboration.

As part of the support mechanism for this class, I introduced a seniors' sharing session, where students who had already completed the class came back to share their insights and advice with the current students. This became very popular, both with the current teams, and with those who were sharing.

In the 2018-2019 academic year, not long after the seniors' sharing session, some of those seniors approached me with a request. They reported a sense of positive impact from their sharing, and wanted to expand their potential interventions. After some further discussion and brainstorming, we created an initiative that came to be called the student mentorship programme (SMP) (Towey, Pike, & Chen, 2021). The SMP, drawing on some of my UIC experience with the TESL Angels and STAs, was basically an opportunity for senior CS students to help more junior students. With some preliminary training, and on-demand support from staff advisors, the SMP mentors could join the tutorial or lab sessions of more junior cohorts (with the teacher's permission) and offer their advice and experience (their mentorship) to the students. This often involved simply sharing experiences of persevering and eventually finding solutions to challenging academic problems; it also provided the staff with an additional channel of communication and feedback on their classes.

These UNNC partnerships, although different in depth to those at UIC, have also remained amongst my fondest memories, and most fulfilling experiences.

6 Metamorphic Thinking

An area of my SE research that I am most excited by is called Metamorphic Testing (MT) (Segura et al., 2016; Chen et al., 2018).

Software quality assurance, including software testing, is an essential part of the SE lifecycle (Ruparelia, 2010). Software testing involves executing the software using various inputs, and checking that the software output or behaviour is correct. The

mechanism used to determine the correctness of this output/behaviour is called a test oracle (Zhou et al., 2018b). Situations where there is no test oracle, or where it is not practical to use it, are said to face the oracle problem (Liu et al., 2013; Barr et al., 2014). The oracle problem is a major impediment to traditional software testing.

MT, instead of focusing on the correctness of individual execution outputs or behaviour, looks instead at relations that should hold across multiple executions of the software. These relations are called metamorphic relations (MRs) (Zhou et al., 2018a). With MT, if an MR is violated, there must be a bug in the software. An example MR for a software program that takes a list of numbers and outputs their sum may be based on the property that any permutation of the list should not impact on the output:

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SUM({1,4,6,7}) == SUM({7,4,1,6})
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MT has a proven history of alleviating the oracle problem (Segura et al., 2016; Chen et al., 2018). It has also been successful in software testing situations not facing the oracle problem (Segura et al., 2016; Chen et al., 2018). MT represents not only a very powerful approach for software testing, but is a new paradigm in how to *think* about testing (Towey et al., 2019).

7   Inspiration from Metamorphic Testing

COVID-19 has had an enormous impact on life, including on how education has been delivered and considered. The switch to emergency online T&L, and later to blended and hybrid delivery, saw a large number of attempts to use new technologies, techniques, and tools (Gill et al., 2020; N.D.). Many techniques and technologies that were barely even heard of before the pandemic have become mainstays in today's new normal T&L. Much of the newly-adopted approaches were untested, and resulted in additional complications and difficulties (Towey & Pike, 2021).

One positive thing that I have observed, in the face of so much disruption, has been the (necessary) willingness to explore and apply new ways of delivering education. We have been forced to rethink, to address the problems, and develop solutions — to apply engineering-thinking. We continue to face COVID-related challenges, but we must also look to the future, and consider what future challenges we need to prepare for, including how to scale up many of the solutions that we have seen develop.

Reflecting again on my SfHE time, at both UIC and UNNC, and looking through the lens of MT, a number of things strike me. MT advocates thinking about relations (relationships), and not focusing on individual correctness, but rather on satisfaction (or violation) or the relations. MT helped us overcome a recent problem with grades administration at UNNC (Towey & Pike, 2021), but beyond SE, MT-thinking may allow for a richer understanding, and even framework for future T&L.

Reflecting on the student partnership experiences, using an MT lens, I can see how the behaviour of my students was not only honourable (and even altruistic), but actually resonated with some potential relations that could be conceived of. For instance, we may identify certain graduate attributes that we would expect to see in, for example, a newly-qualified TESL teacher. These may include not only the skills, but also the attitudes and dispositions we would hope to see in a teacher. The TESL Angels displayed these, long before they graduated. The UIC STAs did, too. SE professionals

need to be able to adapt, work with different stakeholders, and deliver finished projects: the UNNC SE teams have also been able to do this, again, long before their graduation.

As I move forward in my own T&L context, I am finding more opportunities to apply the MT lens. I anticipate a time when we engage with T&L assessment in a very different way to how we do currently. Our focus on the evaluation of individual outputs (exams, essays, programs, etc.) may give way to an alternative, based, like MT, on more comprehensive relations across multiple activities and observations.

Acknowledgements

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