This document may be used for private study or research purpose only. This document or any part of it may not be duplicated and/or distributed without permission of the copyright owner.

The Singapore Copyright Act applies to the use of this document.

This is the author’s accepted manuscript (post-print) of a work that was accepted for publication in the following source:


Notice: Changes introduced as a result of publishing processes such as copy-editing and formatting may not be reflected in this document.

The final publication is also available at Springer via http://dx.doi.org/10.1007/s40692-015-0049-7
Mediating approaches to the use of ICT in teaching and learning through the lenses of ‘craft’ and ‘industrial’ educator

Horn Mun Cheah and Kenneth Y. T. Lim

Abstract ICT has been viewed as a tool to support curriculum re-design and teachers’ pedagogical beliefs shift from teacher-centred to student-centred. While schools are being equipped with varied array of ICT tools, ICT has not successfully brought the shift in pedagogies to student-centred models in many countries. As the use of ICT in education gains traction within formal education, teaching and learning are framed as two overlapping and interconnecting sets of processes—transfer and deepening. The two sets of processes are not operating independently, for they are mutually reinforcing and iteratively enhancing learning. To conclude, the paradigms of ‘craft’ and ‘industrial’ educator are introduced as a suggested means of lensing the role of teachers in ICT-mediated learning environments.

Keywords: ICT-mediated learning environments · Teacher capacity building · Technology-supported transfer · Technology-supported deepening · Student-centred learning · Teacher belief systems
Introduction

Since the awareness of information and communication technologies (ICT) became global in the early 1990s, their potential applications in a wide variety of human Interactions and processes were embraced with enthusiastic anticipations. The ensuing melée towards ICT nirvana in the various arenas was akin to a ‘gold rush’, in which disproportionate advantages tend to accrue to the first few adventures who cracked the effective use of ICT for popular/necessary usage. However, as technology innovations emerged, new players who were able to better exploit them could potentially displace established players in the same or related fields. The emergence of Google as so much more than its original roots in search is a case in point.

A major theme with regard to ICT centred on their use in education. ICT has been viewed as a tool to support curriculum re-design and teachers’ pedagogical beliefs shift from teacher-centred to student-centred (Koh and Lee 2008). It has elicited a wide range of responses, from fear of the technologies and rejections of their use in the teaching and learning (T&L) context, to visions of the impending replacement of the teacher in the classroom. While schools are being equipped with a varied array of ICT tools, ICT has not successfully brought the shift in pedagogies to student-centred models in many countries (Chen 2008; Liu 2011; Tondeur et al. 2008). As a consequence, successful ICT integration in Singapore schools aroused quite a few researchers’ interests (Chai 2010; Jacobson et al. 2010; Lim, 2007; Lim, & Khine, 2006; Teo 2008; Teo et al. 2008). As understanding of the potential and limitations of ICT in education matures, the acceptance of their place in education, to varying degrees, has largely been established. Over the last few decades, studies have claimed that a crucial factor for successful ICT integration into the classroom is teachers’ pedagogical beliefs (Ertmer 1999, 2005; Windschitl and Sahl 2002). It seems clear that ICT, in and of themselves, does not effectively contribute to T&L without being guided by pedagogical considerations.

Use of ICT in teaching and learning

As the use of ICT in education gains traction within formal education, three overlapping trends of how ICT is actually being applied can be observed in the classroom today. These can account for most T&L interactions involving ICT, which can be broadly classified as the use of ICT (a) that enhances efficiency, (b) that are transformational and (c) within a highly connected environment. The main characteristics are as described in Table 1.

The most basic use of ICT in education is the efficiency gain, when properly applied, that technologies can bring about. For instance, the use of digitised teaching resources can allow changes and updates to the materials to be made relatively quickly. This can save time and efforts which can then be spent meaningfully, such as enhancing the pedagogical capacity of the teacher. The use of ICT for efficiency purposes can also bring about greater learner engagement, particularly for learners who encounter these technologies for the first time. However, such uses tend not to fundamentally change the T&L interactions, where the teachers essentially teach the same way he or she has always been teaching without the use of ICT. While there
could be nothing wrong with this approach, this way of using ICT misses the opportunity to more fully tap into the affordances provided by the technologies. Also, since the T&L interactions have not changed, the learning outcomes of such interactions are likely to remain firmly in the control of the teacher.

<table>
<thead>
<tr>
<th>Use of ICT</th>
<th>Characteristics</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Efficiency based</td>
<td>No fundamental change in T&amp;L interactions.</td>
<td>Using powerpoint slides to present lesson rather than transparencies.</td>
</tr>
<tr>
<td></td>
<td>Teacher primarily controls learning outcomes.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Gains in productivity.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Initial learner engagement.</td>
<td></td>
</tr>
<tr>
<td>Transformational</td>
<td>Fundamental change in T&amp;L interactions.</td>
<td>Wireless network enabled coordination of field trip groups.</td>
</tr>
<tr>
<td></td>
<td>Potentially enhance &amp; deepen understanding.</td>
<td>Visualisation/Simulation of complex concepts.</td>
</tr>
<tr>
<td></td>
<td>Teacher largely controls learning outcomes.</td>
<td></td>
</tr>
<tr>
<td>Connectedness</td>
<td>Teacher loses control of learning outcomes.</td>
<td>Learning from non-traditional education sources.</td>
</tr>
<tr>
<td></td>
<td>Deep, but could be narrow.</td>
<td>Assimilation of diverse perspectives.</td>
</tr>
<tr>
<td></td>
<td>Connected, yet could be disconnected.</td>
<td></td>
</tr>
</tbody>
</table>
As technologies advance and the pedagogical uses of these technologies mature, the use of ICT in education starts to fundamentally change the T&L interactions. Previously, unattainable interactions now become possible with the use of ICT. For instance, the use of wireless technologies coupled with a collaborative platform can allow research groups to conduct coordinated real-time geological mapping at different locations. Such transformational use of ICT in T&L can potentially deepen understanding, in particular, for cases where complex concepts are made ‘visible’ through ICT, such as the simulation of electromagnetic fields (Xu et al. 2012). On the whole, when supported by pedagogically sound T&L interactions, the use of ICT can lead to enhanced learning (Sutherland et al. 2004; Tüzün et al. 2009). Depending on the design of the T&L interactions, the learning outcomes of the transformational use of ICT in the school context can still be largely determined by the teacher (Prestridge 2012). This is because the design of these interactions is guided by curricular needs and their associated high-stake assessments.

The appearance of web 2.0 tools in the early 2000s increased the connectivity within the online space, adding greater possibilities for how information and knowledge are transacted, as well as redefining social interactions from a variety of devices and platforms. The increased connectedness has resulted from explorations in the use of blogs, Twitter, Facebook and Instagram to open up online environments for learning.

An important corollary in the connectedness use of ICT in T&L is that the teacher is no longer the sole or key source of skills and knowledge. With easy access to a wide variety of online communities, it is relatively simple for the student to seek out information and to learn skills from these communities. Where these acquisitions complement or support the learning in the classroom, the student can
achieve a greater depth of understanding. However, when contradictions happen, it can result in a challenging learning experience for the student. In such cases, the skilful resolution of the contradictions, guided by a teacher, when incorporated as part of the learning process, can lead to substantial gains in learning (Vygotsky 1978). The challenge arises when these contradictions are left unresolved, either through the ignorance of the teacher who could not realistically monitor all online activities of the students, or the failure of the students to seek resolution. This can hinder the learning progression of the students.

A further complication in the connectedness environment is the potential disconnection experienced by members of an online community with other communities. While the learning can indeed be very detailed and deep within an online community, it can also get to be very narrow. Often, online communities are formed through common interests (Hung et al. 2008). Participants in such communities then add on to the pool of knowledge through personal experience and acquired perspectives. Over time, these communities could effectively stop embracing a diversity of perspectives, resulting in a deep but narrow take on the subject matter at hand. The ideas and perspectives of the learners, acquired within these communities, can be very hard to dislodge once fully formed. The role of the teacher will need to expand for providing a good ‘balance of perspectives’ for the students through, for instance, careful and scaffolded explorations of ideas.

Framing teaching and learning processes

Following on from how ICT is used in education, it is useful to frame teaching and learning as two overlapping and interconnecting sets of processes—transfer and deepening. The transfer process broadly refers to the interactions that serve to transfer values, skills and knowledge (VSK) to the learners; and the deepening process represents the interactions through which VSK are assimilated, internalised and applied in a diverse range of contexts. The two sets of processes are not operating independently, for they are mutually reinforcing and iteratively enhancing learning.

To illustrate how the two sets of processes operate, first consider a traditional classroom without the use of ICT. In this case, VSK are transferred primarily through direct instructions, such as when the teacher lays out the facts to be learned, sets up practices to help students acquire the stated skills and articulates the values that reflect societal norms (Prestridge 2007). Tests, quizzes and examinations then follow to ascertain the degree to which these transfers have taken place. To deepen the learning, the teacher may choose to set class work and homework that aim to strengthen the understanding and for the students to demonstrate their ability to apply the newly acquired learning to familiar and new contexts. This generally requires intense human agent interactions, whether between the teacher and the students or among the students, for real understanding to take root. These interactions can be part of or a mixture of typical characterisations of pedagogical approaches, such as drill-and-practice, inquiry-based or even problem-based learning. Through these pedagogical interactions, the skillful teacher gradually builds up and deepens the learning of the students.
Technology-supported transfer

Assuming that there is a case to be made for ICT-mediated pedagogical practice, it is acknowledged that many examples can be described as operating at the efficiency usage level. Nevertheless, a shift towards transformational and connectedness has become noticeable. Given this context, the use of ICT to support the transfer process is exemplified by what might be loosely referred to as the Flipped Classroom approach (Bergmann and Sams 2012) as well as online learning sites such as the Khan Academy. In a simplified way, the flipped classroom could be described as obliging the student to acquire sufficient knowledge prior to engaging the larger learning community, led by the teacher, to unpack and understand the knowledge at a greater depth. The acquisition of knowledge is often done via a scaffolded environment through the use of ICT, such as reading up online on the subject at hand, watching an expository video, and attending an online lesson. In a similar vein, the build-up of knowledge and skills provided by the Khan Academy platform through an engaging delivery of content serves to illustrate the effective use of ICT, when coupled with strong pedagogical underpinning, in the transfer process.

The key characteristic of using ICT in the transfer process is the requirement for a careful design of pedagogies that can be delivered meaningfully through the use of technologies. The chosen pedagogy is built into the entire T&L interactions represented by the transfer process. When properly done, it can cater to a reasonable range of learner profiles, for instance, through several different pedagogical approaches, with little teacher intervention once the delivery platform and processes are established. In this sense, the use of ICT in the transfer process can lead to a significant jump in efficiency.

An important aspect of technology-supported transfer processes is that when comprehensively designed and reliably executed, a case might potentially be made for the teacher to be effectively taken out of the interactions once the processes start. In such a scenario, the role of the teacher would be characterised as having been reduced to determining the stage of learning of the students, selecting the appropriate technology-supported procedures, and getting the student started on the learning. This ‘industrialisation’ of learning is similar in nature to a technology-guided call centre operation, where the operator does a quick diagnosis of the caller’s needs, selects the appropriate set of questions/procedures as determined by protocols and simply executes these same procedures. In such a setting, the skills level demand on the teachers is significantly reduced.

Technology-supported deepening

In general, the deepening process requires active engagement with the learner to (a) determine his/her understanding and ability to apply what is learnt, and (b) adjust pedagogical responses as deemed appropriate to enhance learning and skills development. The interactions involved in this process are often very complex and heavily dependent on the accuracy in judging the state and stage of learning; they are mostly based on the information made available through direct/indirect
observations, learner performance data, skillful questioning by the teacher, learners’ discourse and other multifaceted inputs.

When technologies are brought into attempt to fully handle the deepening process, they tend to use a range of observable proxies to make these pedagogical judgements so as to administer the appropriate response to support and/or guide the learning of the students. There are many challenges in this approach, which can be categorised as follows.

First, there is the need to obtain accurate information of the teaching and learning interactions. This usually means tracking the actions of the students when they interact with the materials, the teachers and among themselves; as well as the actual discourse, which can be both verbal and non-verbal. To effectively track actions requires a highly controlled computerised environment, where the student interacts with others only through this environment. For instance, a carefully constructed set of tasks can monitor what actions the student takes to complete the task. Such environments will need to be necessarily comprehensive in working through all possible actions, which will become increasingly challenging to construct once the complexity of the task growths. Unfortunately, such complexities are unavoidable for tasks that aim to deepen understanding and/or to enhance soft skills. A further, and much more difficult challenge, even if such environments can fully capture all actions, is the need to track the discourse that will more often than not arise in teaching and learning interactions. The discourse can be in the form of short exchanges of factual information, an extensive qualitative discussion of the ideas encountered or even non-verbal facial expressions. The technological environment to actualise this will likely involve not just the capture of typed text, but also video recording of facial changes as well as sound recording of verbal exchanges.

The second set of challenges revolves around the interpretation of the captured T&L interactions, i.e. actions and discourse. The difficulty is that even if the same action is recorded for, say, two different students, its interpretation can depend on a number of things, including cultural differences and the context of the actions. For instance, a failure to response to a question could be for one of several reasons, such as the student not knowing the answer, not understanding the question or simple reticence when interacting in a group. At a simple level, these can be overcome through triangulating several actions so as to increase the accuracy of the interpretations, or have repeated skills/knowledge being tested within the same task. The challenges get significantly harder when interpreting discourse, especially when the discourse needs to be triangulated with actions and the flow of the discourse itself. At present, technologies can support this to some extent. For instance, by collecting a large enough number of graded discourses on one topic/task for the full range of discourse quality, then programming these into a set of analytics, the interpretation of future discourses on the same topic can be managed. The limitations of such an approach should be obvious, particularly when the level of artificial intelligence or equivalent technologies is still not matching the human being’s ability to observe and interpret.
Craft or industrial educator?

To further tease out the implications of using technologies for teaching and learning, it is useful to consider the following thought experiment: if an environment was to exist in which technology was being used to manage both the transfer and deepening processes, the teachers’ role would largely be reduced to that of a factory operator working on a conveyor belt. Their task would then be to ensure that the system continued to function without a glitch, and that the main ‘decision’ to be made would be to spot any exceptions outside of the preconceived range of the system, and then to duly report them.

In this scenario, the task of conceiving a good range of T&L interactions, pedagogical practices and assessment approaches for the purpose of programming them into a system would be done by a small team of highly knowledgeable educators. This latter team would have to anticipate a wide range of T&L interactions for students in differing learning contexts, individualise the pedagogical responses for each student so as to enhance their learning experience, and adaptively administer assessments which ascertain where the student is in terms of VSK attainment.

Once such a system was to be designed for the targeted learning areas, e.g. grade 10 Biology, it could be deployed to manage the learning of the students, with the educator on the ground focusing on managing the system (and not so much the learning of the students). In other words, when decision-making with regard to matching pedagogical responses to the learning needs of the individual student is not in the hands of the educators on the ground, the skill set of the latter in being able to make such decisions becomes redundant. The use of this system not only could lead potentially to cost-savings and greater efficiency, but it also has the effect of de-skilling the educator except for the select few who are needed to design the system. The population of educators could therefore be characterised as consisting largely of ‘industrial’ educators with limited opportunities to apply pedagogical and assessment skills, and a very small group of education designers. The learning experiences of the students would then be primarily dependent on the quality of the design of the learning systems and their implementation.

Note that such an ‘efficiency-optimised’ industrial model of education needs not be of a limited ‘few-sizes-fit-all’ structure. One of the key advantages of technologies is precisely that they can cater to the learners individually and in an engaging manner. As such, the learning experience of well-designed systems can potentially be enriching. However, the basis for such a highly adaptive learning system is its ability to handle both transfer and deepening processes at a level commensurate to, or better than, that of competent human educators. While the technologies have made significant progress for the transfer process, and are competitive with respect to human educators, they have yet to satisfactorily match human educators in the deepening process mostly for the reasons articulated earlier.

It can be argued that even while such systems are not perfect, i.e. as compared to competent human educators, they could still serve the important role of augmenting the teaching force by ‘replacing’ less-than-competent teachers. The assumption is that the students can access a limited but reasonably good quality of education,
while avoiding the detrimental impact of poor (human) teaching. However, although one can almost certainly find examples where this assumption holds, this approach irrevocably shifts education from diversity towards uniformity since there is a natural limit to what a computer system can do, particularly in being able to responsively and appropriately guide the learning of the students. Besides, the impact of this diversity will not be felt till ingenuity borne out of diverse interactions begins to bleed out of the population. For instance, the precision engineering industry, in which the expertise mostly resides with the floor engineers, was able to meet the demands of increasingly complex modern machinery compared to others who mostly depend on expertly designed systems (Prais and Wagner 1983; Culpepper and Finegold 1999).

A further objection to an ‘industrial’ approach to education is that it weakens the incentives to strengthen the capacity of the educators by simply using imperfect systems which continually reduce their involvement in the T&L processes. The focus of education resources may then get increasingly channelled to improving systems which, at least for the foreseeable future, cannot hope to match the abilities of competent educators, rather than give priority to enhancing the quality of educators. In the long run, this could lead to a deterioration of the skills of educators as a whole over time.

It is important to clarify that the above objections are not against the use of technologies in T&L. Rather, they make the argument for placing the educator at the core of the decision-making process in the T&L context, with technologies primarily playing a supporting role. Technologies can do this by providing inputs to the educator that will help in shaping effective pedagogical responses to the learning needs of the students. These may include the learning preferences and assessment performances of the students, which, when coupled with the exercise of wisdom on the part of the educator, provide the foundational basis for effective and meaningful T&L interactions. For educators to be able to deploy a wide and appropriate range of tools to support their teaching require a deep understanding of pedagogies and the ability to translate this understanding into T&L interactions. In essence, they need to be ‘craft’ educators.

The model for ‘craft’ educators is one in which T&L decisions are made by educators directly engaged in the T&L interactions. Thus, the role of designing such interactions is combined with the responsibility of implementing them by the same educator, in contrast to an ‘industrial’ arrangement, where the design is centrally done by a small group of educators who do not generally participate in implementing their own ideas. To be able to teach, observe, assess student achievements in VSK and develop ideas to enhance the entire T&L process work require the craft educator to have deep pedagogical knowledge and the practical experience to apply that knowledge in the T&L environment. They need to be reflective in their practice, and have the ability to ‘measure’ if their ideas work, which broadly means having sufficient action research capability. And with technologies playing an increasingly effective role in the transfer process, the craft education will necessarily need to re-balance his/her role to focus more on the deepening process.

The need for craft educators is premised on the assumption that teaching and learning involve complex human agent interactions that the current technological capability cannot satisfactorily handle. In general, the craft educator needs to be
Table 2 Comparison of ‘craft’ and ‘industrial’ educator

<table>
<thead>
<tr>
<th>Educator</th>
<th>Characteristics</th>
<th>Implications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Craft</td>
<td>Same educator design &amp; implement T&amp;L interactions.</td>
<td>Potential unevenness in T&amp;L delivery.</td>
</tr>
<tr>
<td></td>
<td>Responsible for T&amp;L decisions.</td>
<td>PD paramount.</td>
</tr>
<tr>
<td></td>
<td>Focus on building T&amp;L capacity of educator.</td>
<td>Need for ‘reflective’ practitioner skills.</td>
</tr>
<tr>
<td>Industrial</td>
<td>Centralised T&amp;L design.</td>
<td>Low-cost delivery.</td>
</tr>
<tr>
<td></td>
<td>Focus on enhancing system.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Carry out T&amp;L decisions determined by system.</td>
<td>De-skilling of ground educators.</td>
</tr>
<tr>
<td></td>
<td>‘Mass’ customisation.</td>
<td></td>
</tr>
</tbody>
</table>

able to observe and interpret a great variety of data and signals from these complex interactions based on an acute understanding of factors, such as cultural context, environment influences, social-emotional state and learning preferences. With this clarity and the skills to probe the depth of understanding of learners, the craft educator can then flexibly respond with appropriate pedagogies to guide and deepen the learning.

A key challenge for operating an education system from the paradigm of craft educators is that the quality of T&L can potentially have significant variations. This can happen for a number of reasons, such as variations in educator quality and the resourcing of schools. Depending on the main causes of this variation, appropriate measures can be taken to ensure that T&L can meet a minimally acceptable level of quality. At the same time, the system can strive to continually improve its T&L quality as a whole, with sufficient incentives for the best educators to further push the boundary of quality T&L.

The overall focus of a system with craft educators is likely to be on continual professional development as well as creating the conditions for educators to responsibly exercise their T&L approaches as ‘reflective practitioners’. In other words, it is important to cultivate the desire for each educator to constantly seek to improve his/her professional practices. This generally requires the educator to be able to diagnose the weaknesses in the teaching, formulate approaches to address them, implement the approaches and be able to ‘measure’ if the new ideas work. Coupled with an able leadership, craft educators can form the basis of meeting the learning needs for a fast-changing knowledge-based environment. A comparison of craft and industrial educators is suggested in Table 2.

Conclusion

The enhanced interactivities introduced through ICT are real and have fundamental impact on teaching and learning. In particular, with technologies being increasingly effective in the transfer process, craft educators will, in general, need to re-balance the roles they play in teaching and learning interactions. The required shift is
towards a greater focus on the deepening process in which the continual exercise of educational wisdom by the craft educator is the crucial element. In fact, coupled with an effective integration of technologies in the transfer process, the craft educator has greater degrees of freedom to sharpen his/her ability to deepen the learning of the students.

Should this focus on ‘craft’ educator be taken on board, a key implication is the need for a concerted push to develop their capabilities. This is likely to involve a strong synergy between centrally planned and ground-up efforts. For instance, government agencies could provide regular updates on technological changes and their potential uses for teaching and learning, while community-based educator groups could take these further and actively examine how such technological usage could be adapted for their respective classrooms, which then informs the agencies about their experiences. Such iterative development of capabilities represents but one possibility.

As a final note, it is important to understand that while technologies can add significantly to the teaching and learning interactions, the craft educator will also need to know what can potentially be lost by the particular use of technologies. For instance, the use of keyboards can certainly have productivity gains, but the practice of writing, which has the neurological benefits of strengthening hand-eye coordination, could be lost when not used at an early age. The question facing the craft educator would be whether the losses incurred by the use of technologies would have any practical impact on the development of the students. If any particular loss is not acceptable, then the craft educator has to use teaching and learning interactions that will alleviate this loss when technologies are introduced. On the whole, the challenge facing the craft educator is an exciting one, for when properly met, it can take teaching and learning to a deeper level.

References


