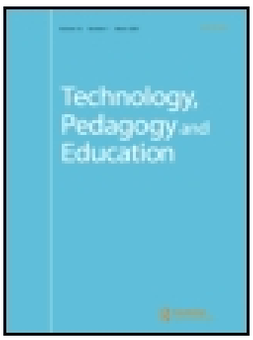

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Theorising the take-up of ICT: can Valsiner's three zones framework make a contribution?

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This article explores the contribution of theory to understanding the take-up of information and communications technology (ICT) and, in particular, it describes how Valsiner's three zones framework came to be used in a study of lecturers in Saudi higher education institutions. The article describes the value of theory and, in the process, illustrates some of the approaches taken in the literature on teachers' use of ICT. The challenges faced in theorising are also covered. The article then goes on to give the background to a study of ICT use among university lecturers before moving to a discussion of methodology and presentation of key findings. Next, attention shifts to explaining key aspects of Valsiner's zones framework and showing how this framework was applied to explain the modest but differentiated use of ICT across eight institutions. Finally, the article discusses the strengths and limitations of the zones framework and highlights some of the wider challenges which theorisation poses.

Keywords: Valsiner; zones framework; take-up of ICT; mathematics; higher education

Why theorise?

Theorising can cover a range of activity in social research but a common feature of most theory is an attempt to offer an explanation as to how and why social processes happen as they do. Theorising involves a process of abstraction – the picking out of what is important in a complicated research context. As such, it requires the exercise of judgement for what is seen as important may go unnoticed or be taken for granted by research participants.

Theorisation thus requires a leap of the imagination though a leap backed up by relevant sets of data marshalled as evidence. This marshalling of evidence is, however, always open to challenge. For example, the significance of particular findings may be disputed, questions asked as to the foregrounding of some data and not others and, more fundamentally, there may be claims of ideological distortion. Any explanation offered by researchers is, further, subject to a kind of infinite regression. Technological confidence, for example, may serve as an explanation as to why some teachers take up information and communications technology (ICT) but confidence comes from somewhere, and if, say, it is a consequence of a particular kind of enculturation, how was that culture constructed in the first place? Theories do not, and

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cannot, provide definitive answers, rather they provoke argument. They provide a way of seeing the world and are valuable for the lens they offer on social activity (e.g. Martindale, 2010).

While explanation is core to theory, theorising will mean different things in different traditions. Within a more positivist approach, theory is tied quite closely to cause and effect explanation and traditional notions of validity. A well-established strand of research into the reported take-up of ICT works within this tradition by seeking to identify statistical associations between the disposition to use ICT and 'variables' such as teachers' beliefs (e.g. Hermans, Tondeur, van Braak, & Valcke, 2008, looking at teachers in Belgium) or their orientation to professional development (e.g. Drent & Meelissen, 2008, researching teacher educators in the Netherlands). In these and other studies there is widespread agreement that teachers with relatively strong constructivist beliefs, or in some studies a more entrepreneurial approach to their own continuing professional development, report a higher frequency of computer use (see also Sang, Valcke, van Braak, & Tondeur, 2010; So, Choi, Lim, & Xiong, 2012).

Theorising in an interpretive tradition, in contrast to the more positivist approaches above, often seeks to construct new concepts that help to describe and explain social phenomena (e.g. Glaser & Strauss, 1967). As an example of an interpretive approach in the context of the take-up of ICT, Olson (1988) was able to show that the phenomenon of 'establishing routines' was essential to the managing of teaching and learning in a classroom and, as a consequence, many teachers find the use of computers disruptive. Other interpretive approaches (e.g. Levin & Wadmany, 2005; Windschitl & Sahl, 2002) have also shed light on the complex nature of ICT take-up and on the interplay between teacher beliefs and the context in which teaching takes place. Interpretive research helps caution against an overly reductionist view of the relationship between beliefs and behaviour.

Interpretivism and positivism are well established as paradigms for educational research (e.g. Cohen, Manion, & Morrison, 2007), however the distinction between the two need not be and rarely is watertight. For example, in the context of an exploratory case study of teacher take-up of ICT, Tearle (2003) was able to throw light on the factors that led to its widespread use as well as the motives and actions of teachers and school leaders in adopting ICT.

Challenges in theorising

There are frequently observed challenges in theorising including: degree of abstraction; attending to both agency and structure; timing; and managing both descriptive/prescriptive goals. These are covered in turn.

All theories should in some way *abstract* from the data, but some aim to be as comprehensive as possible, while others instead aim for 'parsimony' and stress only key variables. The more comprehensive a theory, the greater the 'fidelity' to a particular setting; in contrast, greater parsimony may facilitate transferability. In an ideal world there would be a two-way relationship between the analysis of local data and more 'formal' theorising, with each helping to inform and shape the other. Theorisation into the educational use of technology, and in the field of education in general, has, however, been critiqued for over-focusing on the local and small scale (e.g. Underwood, 2004) and for neglecting broader sociological theory (e.g. Selwyn, 2011). In the specific context of the take-up of ICT, research has often pursued a

'factors' approach, i.e. one in which the factors that encourage/discourage ICT use are identified – see, for example, Cox, Preston, and Cox (1999), Gaffney (2010), Hammond, Reynolds, and Ingram (2011), Mumtaz (2000), Scrimshaw (2004) and, in respect to teachers, the previously cited examples of Drent and Meelissen (2008) and Hermans et al. (2008). This factors approach has undeniable strengths and can help guide policymakers wanting to promote the use of ICT. However, it offers a relatively weak theoretical contribution in the sense of generating, or indeed engaging with, more abstract theoretical concepts. Of course general theory, or at least engagement with conceptual categories familiar to researchers in other fields, does find a way into research on ICT take-up and examples include complexity theory (e.g. Morrison, 2005; Phelps, Graham, & Watts, 2011), community of practice (e.g. Hung, Chee, Hedberg, & Thiam Seng, 2005) and activity theory (e.g. Demiraslan & Usluel, 2008; Lim & Hang, 2003). However, a general criticism made of the use of theory in ICT research is that frameworks come in and out of fashion without due regard to past traditions (McDougall & Jones, 2006). Theories too tend to be used in a rather formulaic way in that they are transferred across to a technology context, rather than adapted to that context. Of course this is not always the case and, for example, Johannesen and Habib (2010) offered a flexible synthesis of two well-established sociological theories (in their case, actor network theory and community of practice) in order to throw light on teachers' varied perceptions of multiple-choice software.

A second challenge in theorising is to offer explanations that make allowance for both the **agency** of social actors and the environmental or **structural** forces that lead actors to behave in a certain way. This creates an inevitable, and ultimately irreconcilable, tension as agency and structure are alternating not simultaneous perspectives on a phenomenon; to use Eraut's (2010) analogy, in trying to examine both agency and structure we are in a similar position to physicists who can view light either as a particle or a wave but not simultaneously. However, if researchers focus primarily on agency then they might be attributing an infeasible degree of free will to social actors and they will end up offering unrealistically romantic or condemnatory accounts. If structural issues are foregrounded then researchers might impose regularity and stability on a context that is unpredictable, even chaotic, and they may miss emergent behaviour.

Researchers tackling the take-up of ICT often struggle with the challenge of balancing agency and structure. One particular problem is that both the 'factors' approach and widely adopted modelling of technology acceptance (e.g. Stols & Kriek, 2011) stress regularity and causal connection at the expense of agency. Furthermore, some researchers have tended to impose causality on data, so that *sensitising* models such as activity theory (see Cole & Engeström, 1993) have been reinterpreted as *causal* models. Researchers, too, have tended to take an oversimplistic approach to assessing teacher knowledge of ICT. For example it is common to see Technological Pedagogical Content Knowledge (Mishra & Koehler, 2006) used as a construct which can be an objectively measured rather than a useful tool for drawing attention to the complexity of teaching with ICT – see, for example, discussions in Graham (2011) and Niess (2005).

Of course some research into ICT has focused on teacher agency and on teachers' beliefs, confidence and their approach to continuing professional development (CPD) (for example, Becker, 1994; Ertmer, 2005) on the assumption that, given reasonable access, teachers themselves make the difference as to whether or not

technology will be used. This may be going too far; decisions as to the use of ICT are always constrained. However, neither the factors approach nor the focus on teacher agency and beliefs seem satisfactory and both appear at odds with changes with the broader field of professional learning in which the interplay of agency and structure has been analysed in more compelling ways (e.g. Billett, 2001, 2010; Hodkinson, Biesta, & James, 2008; Hodkinson & Hodkinson, 2004).

A third challenge for researchers is whether theory should make an appearance **prior to** or **after** data collection. On one hand, within a more quantitative/'positivist' tradition, researchers generally set out with implicit, or frequently explicit, hypotheses, 'theories' or conceptual frameworks. Eid and Nuhu (2011) provided an example in the context of higher education in Saudi Arabia, the setting reported in this article. In interpretivist case study, on the other hand, and particularly within the grounded theory tradition, theorising emerges from the data. The advantage of the former is that an inquiry can be better focused, and its links with earlier frameworks made more explicit, but a disadvantage is that research can end up reductive and unable to contribute new theorisation. A more bottom-up approach can lead to more original research but, for its critics, it does not build adequately on a past body of knowledge and exaggerates the degree to which researchers can interpret data without preconceptions.

A final challenge for researchers is to ask whether their use of theory is intended to be **prescriptive** or **descriptive**. This raises particular questions for educational research, which is almost instinctively action oriented and concerned with 'what should be taught', in a way that social research in general tends not to be (see Hammersley, 2004, for more on this). The action-oriented nature of educational research is valued as this can inform practice but, in respect to the take-up of ICT, it carries the danger of 'buying into' technologically determinist narratives surrounding the use of ICT (see Selwyn, 2011 and, earlier, Cuban, Kirkpatrick, & Peck, 2001) and underplaying the constraints that teachers face.

To sum up, theorisation is core to the conduct of social research. It can help explain complicated facts and guide action and understanding. However, discussion of theorisation is underdeveloped – particularly so within the ICT research community. The aim of this article is then to stimulate interest in theorisation by exploring one particular approach (Valsiner's zones framework) to analysing the take-up of ICT and compare its use with a more traditional 'factors' approach. It describes a particular research context and the findings that were generated within that context. It then explains the nature of Valsiner's framework and how this was used to provide a lens on lecturer take-up of ICT. This is an unusual article in that we are reflecting on analytical frameworks within a research project rather than providing straight reporting of findings. Furthermore, it is unusual (though see Trenholm, Alcock, & Robinson, 2012) in comparing two approaches to theorisation and offering a kind of theoretical triangulation. While we suggest that the zones framework offers useful insight into the take-up of ICT, our overarching aim is to make the case for a more reflexive and critical approach to theorisation.

Background to the study

Our study concerned the take-up of mathematical software and generic ICT tools such as virtual learning environments and overhead projection, by lecturers in higher education institutions in Saudi Arabia. The context of the research is an interesting

one as there has been considerable growth in and access to higher education in Saudi Arabia (see Smith & Abouammoh, 2013) with concerted attempts to expand student numbers and to develop a more learner-centred pedagogy, while at the same time improving the international research prestige and status of higher education (Borg & Alshumaimeri, 2012). Of course the Saudi context has distinctive features but the study addressed a familiar issue: how do we understand the gap between the opportunities afforded by ICT and the take-up of ICT, which, in higher education as in the school sector, has not been on the scale that is often anticipated (see for example Blin & Munro, 2008; Gouseti, 2010; Selwyn, 2007, 2014).

To address this question, an idea of the opportunities afforded by ICT is first needed. In respect to teaching and learning mathematics, Pierce and Stacey (2010) usefully mapped out a range of uses for technology including the provision of automatic practice; collaboration; repositories of resources; support for administration; a conduit between learners and tutors; tools for assessment and monitoring of learning. Social media too, whether developed bottom-up by learners themselves or led by institutions, may have particular value for providing affective support for learners of mathematics, in both distance and face-to-face contexts, given that this is an area of the curriculum which is often seen as generating high anxiety (e.g. Goodband, Solomon, Samuels, Lawson, & Bhakta, 2012). Specific mathematical software may further assist with the visualising of complex mathematics, the representation of mathematical objects in multiple ways and the promotion of interactivity (e.g. Barzel, 2007; Buteau, Marshall, Jarvis, & Lavicza, 2010; Palais, 1999). In specific areas of the curriculum, software may provide opportunities for computer-based simulation of techniques, tools for handling large sets of authentic data, as in the teaching of statistics, e.g. Neumann, Neumann, and Hood, 2011, and for widening the range of 'accessible geometrical constructions', as in Straesser's (2002) discussion of Cabri. Of course there is not universal agreement as to the value of technology. Some have argued against its excessive use (e.g. Berger, 2009; Haciomeroglu, Aspinwall, & Presmeg, 2010), with fears expressed that ICT can lead to a kind of 'black boxing' or the hiding of underlying conceptual propositions from the learner.

In spite of the opportunities described above, and the widespread use of software by lecturers in their own research and mathematical practice, the use of mathematical software and ICT in general remains 'patchy' (e.g. Joubert, 2013; Lavicza, 2010; Marshall, Buteau, Jarvis, & Lavicza, 2012) with a set of factors familiar to the wider research on take-up of ICT seen as constraining its use. These factors include traditional forms of assessment, a lack of support for, and leadership of, change and the prevalence of teachers' 'instructionist' beliefs and widespread scepticism over the contribution of technology. If software is to fully impact on the teaching and learning of mathematics, a refreshed understanding of mathematics as a subject is needed (e.g. Straesser, 2010).

Methodology and findings

This was a mixed-methods study carried out in eight universities – these were all the established universities in Saudi Arabia at the time of the data collection (2011–12). In the first phase of this study, face-to-face semi-structured interviews (n = 18) were carried out with lecturers who were purposively selected to offer a range of experiences of, and perspectives on, ICT – though note that while female lecturers were surveyed, for cultural reasons they were not interviewed. Interviews covered three

main themes: use of ICT (the 'what', 'how', 'when' and 'where' questions), the value of ICT use (the 'why'), barriers to ICT use (the 'why not'). Interviews were transcribed and coded around three main categories: use of mathematical ICT and learning management systems; explanations for use of ICT in teaching; and explanations for not using ICT in teaching.

In the second phase of the study, a questionnaire survey to the entire population (n = 421) of mathematics faculty members within the eight universities was carried out. Where distance allowed, the questionnaire was delivered by hand in hard-copy format (n = 170) but otherwise through email (n = 251). The items in the questionnaire explored use of and attitudes towards ICT in relation to variables such as teaching experience, subject specialisms, nature of students and access to ICT facilities. A particular focus throughout the study was on mathematical software but more generic ICT was also covered. One hundred and fifty-one lecturers responded to the questionnaire. The data were collated using SPSS software and largely descriptive reporting carried out with use broken down against key variables. Due ethical procedures were followed in the collection, interpretation and presentation of data. The research design could best be described as a concurrent mixed-methods two-strands approach (Tashakkori & Teddlie, 1998) though insights from the interviews did inform the design of the survey. Interpretation of data was assisted by observations collected by one of the authors on visits to four faculties when conducting the research.

Findings

The findings of the study were organised around the overarching themes: the context in which ICT is used; how it is used; differences in how ICT is used; what encourages ICT use; what discourages use. The interested reader should turn to a supplementary document, accessible at http://wrap.warwick.ac.uk/71516/1/WRAP_dataset_for_Valsiners_three_zones_framework_Hammond_Alotaibi_2015.pdf, for the detail of the findings including summaries of interviews, survey questionnaire results and examples of raw data. However, in brief, the key facts of the case were:

1. A wide range of available tools were accessible. (For example, lecture halls had overhead multimedia projectors; learning management systems were set up; mathematical and statistical software packages were available.)
2. There were differing perspectives on the accessibility of tools. (For example, the majority felt that it was not difficult to schedule a class in a computer lab though a sizeable minority disagreed.)
3. Training in the use of tools was provided though CPD was not personalised. (For example, most respondents participated in training workshops on the general use of technology in teaching.)
4. Lecturer autonomy was wide but contradictory. (For example, lecturers felt they had considerable choice in respect to how they taught but they had to follow a predetermined syllabus.)
5. The use of ICT was underdeveloped. (For example, only a quarter used the virtual learning environments.)
6. The use of ICT was differentiated. (There were low users, mid users and high users of ICT. Low users used ICT rarely; high users had created archives of web resources, had started up blogs and, in some cases, had led workshops showing the use of mathematical software.)

7. ICT use was channelled in particular cases. (A key finding was that lecturers who taught statistical and computational mathematics courses used software more, and were more likely to assign homework that required the use of software.)
8. There was a widespread perception that the use of ICT had value. (For example, most felt ICT was good for 'doing' mathematics and helped 'motivate' students.)
9. There was a wide perception that ICT had become easier to use. (For example, contemporary mathematical software was compared favourably to more 'traditional' programming languages such as Fortran or C++.)
10. ICT use was promoted, but inconsistently. (For example, lecturers thought that heads of schools and university managers were 'pushing' the use of e-learning but direction and support were limited.)
11. There were some negative perceptions about ICT use. (For example, some lecturers found it more natural to use 'chalk and talk' in class and felt that students could become over-reliant on the software.)
12. There were environmental constraints on ICT use. (For example, the use of software was encouraged but in many cases such use was not assessed.)
13. There were *curriculum* constraints on ICT use. (For example, many felt there was little time to deviate from a content-heavy and inflexible curriculum.)
14. There were *training* constraints on ICT use. (For example, there was a lack of training on how to use mathematical software.)
15. There were *access* constraints on ICT use. (For example, there were no computers for students to use in lecture halls.)
16. There were *student* constraints on ICT use. (Some saw students as a conservative influence on their teaching and this dampened their desire to innovate.)

These key findings were originally framed by the more conventional 'factors approach' (e.g. Joubert, 2013; Lavicza, 2010; Marshall et al., 2012 cited earlier), in which the use of ICT was explained by listing the factors that encouraged/discouraged its use. Indeed the findings seemed to fit a well-reported pattern. In particular this was a case in which take-up of ICT was relatively modest [5] or underdeveloped. Access [1], perception of access [2], appreciation of the value of ICT [8] and ease of use [9] were clear factors in the take-up of ICT and restrictions on access [15], training [14], curriculum [13] and general environment [12] [16] offered constraints even if ICT use was promoted [10] [7]. There were the expected 'second order' factors (Ertmer, 2005) so that those who saw benefit in using ICT were innovative in its use [6] and those that had doubts less likely to use ICT [11] – thus illustrating the enduring relevance of Becker (1994). (Note that the numbers in [square brackets] here and throughout refer to the 16 key facts of the case presented above.)

However, there were three difficulties with presenting the take-up (or non take-up) of ICT as an outcome of competing sets of encouraging and discouraging factors. First, this was not paying due regard to teacher agency. Lecturers exercised agency: they possessed beliefs, they identified opportunities, they developed, or chose not to develop, the competence and confidence to use ICT. However, if this exercise of agency is presented as a factor that 'caused' the use of ICT, then lecturers become objects rather than subjects of their own activity. We wanted to rethink how the interplay of structure and agency could be represented in a more coherent

manner. Second, the more traditional factors framework underplayed the degree to which perceptions of the environment differed. It was not so much that lecturers were seeing the same environment differently but rather they were seeing different environments and, furthermore, by introducing technology of their own (for example, some had introduced their own freeware to support forums and share resources), they were altering the environments in which they worked. Third, we wanted to give a better sense of the shifting worlds in which lecturers worked, it was not so much that a particular factor existed to encourage or discourage the use of ICT, but that lecturers were stepping in and out of contexts which were both open (they could teach how they liked) and constrained (they saw little room for deviation from the specified curriculum). In seeing these shifting contexts we may have been influenced by the more general case of Saudi Arabia as a country with zones of constraint, associated with conservative cultural traditions, co-existing alongside zones of free movement associated with modernity. Finally, we wanted to be sure that we had not assumed that teachers should use ICT, or use ICT more, and felt that value judgements were bound up in the language of encouraging and discouraging.

In addressing these difficulties, we cannot exactly recall when we settled on a zones framework, but there was an 'aha' moment when fitting the findings around the theory. This was not grounded theory as classically conceived but nonetheless the zones framework was not selected prior to data collection and its relevance established by constant checking of data. Something now needs to be said about the three zones.

Valsiner and the zones framework

Valsiner is best known for a 'zones framework', first developed through a detailed examination of Vygotsky's social cultural theory, in particular in the context of the field of child development (Valsiner, 1997). Put briefly, the framework sees human activity as taking place within three zones: the Zone of Free Movement (ZFM), the Zone of Promoted Action (ZPA) and the Zone of Proximal Development (ZPD). The ZFM defines possibilities: 'what is available to the person acting in a particular environment at a given time'(Valsiner, 1997, p. 317). In this sense a Zone of Free Movement is a little misleading; a ZFM is a zone of constraint as well as opportunity. The ZPA defines what, in respect to the person's actions, is being promoted. The ZPD, borrowed from Vygotsky, defines the set of possible next states in the person's developing relationship with his or her environment: the ZPD directs the process within the boundaries set up by the ZFM/ZPA system inside which the individual is allowed to act. Valsiner suggests that while the ZPD has a personal character it is constructed jointly with other people. An agent is constantly involved in 'importing' meanings through interpersonal communication with others, 'processing' these meaning (in his or her intra-psychological system) and then 'exporting' them through social interaction within a wider social system (Valsiner, 1997). A key term in the framework is that of 'canalisation' to describe how activity is channelled in particular ways within the three zones. For example, it is difficult to canalise activity at the margins of an actor's ZPD, but similarly problematic if the ZPA/ZFM complex is broad and if what is being promoted is unfocused. Although activity is structured within a zones system, the crossing of the ZPD requires agency and can be carried out without direct help, i.e. it can be self-scaffolded (Valsiner, 2005).

The use of the zones framework has been taken up in technology settings (e.g. Koot & Garde, 2013) and is increasingly influential as a lens on the take-up of ICT

among teachers and pre-service teachers of mathematics (e.g. Blanton, Westbrook, & Carter, 2005; Goos, 2005, 2013; Goos & Bennison, 2008; Hussain, Monaghan, & Threlfall, 2011) as well as those learning mathematics (e.g. Galligan, 2008).

How the zones framework was applied

Table 1 gives an outline as to how the zones framework was characterised in this study. Each of the three zones is considered below in more detail.

First, in respect to the **ZFM** there were opportunities to use ICT to carry out teaching activity but also opportunities to use ICT to prepare for teaching and assess students formatively and summatively [1] [9]. Hence it was useful to think of the ZFM as the opportunities for action which existed inside classrooms and beyond classrooms, i.e. the lecturers' offices, computer labs and through various computer programs and networks.

For Valsiner, drawing on Gibson, opportunities exist as affordances (Valsiner, 1997, p. 127), they present themselves in the eye of the beholder. Thus some lecturers saw software as offering epistemic and motivational opportunities [8], but others saw, and recoiled from, an opportunity for 'button pressing' [11]. It was also useful to think of the ZFM as including accepted routines about teaching and learning. For example, assessment policies and curriculum content were decisions taken by social actors but they would often appear as 'reified', i.e. fixed and immoveable facts about teaching [13]. In this study the ZFM was particularly broad in that lecturers were allowed to freely choose tools, including ICT, in their teaching and in preparation for their teaching [4] and introduce new tools into teaching for themselves. However, the ZFM was also constrained in that classroom resources were restricted [15],

Table 1. Characterisation of the three zones.

Valsiner's zones	Characterisation	Elements of the zone
Zone of Free Movement	Particularly broad with some narrow features	Technology: access to a variety of hardware and software inside and outside of teaching rooms, different perceptions of opportunity Support: opportunities for technical and other support Curriculum: assessment and other cultural practices seen as fixed Students: different perceptions of abilities and motivation to use technology
Zone of Promoted Action	Broad and often weak	CPD: generic courses offered Policies: general encouragement in documents and departmental plans Support: services available which support ICT use Values: research output seen as more rewarded than teaching Curriculum: expectation of using software in some courses, but not in others Pedagogical support: under-developed
Zone of Proximal Development	Highly differentiated	Knowledge, confidence and competence: varied in respect to ICT Attitude to ICT: differentiated perspectives on its value

syllabuses were fixed and content full, leaving little time for deviation [13]. The ZFM further took in the wider environment, in particular peers and those offering pedagogical leadership. Here there were opportunities to develop more 'bottom-up' collaborative practices to support and develop teachers' use of ICT, but such strategies were not well developed. Students could be seen as another part of the equation, both as an opportunity, for example their ICT skills and interest in ICT might serve as a stimulus to use ICT, but also a constraint, as they might not go along with change and were perceived as having largely instrumental motivations for learning [16].

To sum up, the ZFM looks broad in terms of what is possible but contradictory. It offers an almost excessive range of possible actions in terms of delivery of teaching but is constrained in terms of the curriculum and the possibility for reform.

The second zone, the **ZPA**, represents actions that are being promoted, in this case by the department or by the university, to direct the lecturers' actions. Elements of the ZPA included all actions that were being promoted by formal professional development activities and training workshops on the use of technology in teaching. There was a general encouragement to use technology [10] but there were mixed messages, for example the use of software was in many cases not assessed [13] and students were only allowed to use basic calculators during examinations. While most of the respondents agreed that there was generally good access to ICT resources [2] and that technology was being promoted, a constraint lay in access to adequate technical support and appropriate training on how to use software in line with the objectives of the curriculum [3] [14]. Departments tended to be 'laissez-faire' in relation to the use of mathematical software and did not always facilitate more flexible, 'bottom-up' types of collaboration [12]. Inside the institution there was a perceived emphasis on research rather than innovative teaching. To sum up, the ZPA was weak and contradictory in terms of what was being promoted and in respect to mathematical software in particular.

The third zone, the **ZPD**, was highly personal – lecturers had different levels of experience of technology and perceived different kinds of benefits and difficulties in using the software [2]. Opportunities for support for using mathematical software were limited and there was in some cases considerable 'self-scaffolding' undertaken by extended users of technology [6]. Initiatives such as the use of discussion forums or archiving of resources were allowable in the ZFM and these represented an important exercise of teaching agency. However, these actions would remain at the fringes of teaching and learning practice [5] if not exported into the department's schemes of work, timetabling and assessment. Such exporting could of course happen, though with uncertain consequences. For example, the use of software in statistical and computational courses had started out as a fringe activity but had over time become routine [7], though in the process the software had lost much of its earlier association with a more learner-centred pedagogy.

Reflection on the zones framework: strengths and limitations

At the start of the article, it was suggested that theorising raises challenges concerning its level of abstraction, the role of agency and structure, timeliness and normative character. How does our use of Valsiner measure up?

First, theory should **abstract** out the key facts of a case and in important ways the zones framework does this by using three conceptual categories to cover all the

findings deemed to be of significance. What might be lost in the raft of detail can be captured by focusing on the key points that when ZPAs are weak, their impact is likely to be patchy; when ZFMs are broad, they can overwhelm and may have contradictory aspects; and in the absence of personalised support ZPDs are not easily crossed. All this may seem very obvious but drawing attention to the obvious is what theory does best. A strength of the zones framework is that it demystifies the conundrum reported earlier: why, in the face of advantages put forward about the use of ICT, is it not used more? There is no mystery: lecturers are working in a context where much is both possible and constrained, the promotion of action is unfocused and support needs to be, but is not, differentiated and personalised.

Second, theory has to position itself in regard to the relative importance of **agency** and **structure** when providing explanations for social phenomena. As already seen, the undoubted strength of the zones framework is that it acknowledges teacher agency without losing sight of context. Furthermore, it sees agency as developmental, something that takes place through interaction with an environment rather than a one-off decision to use ICT or not. This distinctive stance explains why the framework was preferred to the more conventional 'factors' approach. Less clear perhaps was why Valsiner's framework was preferred to activity theory or CHAT, given that Valsiner is a much-respected commentator on Vygotsky and has incorporated some of the same conceptual tools as CHAT. A partial answer is that the zones framework offered a better fit for our focus *in the first instance* on the teacher, and the importance of personal construction, rather the system itself (see Hodkinson & Hodkinson, 2003, for a broader discussion here). Using Valsiner's framework, we were better able to see that the decision to use ICT began with a perception of an opportunity, albeit within an environment that either supported or constrained further action. Of course CHAT should not be misrepresented as a structural and inflexible model and CHAT has itself undergone significant adaption by, for example, giving greater emphasis to expansive learning – see Timmis (2014) for a description of 'three generations' of CHAT and Blin and Appel's (2011) creative use of CHAT in a case study of communication technology in language teaching. However, the zones framework was a more natural approach for addressing our interest in understanding teachers' perceptions of their environment. In addition, the presentation of just three key conceptual categories (the three zones) offered greater 'parsimony' than the models of CHAT we had reviewed and encouraged greater flexibility when interpreting the data. Indeed, our experience confirmed a point made by Galligan (2008) that diagrammatic representation, as with the 'triangles within triangles' associated with CHAT, can mislead by suggesting causality even when such causality is not intended. By avoiding such representation, Valsiner's framework invited a more exploratory approach.

In Valsiner, agency involves self-scaffolding and here lecturers' actions affected both the environment (for example, the introduction of new tools into the environment) and the perception of that environment (for example, whether students really do offer constraints on or opportunities for innovation). However, individual agency by itself is not enough; social interaction is needed to 'canalise' the use of ICT. Thus patchy take-up of social media was an emergent practice in our study and could be contrasted with the use of statistical software in computational courses as a routine or canalised activity. In steering a path between excessive determinism (as seen earlier, often claimed as a feature of research into ICT) and excessive subjectivism (the assumption that all would be well if only teachers could believe different things

about technology), the use of the zones framework enabled our findings to better connect with the wider field of professional learning. For example, as with the idea of a ZFM, Billett (2001, 2010) sees workplace learning as 'invitational', i.e. individuals can be invited to engage in their own professional development but take-up depends on the perceptions they have of the work environment. One consequence is that some will see opportunities in unlikely circumstances, as indeed seen in this study in the innovative use of social media, and some will resist training even when it is carefully promoted. However, a difficulty remains with the concept of canalisation in this study, as indeed in the ecological view of Billett, in that it appears underpinned by a kind of probabilistic reasoning: under circumstances x and y people are more likely to act in a particular way than under circumstances a and b. This is quite defensible, indeed intuitively obvious, but is not entirely satisfactory.

A third challenge is that of **timeliness**: when should theory make an appearance? The approach taken here was to revisit data from a different framework and carry out a kind of methodological triangulation. An informed decision about the zones framework was not taken at the start of the research – in fact it had not even been considered. In our experience this is not unusual in social research and suggests that researchers should not be over-committed to an approach in advance of data collection as they do not know what they are going to find. Furthermore, in coming to the zones framework later on, we were more confident of adapting the framework to fit the data rather than vice versa – for example, 'weak' was added as a further dimension to 'broad' in describing a ZPA and this is a not a trivial matter; the idea of ecological perception, underplayed in some other interpreters of the framework, was stressed, and cultural constraints on the curriculum were foregrounded. However, there are clearly disadvantages in post hoc theorisation. In particular if we had explored the zones framework at an earlier stage we would have understood from other studies how important observation of activity was for Valsiner himself and for some, though not all, of the researchers cited earlier (e.g. Goos, 2013). We might also have undertaken a more longitudinal approach and sought to better track the process from emergent activity to reified procedure. These were lost opportunities though there is always a balance to be made between forward planning and flexibility. The key shortcoming in this study was not failing to predict the use of the zones framework but rather not engaging deeply enough with epistemological or ontological assumptions in designing the study (something discussed in another context in Grix, 2002).

A fourth and final challenge facing research into technology is its **normative character** and how, if at all, might prescriptive and descriptive analyses be merged. Here the zones framework helped us to avoid seeing non-adoption of ICT as 'our problem' and we were able to deal seriously with lecturers' objections to technology, in particular their perception that the use of technology could lead to 'black boxing'. The framework is not then a prescriptive one, but it can help inform those planning for change, in particular by drawing attention to tensions in policymaking. For example, an obvious means of encouraging take-up of ICT would be to create much stronger ZPAs, narrower ZFMs and set out goals that are in the reach of all lecturers. However, it can also be seen that restricted ZFMs, if coupled with strong ZPAs, may come at the expense of weakening personal agency, disregarding emerging practice and limiting teachers' ZPD. The framework thus warns against over-simplification and against causal models of take-up.

Although Valsiner's framework was found to be useful, theories do not and cannot provide definitive answers – they are able to foreground some issues and background others. In this case there are three issues which could be better foregrounded by adopting alternative approaches.

First, our use of Valsiner finished with only a local or 'substantive' explanation – an inferior kind of theorising for social theorists (Martindale, 2010). Perhaps this shortcoming was because some of the theoretical complexity which Valsiner offers might have been underplayed, but there is a discipline element to consider as well. The zones framework was developed within the field of social psychology and this is a field which tends to offer frameworks rather than generalised social theory.

Second, and very much related to the first point, Valsiner has a limited focus on cultural traditions; for example in his study of meal times, Valsiner (1984) showed a concern for cultural practices surrounding food but not the sociologist's interest in where these practices come from and whose purposes they serve. In fact Saudi Arabia presents a very rich context for sociological inquiry (see Macfadyen, 2011, for a well-aimed critique of Hofstede) with researchers pointing to the unsettling consequences of modernisation (e.g. Agarwal, Lim, & Wigand, 2012) and the impact of ICT on learning cultures (e.g. Eid & Nuhu, 2011). This wider literature could have provided broader insight into the context in which the study took place and a better sociological awareness of the way that cultures act on the individual.

A third issue is that the zones framework is not a pedagogical one; it shows, for example, that there is a ZPD that needs to be crossed but, to pursue the metaphor, not what lies on the other side. Research on what constitutes desirable teaching with technology remains of huge importance and here the notion of 'instrumental genesis', an influential one in mathematics education (e.g. Bretscher, 2008; Drijvers & Herwaarden, 2001; Maschietto & Trouche, 2010), helps to capture a sense of what the purposeful employment of technology looks like. In this sense this study has contributed to understanding the take-up of ICT, but more focused pedagogical research is needed to address how technology might, to borrow from Day's perspective on CPD, 'contribute to the quality of education in the classroom' (Day, 1999, p. 4).

Conclusion

This article began by looking at the role of theory in the context of the take-up of ICT. It saw the promise of theory as helping us to understand what is happening in a particular context by abstracting the important facts of the case and describing how these facts are related. As such, the zones framework was found to be a useful theory to view the take-up of ICT as it drew attention to the kind of environment (zones within an activity system) in which lecturers act. As a consequence, the framework enabled a perspective on individual agency – why it is important and the limits of its importance. However, any theory is a stepping stone to further questions, in this case there are gaps associated with social psychology as a field. Thus the overall aim of the article is to stimulate further debate on theory and theorisation in the field of ICT research.

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