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Managing information in education: a view from South Africa

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Abstract

Purpose – A three-year study of information technology and information systems management in South Africa has delivered (amongst other things) a bibliography and a new reference model. The paper aims to discuss this issue.

Design/methodology/approach – The new reference model indicates the key informational components of the education "system" that education management must acknowledge, understand and deal with. This paper presents an overview of these two principal outcomes from that research, leading to a view as to how education can be improved through better information management.

Findings – There is some available reported work that addresses management, or information, or education, but relatively little that brings the essence of these three domains together. The derived reference model effectively addresses a number of set objectives, hence providing a basis for improved understanding of how information can be more effectively managed in education.

Originality/value – The new reference model comprises an arrangement of ideas that allows education managers to focus on a more strategic approach to their management challenges. It also provides foundations for further research. Although the study was undertaken in South Africa, it has relevance to all countries and regions where education needs improved management.

Introduction

The origins of the study reported here can be traced back to a two-day meeting in Cape Town, in 2013, of expert academics, managers and administrators. The meeting discussed the impact of information technologies on education and the need to manage information technology- related investments in a more thoughtful and effective way. Four questions guided these initial discussions:

- What does "management" actually mean, in the educational context?
- What "value" is there in using technology in education?
- How will "good management" deliver that "value"?
- What are the "factors" that lead to management success (or failure)?

After a period of exploratory work, it was agreed to undertake a major bibliographic analysis and to develop a reference model[1] that would summarise the things that education managers need to be aware of, and about which they need to have information. The purpose of

this paper is to present an overview of these two deliverables. By way of introduction, the paragraphs that now follow summarise the outcome of the early discussions, according to each of the four questions that were tabled.

Management means dealing with differences

Different people see technology differently. Mobile devices are not seen by young people in the same way as those who are older. To a youngster, a smart phone is something that serves multiple functions; to an aged retiree they look like an unnecessarily complex telephone. At a basic level, smart phones, desktop computers, tablets and laptops are built with different hardware and software technologies that place different constraints on both systems developers and users of systems. At the highest level, the contexts within which education is delivered are different, the languages used are different, and the motivations and attitudes of key stakeholders are all different. This all adds up to complexity that needs to be managed.

It was agreed that an important step in dealing with complexity is to start with stakeholders: to understand their perceptions and expectations and to then work down to the details of technologies, systems and information management practice.

Education is a chain of generated value

Education starts with the resources that are required, including information technology and systems, and ends with benefits to society as well as to the individuals that are educated. Hence, it can be seen as a chain of diverse activities that deliver value that will be seen differently by different stakeholders. Information technology is a cost driver, and therefore an investment. However, investments in information technology in education are often not delivering the expected benefits and little research was found that deals with this at a managerial level – perhaps the chain is broken.

In a search for the best value the very structure of education is changing. In South Africa, families having the means to do so are switching their children to home schooling, exacerbating the divide that exists between rich and poor; at the other end of the scale, open courses are now offered globally, with tens of thousands of learners all registered at the same time, and at little or no cost. Somewhere in the middle, school learners and undergraduate students (and legions of others) consider that they gain more from what they find on YouTube than they do from lectures and classes.

Hence, it was agreed that the choices available to learners are changing and expanding the stakeholder groups who are involved – it is the perceived value of different education options that will increasingly determine the choices that are made. It is also about delivering timely value. Education is a key stage in the overall chain of value that develops and delivers new knowledge – with information technology and systems, research can be more immediate, publication can be instantaneous, and learning can be driven more by learners than by teachers.

Good management has to deal with complexity

Connectivity is a primary factor driving change and complexity: younger people are now constantly connected to the internet and the World Wide Web. Timescales, time horizons and information boundaries are all being redefined. Hence, the extent and depth of the detail that has to be managed are both extending. Problems relating to information technology in education include added complexity and the challenge of managing the change that is disrupting education. Teachers are no longer the sole and necessary source of knowledge, rather they have become the managers of processes that bring extensive education resources closer to the learner, enabling access to a vast range of sources of knowledge. Researchers are no longer content to wait for years to see their work published, they want to share it immediately.

This brings us back to differences: complexity derives from the differences in teachers, learners and contexts, so that one size will not fit all. Learning might be becoming fragmented but technology can join it up, if we are smart. Truly strategic management is needed to deal with this complexity.

Change can be managed, but with difficulty

Change can be achieved progressively by recognising that early benefits are often concerned with efficiency (taking a minimalist approach to change), whereas later benefits are likely to be concerned with the more challenging issue of effectiveness, demanding a much more committed approach by senior management. At the heart of change is the finer and finer "granularity" of education: technology changes quickly, attention spans are reduced, periods of learning are compacted, sources are more numerous, more diverse and compact. Hence the drivers for change actually include the technology suppliers (who constantly offer new technologies) as well as the learners (whose expectations of learning seem to differ from teachers' expectations of teaching).

It was noted that when faced with change, people often give up too easily: this is true of both teachers and learners. There are signs that some educators are leaving the profession because they cannot face the changes that are at hand. Learners adopting the new online mode of learning are found to be much more likely to drop out than those in traditional modes of learning. The management challenge is not just about the complexities of technology, it is about the moods and attitudes of the people who are involved.

Summary

In this way, the meeting of experts provided direction for the three years of research that followed. There was an extended bibliographic study that confirmed the lack of prior research into information management in education, and a set of objectives were established for a reference model that would establish a better foundation for understanding and management action. It was decided that an effective reference model would:

- allow review and assessment of the general potential of information technology and systems in education;

- identify specific areas in education where information technology and systems may have useful application;
- enable a portfolio view of present and future opportunities; and
- provide a means to organise empirical data about the execution of education.

This paper now summarises the results of the bibliographic analysis and presents the reference model. The model is then assessed against the agreed objectives above. Finally, a view is provided of the actions that education managers can take, based on the outcome of the study[2].

Bibliography

Scope

The review of published literature initially discovered more than 700 candidate articles, of which 639 were inspected and categorised according to their content (relating to management, education and technology), their origin (by journal title and by country), and their potential relevance to the project. Of these, 163 papers were considered to have a useful combination of the domains of interest and were read, annotated and evaluated. It became clear that while there was a significant body of literature that touched on the separate themes of management, education and technology, and that might contribute to our understanding, it all needed "joining together", reinforcing the idea that a reference model is needed.

Summary of the bibliographic findings

Although there was only limited work that embraced each of the three themes at the same time, there were messages that emerged:

- Things are indeed changing: there is considerable evidence that in South Africa (and elsewhere) the ability of many education institutions to accommodate and successfully manage change (at all levels) is very limited.
- The statistics: surveys confirm poor overall educational performance in South Africa, but some of the good stories from individuals are indicative of what can be done. The importance of the "champion" in achieving success is very clear.
- There is diversity: differing capability, experience and outcomes in South Africa make clear the need to deal with the differences that are to be found in technologies, and in teachers, learners, communities and contexts. "One size" does not fit all.
- Maturity is a major issue: there is clearly a life cycle of institutional learning (about managing information in education) that reveals the different required management competencies and capabilities, over time.
- Perceptions are just as important as reality: qualitative research examines people's perceptions whereas quantitative statistical research just measures variables. Managing expectations and perceptions is more important than managing actuality.
- Stakeholder issues are significant: techniques for analysing the needs and expectations of stakeholders are well established in the general management discipline. Whilst the word "stakeholder" is often used in the education literature, there is little evidence of an adequate response by researchers and education managers to the importance of stakeholder analysis.

- This is about more than just teaching and learning: managing information technology and systems in education demands attention to issues of culture, a recognition of the importance of people, and attention to the sociology and socio-economic conditions that prevail.
- The business of education is complex: superimpose the management of information technology and systems on the many other complexities at hand and we have a serious challenge to deal with. Managing complexity may be one of the critical competencies that we need to make the best of our opportunities.
- Information technology and systems can impose high levels of change: depending on a focus on simple efficiency, or higher levels of educational effectiveness (not the same thing as efficiency), the degree of change involved varies and education management needs to respond accordingly.
- A present example is "learning analytics": shall we measure how quickly learners type their work? Monitor how long they have been working on a document? Analyse all the searches that they did on the internet? Build graphs of who they talk to, and for how long? As we move forward, we will be increasingly tempted to measure everything, at ever-increasing levels of detail.

Discussion

Out of this research, the issue of managing differences became pre-eminent because it embodies the need to deal with different contexts, capabilities, competencies and attitudes, and it cautions us not to over-simplify a complex situation. Existing research into the management of technology in South African education – such as it is – needs to be tempered and located properly in a complex space, that accommodates education at different levels (primary, secondary, tertiary and elsewhere), in different places (e.g. rural and urban), with different cultures (wealthy and poor), and with different objectives (efficiency, effectiveness or evolutionary – each quite different to the others). It is a traditional problem with information technology and systems that the "user space" is often seen far too simplistically, with inadequate attention to the subtle differences that implementation of new systems. One way of dealing with this is to implementation of new systems. One way of dealing with this is to invoke existing stakeholder analysis and stakeholder management techniques that are well established elsewhere.

This study was based in South Africa but almost certainly brings useful messages to other regions. It is clear that education is already an international business, that technology is extending and consolidating the internationalisation of education, and if one region cannot match the efforts and achievements of others (against which they will be continuously benchmarked) then its future educational prospects are bleak. The differences in the capability of undergraduates coming from different regions reveal the importance of working to international benchmarks. Understanding the potential for an educational system in a competitive international context, and understanding all stakeholders' needs and expectations, will be considerably assisted by the availability of an effective reference model.

The reference model

The idea of a "reference model" to help manage complex situations has quite a long history that we do not need to be concerned with here, but the idea has become associated in modern times with the rise of systems and systems thinking, and it contributes to dealing with complexity.

People in management roles generally deal with complexity by means of "abstraction". They take a simplified but well-organised view of a complex domain in order to render it understandable, manageable and tractable. This idea, which in its simplest form can be referred to as "reductionism", can of course be traced back to the work of French philosopher Descartes in the seventeenth century, but more recently it has become a feature of ontological thinking; this way of thinking considers that any reality that we wish to understand can be seen as (or is actually composed of) a set of entities that are related. All we have to do, it might be said, is to find candidate entities, understand their relationships, evaluate their importance and agree to incorporate them into a final model. The adoption of an entity-relationship modelling discipline is of course appropriate in any study of information, and it renders the model suitable for data designs that can accommodate either research data (collected in future studies of how education is working) or operational data (if an institution wishes to incorporate the utility and performance of its education systems in its business intelligence reporting). The full reference model, as it emerged after a considerable period of reflection, discussion and debate, is shown with some explanatory notes on the following pages (Figure 1).

Reference model walkthrough

The reference model reveals how different elements in the overall education "system" are enabled by, or dependent on, other elements. If there is no technology, then there can be no systems; if there are no systems, there is no improvement to teaching and learning, and so on.

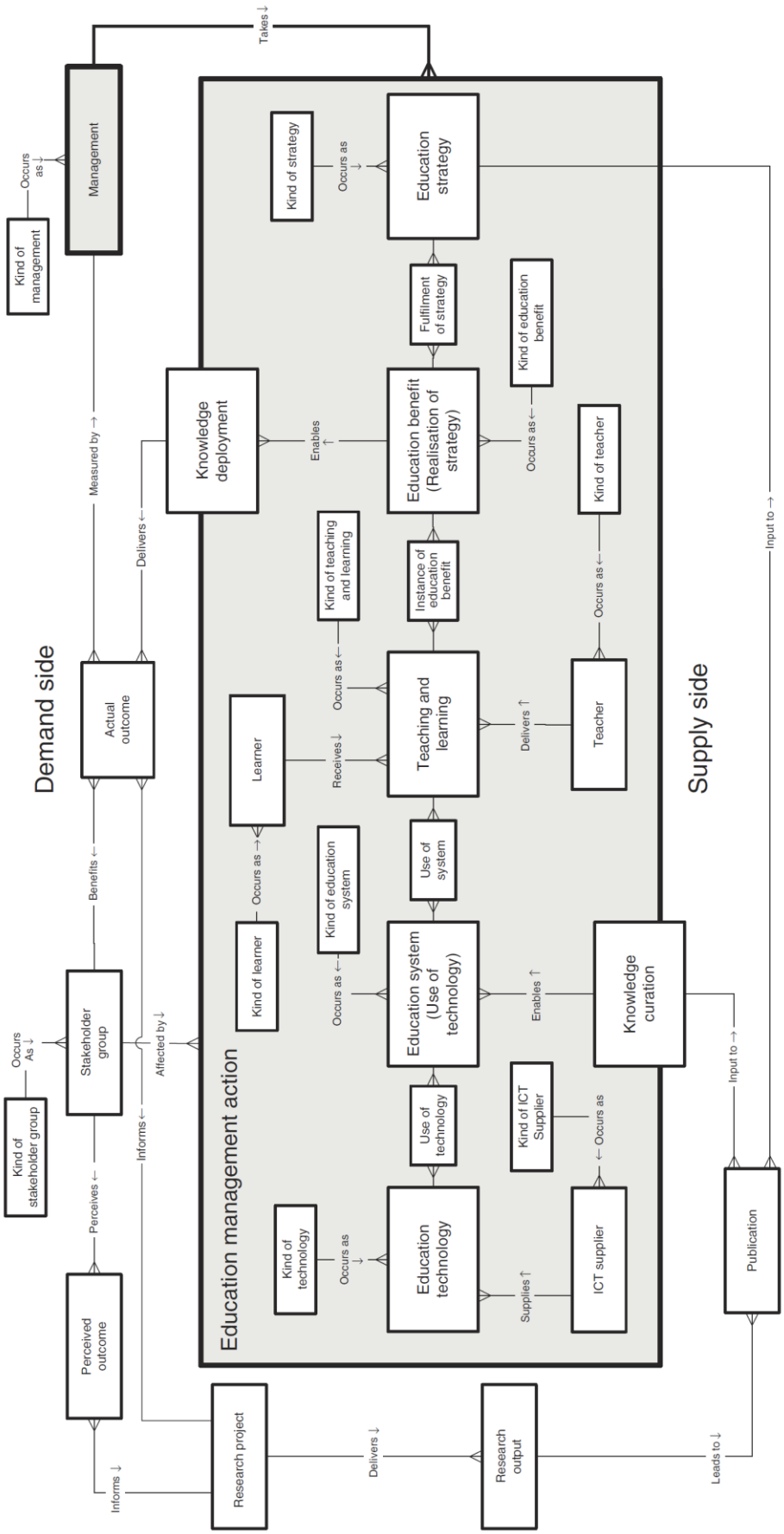
The following "walkthrough" provides a narrative that further elucidates the model:

1. The model introduces the idea that there is management, and there is management action. Management action embodies most of what we are interested in here.
2. Fundamental to education is the idea that there is knowledge that must be imparted so as to capacitate learners to progress academically and, ultimately, to make a useful contribution to the needs of society, business and government. The model shows knowledge deployment and knowledge curation in order to make this clear. The choice of the word "curation" is tentative at this stage, but it is a word that has grown in common use recently and its meaning is conveniently "open", so as to embrace all forms of gathering, growing, organising and making information available for education.
3. There is a "demand" side and a "supply" side but generally the servicing of demand by means of supply works from the left to the right.
4. There are two views of this model: from the supply side it really all begins with education technology and ends (somewhat distantly) with education strategy; for the demand side it all begins with education strategy and ends (again, somewhat distantly) with education technology. In this way we can begin to see how the perceptions of education management

can be reconciled with the perceptions of technology enthusiasts. And we can reveal some of the complexity in a way that renders it manageable.

5. Education technology and education strategy have three important entities between them, so that all five taken together comprise a "chain of value", showing how an investment in technology might be judged to be useful in meeting strategic needs:
    - Education technology (... is used in an ...);
    - Education system (... that supports ...);
    - Teaching and learning (... that delivers ...);
    - Education benefit (... that fulfils ...); and
    - Education strategy (... that hopefully meets a national or regional purpose).

    We started with education system, teaching and learning, and education strategy; the introduction of education system and education benefit are critical moves to deal with many-to-many relationships, and to reveal two fundamentally important features of a complete management regime without an understanding of the systems we are using, and the benefits we are seeking, there will be no possibility of a complete and coherent view with which (or from which) to manage effectively:
6. Then, multiplicity at each of the four junctions of these five important entities is resolved with four associative entities, as explained above. These are the four points where performance data might be captured (or perceptions elicited) in order to inform decisions about information technology and information systems investments, and to evaluate the outcome of an investment of time, money and effort at each stage.
7. Teachers and learners are central to the model, but other important role players include ICT suppliers and other stakeholders; further development of the model could incorporate and show other specific stakeholder groups, but at this stage only ICT suppliers are shown.
8. In order to deal with the issue of differences (in teachers, and learners and contexts) it is necessary to introduce five typologies:
    - Kind of management;
    - Kind of technology;
    - Kind of teacher;
    - Kind of learner; and
    - Kind of strategy.
9. Finally, it would not be a complete model about education if research and publication were not included. By understanding the real-world outcome of education, through careful research (whether "academic research" or simply "policy reviews"), and by promulgation of the outputs of research projects through publication, it is possible to extend our collective knowledge and maintain an active and progressive curation of knowledge for the benefit of education. This the virtuous circle that augments and improves education, and delivers ever-improving outcomes for the benefit of all.



Benefits of the reference model

According to the model, management actions are concerned with the five stages in managing the value of information technologies in education. Taken together management actions involve ...

- understanding and acquiring the technologies ...
- that are needed for the education systems ...
- that will make appropriate contributions to the processes of teaching and learning ...
- that will deliver education benefits ...
- that serve the aims and objectives of education strategy.

But the overall dependencies are complex and the model shows how specific instances of the use of technology and the use of systems deliver specific benefits that make specific contributions to the fulfilment of strategy.

The positioning of the teacher and learner, adjacent to teaching and learning, requires that their use of technology and their contribution to strategy are seen only through the systems that they use and the benefits that they enjoy. Equally, the positioning of knowledge curation and knowledge deployment reminds us that the flow of knowledge into and out of the education system is what moves everything (and everyone) forwards.

Outside the domain of management actions we have stakeholders, with ICT suppliers, the "real world" and researchers highlighted, but no restrictions on other stakeholder groups that could be incorporated. The model shows how we can begin to get a grip on the differences identified early in the project that were the first signs of the complexities that managers must deal with; these differences are to be found in the different kinds of teachers, learners, technologies, strategies, managers and stakeholders – all of which have typologies appended. Other typologies (such as for suppliers, and systems, and benefits) can easily be added if needed because of particular management or research needs.

The model gives substance to the idea that there is a virtuous circle of educational activity, whereby research can examine the results of education and the needs of the real world, and publish the kind of knowledge-based learning resources that education needs.

Finally, and perhaps most importantly (because we are concerned with managing change), the model provides a framework for measuring the before-and-after condition of an education institution that tracks the consequences of management actions. If operational data are continually accumulated that relate to the main features of the model, then the differences between one point in time and another can easily be established.

Assessment of the reference model against requirements

The reference model was developed with six objectives, that are now reviewed in the notes that follow:

- To allow review and assessment of the general potential of Information technology and systems in education.

It is generally accepted that there is much potential to be gained from information technology and systems investments. The nature of education is changing dramatically as technology evolves, and things will continue to change. However, the human factor is of primary importance because there is considerable evidence of difficulty, disappointment and a loss of confidence that limits the potential if it is not dealt with. This derives from the depth and extent of the changes that we face (when seen on a global scale) but also the inability of different stakeholders to effectively communicate and discuss the merits and demerits of new systems ideas. Hence, the need to manage education strategically is paramount. The study found endless passing references to "strategic" issues but little recognition that true strategic management is needed to deal with them.

The potential of Information technology and systems in education is limited by a failure to connect the enablements and dependencies, as revealed in the model. The model establishes a set of ideas and relationships that can inform more useful and effective discussion of the issues, because it "joins the dots".

- To identify specific areas in education where information technology and systems may have useful application.

The bibliographic analysis revealed much research that has been finely focussed – on one institution, or one subject, or one technology, for example – making it difficult to take a holistic view of usefulness based on existing work. The occasional evidence that information technology and systems in education sometimes make no real difference, is worrying.

The model now allows the organisation of information about the application of information technology and systems at different levels. The technologies, the systems that render them usable, and the teaching and learning that needs those systems can all be organised according to the model, and the differences within each can be logged and analysed. However, it was not the intention of this study to catalogue all technologies, systems and teaching and learning activities. The reference model provides the means to identify areas where there might be useful application, and then track the dependencies (on technology and systems) and the enablement (of strategic objectives). It is independent of the shifting sands of technology and education over time, rather it provides a framework with which to measure, tabulate and analyse the performance of education over time.

The key here is the idea of "utility". Any collection of technologies and systems can be catalogued using the model, and related to the educational activity that uses it and benefits from that use. The logic of the model allows for a complete "cost-benefit" analysis that relates the investment costs (of technology and systems) to the strategic aims and objectives of the institution.

- Enable a portfolio view of present and future opportunities.

All that is needed to establish a portfolio of education systems and practices (and their benefits and outcomes) is provided in the model. It immediately provides a coherent framework within which an institution can catalogue their technology, systems, practices, intended benefits and strategies; it allows for the identification of key partners and their expectations, as stakeholders. At the same time it has flexibility: more detail can be added, perhaps some detail could be discarded, and the words and phrases that are used can be amended to suit a particular situation because particular situations vary. For example, university departments and faculties do not share the same pressures and imperatives; undergraduate and postgraduate work differs in the detail and approach to administration.

The portfolio approach accommodates such differences, and the reference model allows consolidation of differences at the level of the infrastructure (on the one hand) and the institutional strategy (on the other) using the critical associative entities.

- Provide a means to organise empirical data about the execution of education.

As noted earlier (in introducing the reference model) the adoption of entity-relationship modelling is appropriate to any study that aims to understand how to manage information. Whilst it is a high-level model, the reference model establishes an organised way to collect, store and analyse two kinds of data: research data emanating from future research work, and operational data gathered by institutions that wish to understand and improve their performance.

Experience makes clear that the most useful data, that gives management the information about what is really going on, is the transactional data that is to be found in the associative entities.

In the case of this new reference model, that means "Use of technology", "Use of system", "Instance of education benefit" and "Fulfilment of strategy". And these are only within the domain of "Education Management action" – outside that we have "Actual outcome", "Perceived outcome", and "Publication". These are the hot spots that inform an understanding of who is doing what, with what outcome.

Conclusion

This has been a successful study to the extent that a considerable volume of literature was found, read and analysed, confirming that there is little existing research that specifically deals with managing information in education. Analysis of the available literature and reflection on the way that education works led to the development of a reference model that offers clarity where confusion often reigns.

The study vindicates the view that information management in education can be improved. The following advice is offered to those in education who are dependent on good information management:

1. Managing information in education is a necessarily complex domain that is changing as a result of information technology and information systems opportunities; nevertheless, this complexity can be managed, by understanding the chain of value that links technology investments to educational benefits.
2. The logic that justifies an investment (in information technology and information systems) by connecting it with the intended benefits must be understood. This logic is found in the chain of value, and the achievement of real value can fail at four critical points:

- where technologies must effectively enable systems;
- where systems must actually contribute to teaching and learning practice (or to any other activity that is identified for improvement);
- where those practices must be seen to improve; and
- where those improvements must contribute meaningfully to strategic objectives.

3. The impacts of information technology and information systems opportunities reveal important differences in the perceptions and attitudes of teachers, learners, administrators and others, about the technologies, the systems, the practice of education and the benefits that are sought; these differences can be identified and managed, by means of stakeholder analysis.

Of course, the unfortunate corollary is that if an institution has no strategy then all of this advice will fail. Given the differences that are evident, in the people and in the technologies and systems, it is absolutely necessary to establish a degree of proper strategic management in order that the dots can be joined. In speaking to audiences about these things, your author has sometimes joked that if an institution decides that its strategy will be anarchistic, then all that is needed to succeed is for everyone to practice anarchy. Being more constructive than this requires that strategies are formulated at appropriate levels. At the institutional level a strategy might be quite simple, and be directed at enabling academic endeavours of different kinds in different departments, schools or faculties; then, at the level of a particular department, school or faculty, a much more specific strategy might set out to improve teaching, or to expand research, or to raise the professional competencies of the academic staff. It all depends on the context, of course. At the level of research, strategies might be more liberal again, but geared to relating research funding to published outputs.

Portfolio management provides the means to acknowledge and deal with those differences with appropriate management actions. This is not the place to expand on this idea, this paper is solely directed at establishing a "view", but by understanding the differences between present and future potential (for information technology and systems), and the differences between systems with long or short reach (within or without the institution), it is possible to devise management styles and approaches that recognise and respond appropriately. Critical operational systems that an institution depends on for its reputation, and the more diverse innovative systems that might, or might not, become important in the future, demand radically different management styles, funding arrangements, and resourcing. All of this can be seen more clearly when technology,

systems, educational practices and intended benefits are all catalogued, and fitted to the available strategies, using the reference model. Further work is already in hand, based on a more detailed study of the four tertiary institutions of the Western Cape in South Africa, that will be reported in due course.

Notes

1. "A reference model in systems, enterprise, and software engineering is an abstract framework or domain-specific ontology consisting of an interlinked set of clearly defined concepts produced by an expert or body of experts in order to encourage clear communication. A reference model can represent the component parts of any consistent idea, from business functions to system components, as long as it represents a complete set. This frame of reference can then be used to communicate ideas clearly among members of the same community. Reference models are often illustrated as a set of concepts with some indication of the relationships between the concepts" (Wikipedia).
2. Further details of the project (including a very detailed review and analysis of the bibliography t of the reference model) are available in the final project report, downloadable from the project website: (http://saicted.wikispaces.com).

Appendix 1

Table AI that follows lists some of the articles that elucidate the key components of the model. The papers referenced here are detailed in the short Bibliography that follows. The full bibliography and bibliographic analysis is available from the project website: (http://saicted.wikispaces.com).

Component	Sources
Stakeholder There are many references to "stakeholder", and occasional identification of stakeholder types, but much more work needs to be done here. The word seems to be used quite loosely without serious attention to the actual stakeholder groups that are under consideration	Downes (1999, p. 336), Hardman and Paucar-Caceres (2010, p. 180), Lemmer (2012, p. 94), Tubin *et al.* (2003, p. 134), Xaba (2011, p. 9)
Management Almost no work is found dealing with the management of educational technology at the institutional level. It seems to be taken for granted except in limited cases, for example, in the case of school governing bodies (where Xaba goes into good detail and Bialobrzeska and Cohen, who have written a complete guide for school principals)	Bialobrzeska and Cohen (2005, p. 97), Banker *et al.* (2011, p. 501), Bytheway *et al.* (2012, p. 116), Czerniewicz and Brown (2009, p. 130), Gudmundsdottir (2010, p. 182), Hardman and Paucar-Caceres (2010, p. 180), Parker (2010, p. 259), Stoltenkamp and Kasuto (2009, pp. 46-49), Vanderlinde *et al.* (2012, p. 517), Xaba (2011, p. 9)
ICT supplier There are many reference to 'resources' but virtually none to 'sources', and few to specific kinds of supply, for example, donor equipment, provincial government initiatives. Cook and Light touch on the 'internet of things' (IoT, about which we will no doubt hear a great deal more, quite soon)	Cook and Light (2006, p. 59), Duffy (2007, p. 182)
Education technology Many very specific references to specific technologies, for example, interactive whiteboards. Very little reference to web services (such as Google, Dropbox and tablets)	Bytheway *et al.* (2012, p. 116), Czerniewicz (2004, p. 150), Czerniewicz *et al.* (2006, p. 8), Ferreira (2010, p. 25), Gachago *et al.* (2013, p. 12), Gülbahar (2007, p. 956), Keats (2009, p. 50), Parker (2010, p. 255), Singh (2008, p. 1063), Slay *et al.* (2008, p. 1330), Straub (2009, p. 645), Wasko *et al.* (2011, 652), Watson (2006, p. 214), Wong and Li (2008, p. 114)
Education system Very little is found that is explicitly about the information systems that actually work to support teaching and learning (and administrative) activities	Parker (2010, p. 259), Wong and Li (2008, p. 115)
Teaching and learning There are copious references to teaching and learning	Balanskat *et al.* (2006, p. 3), Bialobrzeska and Cohen (2005, p. 96), Chigona *et al.* (2010, p. 30), Churchill (2006, p. 495), Cook and Light (2006, p. 59), Czerniewicz and Brown (2009, p. 130), Frantz *et al.* (2011, p. 17), Gachago *et al.* (2013, p. 12), Gudmundsdottir (2010, p. 176), Hart (2007, p. 44), Howie and Blignaut (2009, p. 361), Lim and Chai (2008, p. 808), Ogbonnaya (2010, p. 10), Ortega and Bravo (2002, p. 2), Rossouw (2009, p. 13), Singh (2008, p. 1063), Slay *et al.* (2008, p. 1328), Stoltenkamp and Kasuto (2009, p. 53), Vanderlinde *et al.* (2012, p. 508), Wolhuter *et al.* (2012, p. 178), Wong and Li (2008, p. 115)

(*continued*)

Component	Sources
Education benefit There are limited and often oblique references to the benefits and advantages of technology and systems in education	McClea and Yen (2005, p. 93), Ogbonnaya (2010, p. 10), Slay *et al.* (2008, p. 1330), Wong and Li (2008, p. 114)
Education strategy Extensive detail alluding to strategy but surprisingly little attention to the real strategic issues: how strategy should be formulated, and the challenges of implementation	Stoltenkamp and Kasuto (2009, pp. 46-49), Wong and Li (2008, p. 115)
Learner Copious references to learners, as would be expected	Bialobrzeska and Cohen (2005, p. 97), Davidson and Desjardins (2011, p. 61), Duffy (2007, p. 182), Frantz *et al.* (2011, p. 17), Gachago *et al.* (2013, p. 12), Gudmundsdottir (2010, p. 176), Hart (2007, p. 44), Howie and Blignaut (2009, p. 361), Lemmer (2012, p. 94), Rossouw (2009, p. 13), Tubin *et al.* (2003, p. 134)
Teacher Copious references to teachers, as would be expected	Chigona *et al.* (2010, p. 30), Churchill (2006, p. 495), Cox and Marshall (2007, p. 68), Davidson and Desjardins (2011, p. 61), Gudmundsdottir (2010, p. 182), Gülbahar (2007, p. 956), Lemmer (2012, p. 94), Ogbonnaya (2010, p. 10), Slay *et al.* (2008, p. 1328), Slay *et al.* (2008, p. 1330), Straub (2009, p. 645), Straub (2009, p. 645), Tubin *et al.* (2003, p. 134), Vanderlinde *et al.* (2012, p. 517), Wedman and Diggs (2001, p. 429), Wolhuter *et al.* (2012, p. 178), Wong and Li (2008, p. 115)
Real-world benefit It is difficult to find examples of research that has looked at the longer term benefits to society (and industry, and government, and communities) that might derive from information technology and information systems	Keats (2009, p. 50)
Knowledge deployment Adequate appreciation of the fact that this has a great deal to do with knowledge management, but [...]	Boyle *et al.* (2012, p. 312), Churchill (2006, p. 495), Duffy (2007, p. 182), Lemmer (2012, p. 94), McClea and Yen (2005, p. 93), Singh (2008, p. 1063), Wedman and Diggs (2001, p. 429), Wong and Li (2008, p. 115)
Knowledge curation [...] very little about the educational processes that originate new knowledge. Plenty of urging for more research to be done, none on the contribution of technology to research itself, as another educational process	Balanskat *et al.* (2006, p. 3) , Cox and Marshall (2007, p. 68), Czerniewicz *et al.* (2006, p. 8), Downes (1999, p. 336), Ferreira (2010, p. 25), Frantz *et al.* (2011, p. 17), Gachago *et al.* (2013, p. 12), Gudmundsdottir (2010, p. 176), Hart (2007, p. 44), Mutula (2009, p. 10), Roman and Colle (2003, p. 88), Wasko *et al.* (2011, p. 652), Wolhuter (2011, p. 612)

Appendix 2. Bibliography

The following 47 papers are listed in Appendix 1 as specific evidence of the origins of the new reference model; these are just a selection of the total of 163 papers that were deemed to have relevance to the project, being concerned with education, management or information technology in some combination or another, that were also fully reviewed. The full bibliography, and a full record of the bibliographic analysis and the development of the reference model, is available at the project website: (http://saicted. wikispaces.com).

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