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Alignment of perceptions about the uses of ICT in Australian and New Zealand schools

A report for The Le@rning Federation of a survey of teachers, principals, other school leaders and sector personnel

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Executive summary

The *aims* of this study were to continue the survey-based evaluation of online curriculum materials produced by The Le@rning Federation; and to examine the nature and extent of the alignment of the perceptions of four sets of respondents who work in different positions in Australia's educational sectors (government, Catholic, independent) concerning the uses and benefits of information and communication technologies (ICT) in classrooms and the factors that encourage its classroom use.

Background research

A brief *review of the research literature* indicates growing evidence that certain classroom uses of ICT increase students' motivation to learn, engagement in learning and their independence in learning. The benefits of classroom use of ICT identified in the literature are increased levels of students' collaboration in learning, their higher levels of engagement and persistence in learning, and more on-task behaviour.

With a few exceptions, the research indicates that ICT use in classrooms is also associated with better realisation of goals that are important for learning and work in the 21st century in that the growth of Web 2.0 is associated with an increasing interest in user-created content, and a capitalising on this for education and training purposes.

Personalised learning, which has become the main strategic framework for integrating ICT into education in a number of countries, together with an increase in the frequency of one:one computing, makes access to high-quality content for all students in all schools a priority.

Finally, in studying schools' adoption of ICT and its integration and sustained use in teaching and learning, the literature indicates that quality of leadership at the school level (in particular, principals) is important in both vision-setting and managerial aspects.

The survey

The survey instrument was based partly on the findings from international research and partly from previously conducted surveys of schools' use of TLF materials. The four sets of participants who were asked to respond to the survey were teachers,

school leaders (such as departmental heads), school principals, and 'sector personnel' (consultants and policy developers in regional and head offices).

Survey findings

1 Teachers vary considerably in their reported rates of familiarity and professional development experiences with TLF materials, and report low levels of professional development, although higher than reported in earlier surveys.
2 A large proportion of teachers have used only a small number of learning objects and have done so only infrequently, although use has increased since the earlier surveys of use of TLF materials.
3 While most TLF materials published to date have been developed for use at years K to 10, a substantial number of teachers use TLF materials in years 11 and 12, suggesting a wider applicability of these materials across year levels. It is evident, however, that heaviest use of the materials occurs in years 3 to 7.
4 The curriculum areas with the highest use of TLF materials are mathematics, English/literacy and science. Studies of Society and the Environment and cross-curricular integrated studies now have higher reported rates of use than those reported in earlier studies.
5 Teachers who use TLF materials continue to report very favourably on their value for students' learning and engagement.
6 Most school leaders (such as departmental heads) indicate some regular use of TLF materials by teachers in their schools, while principals report relatively high levels of overall use by teachers. Both principals and school leaders see an increasing awareness and use of TLF materials by teachers in their schools.
7 Sector personnel estimate that schools have high levels of familiarity and involvement with the goals of TLF and a positive response to the quality of TLF materials, estimates that are higher than those made by the other three groups of respondents.
8 With regard to the levels of classroom use of TLF materials, the benefits, and to the factors that encourage its use, the four groups of respondents (teachers, school leaders, principals and sector personnel) report strikingly similar *relative* ratings. Misalignments, summarised 9 to 12 below, tend to reflect the extent of endorsement of particular options.

9 The four groups of educators sampled are not well aligned on the estimated frequency of various purposes to which ICT are put in classrooms.

10 With respect to the reported benefits of using ICT in mainstream classrooms, particularly the benefits for learning and curriculum access and for communication purposes, there are substantial differences among the four groups, with teachers showing the least enthusiasm and sector personnel the most.

11 Regarding the benefits of using ICT in non-mainstream classrooms, again the ratings from teachers are the lowest of the four groups and sector personnel the highest.

12 The estimated benefits nominated by the four groups of respondents for mainstream versus non-mainstream classrooms, indicate that the respondents have relatively finely tuned judgements, accurate or otherwise, about the benefits of ICT in classrooms for diverse groups of learners.

13 In estimating the importance of a range of factors that enable teachers to adopt new digital/online technologies in their teaching, teachers place less emphasis on those related to ease of use and support in ICT than do school leaders and sector personnel. Teachers also view pressure from outside sources for them to use ICT to be of less importance than do sector personnel. Policies and syllabuses for ICT are seen as a stronger influencing factor by teachers than by principals and sector personnel.

Conclusions

The report concludes with a discussion of prospects for enhancing implementation and of the need for research and professional development. In drawing on the findings of the survey, the following conclusions seem warranted.

1 The integration of TLF content into classroom practices needs to be further improved, both quantitatively (frequency of use) as well as qualitatively (in the purposes for which the learning objects are used). The use rate and use quality is hampered by the fact that ICT adoption is, in general, still at a low level.

2 Since the respondents at all levels of the educational system have, by and large, a similar, and positive, view of the role and benefits of ICT in general, and of TLF content in particular, the adoption of ICT in general and TLF content in particular is probably more influenced by organisational and practice-related factors than by

general technophobia, lack of motivation or lack of alignment with curriculum and pedagogy.

3 The focus on technical skills in teachers' professional development yields diminishing returns. Since teachers are not only users, but also frequently the adopters and, in some instances, even (co-)designers of learning and classroom technologies, professional development needs to prepare them for these more extended roles. Further, because teachers' decisions need to take into account evidence of students' ways of engaging with subject matter and technology as well as learning outcomes, they need to be better prepared to use ICT for formative and diagnostic assessment.

4 In the study of the processes of innovation in the classroom, educational researchers would benefit from the use of designs and methods that can trace teachers' and students' practices over stretches of time (weeks and months), in contrast to use of simple outcome measures administered at one or two points in time. Innovation processes rarely follow a linear path, and the non-linear effects of ICT innovations are substantially mediated by users. Design-based research has proved to be a viable way of tracing innovative processes these functions in a rigorous yet adaptable way.

Introduction

Aims of the study

The study has two main aims:

- To continue the survey-based evaluation of online curriculum materials produced by The Le@rning Federation
- To examine the nature and extent of the alignment of the perceptions of four sets of respondents who work in different positions in Australia's educational sectors (government, Catholic, independent) concerning the uses and benefits of information and communication technologies (ICT) in classrooms and the factors that encourage its classroom use.

The report builds on a sequence of earlier studies that have evaluated the perceived and demonstrable efficacy of the online curriculum materials produced by The Le@rning Federation, an initiative instigated by the Australian Government's Ministerial Council on Education, Employment, Training and Youth Affairs. The findings of those earlier reports (see Freebody 2005; Freebody & Muspratt 2007b; Freebody, Muspratt & McRae 2007a, 2007b) were based on data from surveys, site visits, interviews and field experiments. Those findings have informed the content of the survey instruments used in the study reported here.

The earlier studies reported rates of adoption and of use of online curriculum materials in general and of The Le@rning Federation's materials in particular. In continuing the evaluation of The Le@rning Federation's online digital curriculum materials, this study is aimed at exploring the bases for the adoption of information and communication technologies (ICT) in schools, and the views of members of multiple strata within education sectors on the factors involved in such adoption and resistance to adoption. More specifically, the survey was aimed at documenting the views of four groups of educators – teachers, school leaders (such as departmental heads), principals and sector personnel (consultants and policy developers in regional and head offices) – on these main questions:

- To what uses are ICT currently put in classrooms?

- What are the benefits of using ICT, compared to standard classroom approaches for (a) mainstream and (b) non-mainstream students?
- What factors enable or obstruct the adoption of ICT in classrooms?

Informed by a systems view of educational innovation, the participants' responses are analysed and compared, using a framework in which attention is given to a nuanced understanding of the alignment, among the four sets of respondents, of perceptions, values, practices and policies; and to documenting their understandings – implicit and explicit theorisations – of the formation and implementation of ICT-related policy, based on the view that, at different points in the process of adoption and use of ICT in the classroom, alignment of sector policy and classroom practice will vary across a diverse education sector. Points of balance and imbalance in the alignment need to be assessed regularly to regulate the productive tension between creativity and the manageability of practice across highly diverse systems, and to ensure that systems do not become static through over-alignment, or dysfunctionally diverse through under-alignment.

The Le@rning Federation

Purposes

The Le@rning Federation (TLF) was established in 2001 by the Australian Ministerial Council on Education, Employment, Training and Youth Affairs (MCEETYA). It has been charged with developing:

- a bank of online materials in six priority curriculum areas:
  - Innovation, enterprise and creativity (years 1–10)
  - Languages other than English (specifically Chinese, Japanese and Indonesian across all school year levels)
  - Literacy for students at risk of not achieving national literacy benchmarks (years 5–9)
  - Mathematics and numeracy (years 1–10)
  - Science (years 1–6 and 9–10)
  - Studies of Australia (years 1–10)
- high-quality digital learning items that are online curriculum resources for all Australian and New Zealand schools

- a workable framework, standards and structures for the sharing of online curriculum content among jurisdictions within Australia, New Zealand and other countries
- an interoperability framework to assist sharing and peer-reviewing of teacher-initiated online resources
- productive relationships with ICT-related vendors to support distribution and use of online curriculum content in schools
- support in school sectors for a local education digital content industry.

To support the goals of MCEETYA, during 2006–2008 The Le@rning Federation intends to develop a further 4,000 items of high-quality, globally recognised online content that is related to the Australian Statements of Learning and other MCEETYA priorities, for all Australian and New Zealand schools.

The learning objects component

TLF defines 'learning objects' as files or modules of learning material that:

- engage teachers and learners in interactive learning activities;
- may include texts, and/or graphic, audio or animated materials;
- are usable in many different educational settings for multiple purposes;
- are usable in educational settings as elements within larger units of work that may comprise other digital and non-digital materials; and
- are accessible from digital repositories as referenced, located, and accessed by metadata descriptors.

Rather than providing specifications or guidelines for the educational use of its learning objects, TLF's approach has been based on these principles (Atkins & Jones 2004, pp 2–7):

- The learning object component of the initiative is to have a strong focus on learners, addressing the needs of all students in an inclusive way.
- The content of the learning objects is to have integrity in terms of the particular knowledge domain from which it is drawn, ensuring its accuracy, authenticity and purposefulness.
- The materials are to be readily usable, with accessible interactive design features in meaningful sequences.

- The learning objects are to be accessible to categories of students generally regarded as educationally disadvantaged.

The learning and curriculum framework that has guided the development of TLF's learning objects is based on:

- problem-based learning
- inquiry-based and investigative learning
- authentic, situated contexts for learning
- constructive and tailored feedback.

Elaborations and illustrations of the principles and framework outlined above are provided on TLF's website. At the time of writing (August 2008) TLF had developed more than 5000 learning objects for use in schools. Prior to release, each new learning object has undergone field trials in classrooms and revisions in the light of feedback from teachers and researchers.

Digital resources component

A second component of the TLF initiative is development of a bank of digital resources that is accessible, through searchable repositories, to all schools in Australia and New Zealand. The use of these digital resources within curriculum programs, schemes of work or individual lesson activities is different from the use of learning objects. TLF's digital resources rely on teachers' and/or students' contextualising the material by establishing its purpose and meaning within the conduct of the lesson or unit of work. Compared with the learning object component of the TLF initiative, the digital resources component has received less attention and, in general, less publicity in schools and school systems.

Research background

Trends concerning ICT in schools

What is known about the impact of ICT on students?

While content is a necessary element of any educational ICT strategy, it is not sufficient for bringing about students' engagement and attainment. Many other elements need to be in place, such as access to the content, teachers' awareness of how to integrate it into teaching practices, and its integration into a whole-school e-strategy. All of them entail some measure of alignment with school leaders' visions and management practices.

A recent landscape review (Condie & Munro 2007), which incorporates information from over 350 individual studies, has identified positive impacts of ICT use on attainment '… in some contexts, with some pupils, in some disciplines …' (p 4). The link between general and specific ICT measures and learning outcomes is still not well established; indeed, inherent methodological problems may mean that such a link cannot be unequivocally established. For instance, since students' ICT use is mediated substantially by teachers, it is difficult to find any direct relation between ICT use and students' learning outcomes; and many studies, in particular of the review and meta-study type, still look for effects of ICT in general, without taking into account the highly specific nature of different types of instructional ICT. The result is that we have no evidence for the benefits of, say, collaborative use of wikis or conferencing technologies for a mathematics tutorial.

Keeping these issues in mind, there is growing evidence in the research literature that certain classroom uses of ICT increase students' motivation to learn, engagement in learning and their independence in learning. The benefits of classroom use of ICT identified in the literature are increased levels of students' collaboration in learning, their higher levels of engagement and persistence in learning, and more on-task behaviour.

Evidence for gains in transcurricular areas such as creativity and critical thinking, however, is so far more mixed. The benefits seem particularly strong for technologies that involve a visual element, such as digital video, multimedia, and software

involving role-play and immersive elements. Language education has profited greatly from access to video and audio materials; science education has profited from animations and interactive simulations; graphic arts education has profited from the availability of software for images and drawing.

Trends in pedagogy

One clear trend in pedagogy relating to ICT is personalisation. This is also a trend with direct implications for those concerned with the creation of digital content. What does personalisation mean for the student? According to 'Harnessing technology', a strategy paper of the UK Department of Children, Schools and Families (DCFS 2005), students are supposed to enjoy:

- multiple approaches to learning and subject matter
- more choice of subject matter
- flexible study time
- easier ways of trying things out before committing
- personal online learning space (with virtual learning environments).

Personalisation is a key element of the UK e-strategy for education, and is obviously dependent on the availability of substantive, high-quality digital content, accessible in a manner that allows for integration into personalised learning plans.

A second important trend is the rise of educational games and immersive environments.

> Serious games, as distinct from leisure games, provide users and players with opportunities to explore non-leisure applications using games and immersive world applications for education and training, as well as supporting business and medical uses.
>
> (de Freitas 2008)

A prominent example is Second Life, which now hosts many educational institutions and resources. While the impacts on learning are inconclusive, there is initial evidence that this form of learning resource fosters students' engagement in learning and their motivation to learn.

A third pedagogical trend is the integration of e-portfolios into the repertoire of assessment methods. Portfolio assessment, well established in areas such as graphic

arts education, is now be found in all areas of education. At the time of writing, portfolio assessment methods are probably employed most frequently in higher education, but they are increasingly considered in years K to12. Portfolios add the important elements of learner-control and long-term 'diagnostic' information to supplement other forms of assessment. They are part of a larger movement towards performance-based assessment that builds on recording students' interactions with computer-based instructional materials, supplying important diagnostic information that is hard to gain from applying (standardised) tests.

Trends in communication

User-created content (for example, Flickr, YouTube) and net-based collaboration and socialisation (for example, Facebook) are the main drivers of change in user behaviour, converging into what is called Web 2.0. Young people in particular spend increasing amounts of their time on so-called social sites, and are among those that contribute most content to these sites. The social Web is an Internet phenomenon fuelled by the availability of mobile phones, their multimedia capacities and their integration with web technologies.

Trends in technology

The main trends in technology with direct relevance to the development and deployment of digital educational content are Web 2.0 technologies, learning design technologies and service-oriented architectures. Web 2.0 is not only a social phenomenon; it is also related to a growing number of technical innovations. At its core are technologies such as Ajax, that make possible the creation of data 'mashups' and provide potentially 'richer' user experiences for web content. Tagging technologies, the rise of folksonomies, and in general the (productive) tension between 'bottom-up', social knowledge creation and 'top-down' information (for example, ontology-based semantic web technologies) are all part of the developments that come with Web 2.0.

The trend towards service-oriented architectures in business computing is also beginning to affect educational computing. The idea behind service-oriented architectures is to optimise the re-use of computational resources and to make their execution independent of their physical location. For educational computing this would mean, for instance, that a certain course structure that is defined at one location

can be executed by orchestrating a potentially large number of services provided at other locations. This allows, for instance, the cross-platform mixing of elements such as learning management systems, social sites and immersive sites. A course run mainly on a Moodle server can refer to activities that take place in Second Life and combine them with elements from Google Docs or Facebook.

An important enabler in educational settings for the realisation of service-oriented architectures is the availability of learning design languages and standards. While learning objects encapsulate content and micro-interactions with users (in our case, teachers and students), learning designs encapsulate the process logic – including the roles and resources – required to describe pedagogical structures on a macro level (for example, courses, modules, lessons and collaboration scripts). This is an active field of research, driven not only by the need for standards (such as the evolving IMS learning design language) but also by the requirements of the users of such languages, especially teachers and instructional designers (Botturi, Derntl, Boot & Figl 2006).

Trends in the alignment of pedagogy and ICT use

In the Sites 2006 study Law, Pelgrum and Plomp (2008) administered three questionnaires (for school principals, technology coordinators, and teachers of mathematics and science) to a sample of approximately 400 schools, involving about four teachers per school. Participation extended to 22 countries but not Australia. The main aim of the study was to find out:

> (a) the extent to which the characteristics of the innovative ICT-using pedagogical practices identified in SITES-M2 could be found within the general population of teachers, as opposed to only among those teachers identified as being involved in highly innovative practices
> (b) how the presence of these characteristics related to contextual factors at the school and system levels.
>
> (Law et al 2008, p 9).

The Sites report distinguishes three broad categories of pedagogical orientation among teachers: ‘traditionally important’, ‘lifelong learning’ and ‘connectedness’. The latter refers to the extent to which students collaborate with peers and experts outside the classroom to create products and publish results. Indicators for each orientation were identified in the three areas of espoused curriculum goals, reported teacher practices and reported student practices. ‘Lifelong learning’ and

‘connectedness’ were taken to be important elements of 21st century pedagogical practices.

In the Sites 2006 study the ‘traditionally important’ orientation was the one most frequently identified among teachers, and ‘connectedness’ the least so. This was also reflected in the stated priorities of school principals, although there was a trend towards seeing increasing value in orientations that reflect 21st century learning. Teachers’ views of students’ practices, however, were lowest on the ‘traditionally important’ orientation, revealing a potentially consequential misalignment between teachers’ aspirations and what they see realised in the classroom.

Significantly for our study, the Sites 2006 study found that, although ICT and Internet were available in almost all schools in the 22 participating countries, only 50% of the mathematics and science teachers interviewed reported having used ICT with their students. However, the variation on this item among the participating national systems ranged from below 20% of teachers to over 80%.

The study found some evidence that the use of ICT affected pedagogy in mathematics and science classrooms. With a few exceptions, teachers who used computers in their classrooms also showed more inclination towards realising elements of 21st-century learning, including, importantly, changes in teachers’ assessment practices. While these correlations cannot be interpreted as causal links, it is safe to conclude that the use of ICT in classrooms creates opportunities for teachers to change their pedagogy to include elements of lifelong learning and connectedness.

The Sites study also looked at factors that might affect teachers’ orientation towards ICT. Neither age nor gender differences were significantly correlated with ICT practices, but academic and professional qualifications, technical and pedagogical ICT competence, and attendance at ICT-related professional development were. Of these three, pedagogical ICT competence was the best predictor of adoption of ICT pedagogical practices. The lack of support from the school for the use of ICT in the classroom was the most frequently mentioned obstacle.

An important finding concerning the alignment of school management and teachers’ practices in relation to classroom use of ICT relates to the relationship of teachers’ classroom practices to principals’ attitudes towards lifelong learning. In cases where the principal avowed lifelong learning in her or his vision of the role of ICT, the

number of teachers who shared this orientation in their classroom practices increased significantly, provided that ICT was accessible and its use sufficiently supported. This is positive evidence for the role of leadership in pedagogical change and, more generally, in the alignment of policy and classroom practice.

Studies of TLF materials

Observations, interviews, and surveys

Below is a summary of findings from earlier studies of TLF materials across Australia and New Zealand, based on direct observations, interviews and extensive surveys:

Teachers reported using the learning objects mainly:

- as an orienting / task-focusing device
- to help students develop new knowledge, concepts and skills
- to model activities not normally possible in the classroom
- to allow students to work at their own pace and level.

Teachers' ratings of students' learning outcomes were based on the extent to which TLF material assisted students to:

- learn factual content and direct content
- reach conceptual understandings
- build new concepts and apply knowledge to new settings.

On all three measures more than 80% of surveyed teachers indicated that the use of the learning objects was 'valuable'.

The use of learning objects was also in general supported enthusiastically by parent home-tutors and by students for their learning and motivational features.

A clear majority of students rated the learning objects as being 'interesting' and 'fun' and 'easy to work through', and more than half indicated that the learning objects helped them 'think about new ideas'.

Students nominated the most helpful features of the learning objects to be: 'providing opportunity to work at my own pace', 'getting feedback that tells me if I am right or wrong' and 'getting information that tells me how to do the activity better'.

A study of students' perceptions of the learning objects they use (Freebody & Muspratt 2007a) found that students prefer learning objects that:

- allow them to interact with the learning object
- allow them control over their progress through the learning object
- do not look like conventional classroom activities
- are generally game-like.

There were no significant correlations in the survey data between general approval ratings and school locations, the proportion of students in the school who had language backgrounds other than English, the proportion of Indigenous students in the school, or the SES index of the school based on its surrounding community.

Multi-level modelling showed substantial variation within and between ratings of learning objects, ratings of individual learning objects within some curriculum domains being significantly higher than those in other domains, on various of the measures used.

Field experiments

In addition to the survey, interview and observational studies, two extensive field experiments have been conducted. The first of these (Freebody, Muspratt & McRae 2006) was a pre-test/post-test study using two groups, one of which used learning objects and the other (control group) did not use them. This first experiment was conducted in years 5–7 mathematics in 19 classrooms. Testing was based on items drawn from the results of the Basic Skills Test conducted in each Australian state and territory at each of these year levels, which focus on the topic of 'number' (arithmetic) and the more complex topic of 'chance' (probability). Findings of the experiment included:

- reliable advantages for the learning object group on 'chance' items on the post-test for both year levels
- no reliable advantages for the learning object group on 'number' items on the post-test for year 5
- trending, non-significant, advantages for the learning object group on 'number' items on the post-test for year 7.

A second experiment involved 31 primary school teachers and 33 secondary school teachers in a pre-test/post-test study with one group using learning objects and a control group not doing so, in years 6–7 mathematics and science classrooms. The design of this study included a comparison between classrooms where the teacher administered the learning objects in a standard way, and those where the teacher used the learning object within the Moodle learning management system use. Findings included:

- predictably significant, strong and consistent effects for differences in entry levels (pre-test scores) on the post-test results, with no indication or trend for any diminution of their advantage as a result of either learning object or Moodle use
- significant positive effects for the use of learning objects in science, effects that were clear and relatively consistent
- no advantage for the group using learning objects in a Moodle learning management system format in science over either the learning object only group or the control group, overall or for any component of the science test
- with one exception, no reliable significant effects for either learning object use or Moodle use in mathematics, the exception being that there was a statistically reliable advantage for the Moodle group on items relating to linear functions. No effects were evident for the other topics.

Organisation and usage

Finally, from site visits and focused case studies, the following conclusions were drawn concerning the rates of use of ICT in classrooms and their integration into classroom curricular work:

- There were common elements in effective use of ICT and its integration into classroom activity:
  - commitment to ICT by school leadership
  - a champion of ICT within the school
  - a working plan for school-wide classroom use of ICT
  - well-directed and high-quality ICT resources
  - a substantial and effective program of professional learning.
- Teachers stated that they need time to ensure that their selection of learning objects, from an increasingly wide range, is appropriate to their needs.

- Technical difficulties presented ongoing frustrations to teachers and increasingly complex and consequential challenges to systems.
- Potentially new learning environments, as represented by the learning objects, were put to conventional, traditional, pedagogical work.
- School executives and leaders often tended to focus on organisational and procedural matters at a whole-school level, and only rarely on whole-school curriculum matters.
- A strategic approach to building teachers' capacity to integrate ICT into their learning and teaching programs did not typically take the form of cohesive, cumulative professional development at the jurisdiction level.
- Major variations were found in awareness and usage of ICT, and of learning objects more specifically; and in the extent to which learning objects were integrated into everyday classroom activities.
- Curriculum implementation in many schools was compartmentalised and faculty-based, with take-up of ICT and learning objects often varying strongly from department to department within a school, because the institutional ICT or learning object 'champion' had not managed to exert influence beyond his or her own department.

These studies, which have been largely focused on learning objects, have reached some converging findings, especially in relation to:

- the positive ratings of learning objects by all categories of respondents
- the efficacy of learning objects in learning settings, even when standardised assessment items are used (that is, items not generally well tailored to the kinds of learning activities reflected in most learning objects)
- problems with adoption and integration.

We return in particular to this latter issue in subsequent sections of this report, after considering briefly the TLF's digital repository and some related research from other sources.

A small-scale study of teachers' use of TLF's digital resources, undertaken in late 2006 (see Freebody & Muspratt 2007a), indicated that take-up and usage of the digital resources has been patchy. The findings of the study, which, given the size of the study, should be taken as only indicative, were that:

- on the whole, teachers found the digital resources to be educationally useful and valuable, accessible and easy to use, and helpful for motivating students
- the descriptions and guidelines that accompany the digital resources were seen as a crucial aspect of their usefulness and were regarded as clear, helpful and informative
- teachers suggested that their use of the digital resources would benefit from the search engine being refined so as to allow more precise location of relevant materials; and from an expansion of the very limited range of materials in some areas where digital resources would have high curricular value.

General

In the concluding statement to their report on the value of learning objects in classrooms, Freebody and Muspratt (2007b) commented on the issue of adoption and the need for a more concerted approach to understanding adoption and diffusion:

> An additional major research and development interest arises from the findings of the site visits: how to build ICT take-up, familiarity and confidence among teachers. This issue connects closely with the general research on ICT dissemination and adoption. It also links with the previously stated need for detailed studies of actual and mature use of ICT: it is only through increased dissemination and adoption that evaluation programs will be able to move beyond the scrutiny of immature practice. Until that happens, an appreciation of the potential benefits of ICT innovation, including those of TLF's learning objects, is unlikely to attract the attention of those who determine educational policy and decisions. (p 63)

The study reported here aims to be, among other things, the first step in research to address these issues.

The research framework

While the provision of learning objects and digital resources can be seen as a curriculum innovation, the 'end users' – teachers and school personnel – most probably see these also as a technology innovation, more precisely as an ICT innovation. This is almost certainly the case in those situations where TLF content is not directly presented but rather mediated by the teacher, that is, where students are directly working with TLF content on a computer, in a lab and/or at home, with access perhaps mediated by a portal. In such situations, the use of TLF content is as much a technology innovation as it is a curriculum innovation, and is subject to all the challenges that technology innovations face in schools and other institutions. For instance, ICT innovations have been a particular challenge for the educational system because they require a more than 'loose coupling' (Weick 1976) between the components of the organisation than educational organisations traditionally provide. In this section, we therefore provide a brief overview of some of the research on ICT innovations in schools, and describe how our survey study builds on this research.

We focus in particular on research on sustaining and scaling-up technology innovations. This because the early challenges that many technical innovation face in school systems (lack of infrastructure, lack of professional development, non-alignment with curriculum and standards) are no longer the main challenges that TLF content seems to face. TLF content as well as the delivery technologies associated with it (CDs, DVDs, web portals, Learning Management Systems) have been available in (most) schools for a number of years, and are well integrated, both into curriculum and infrastructure.

Although the presence of ICT is now commonplace in schools, its use varies greatly between teachers in quantitative terms (for example, time); and the quality of technology use for learning is generally low (Fishman, Marx, Blumenfeld, Krajcik & Soloway 2004). While ICT-enhanced innovations brought to schools by professional designers and researchers may be initially accepted, sustaining them beyond the time when designers have left the school, and scaling up innovations beyond the local contexts are still hard to achieve. Fishman and others (2004) identified 'usability' as a success factor: 'innovation is usable if a school organisation can adapt the innovation

to local context, enact the innovation 'successfully' … and sustain the innovation' (p 51).

A variety of other potential reasons have been identified, some of which include: teacher capabilities, technology infrastructure, school culture, and organisational constraints. Given that each of these factors has been found to affect ICT and innovation adoption, the conclusion ought to be that the causes are *systemic*, that is, they are embedded not only in individual attitudes and capacities, but in the interdependencies of different factors and different levels that make up the educational system as whole. The systemic nature of ICT-based innovation is also evident in success stories on technology integration in schools (Kozma 2003; Means, Blando, Olson, Middleton, Morocco, Remz et al. 1993). Further, this argument is congruent with the more general literature on educational and organisational change and innovation (Senge 2000; van de Ven & Hargrave 2004).

Means and others (1993) identified six common features of successful technology implementation efforts:

- ready technology access and technical support
- instructional vision and a rationale linking the vision to technology use
- a critical mass of teachers involved in technology activities
- a high degree of collaboration among teachers
- strong leaders
- support for teacher time for planning, collaboration, and reporting technology use.

Although not explicitly formulated in terms of a systemic framework, these features speak strongly for the importance of alignment among change agents and between organisational levels.

More directly addressing the issue of alignment, Knapp (1997) argued that pivotal to successful reform is that the major ideas are interpreted in a similar manner at all levels of the school system. Indirect evidence for this 'interpretational alignment' claim is provided by the numerous studies that show that 'bottom-up' innovations in general scale up better and are more sustained than 'top-down' reforms (for example, Honey & McMillan-Culp 2000).

Blumenfeld, Fishman, Krajcik, Marx and Soloway (2000) identified organisational culture, capability, and management and policy as three areas impacting on whether instructional innovation will be adopted and sustained. *School culture* refers to local norms, routines, and practices. If an instructional reform is inconsistent with school culture, it will be rejected or subverted (Fullan 2001, Tyack & Cuban 1995). For instance, a school climate that supports risk taking and open communication about what works and does not work is more conducive to the spread of ICT based learning practices. *Capability*, in particular but not only teachers' beliefs, understanding of the reform, and their expertise in carrying it out is another impediment (Blumenfeld et al 2000). As discussed above, and along with other reports, the recent third Sites study shows (Law et al 2008) that ICT is still not used much by many teachers, not even in science and mathematics. Capability development in the form of professional development appears to have been too focused on the merely technical aspects and not enough on pedagogy and classroom integration.

The extent to which instructional innovation will be sustained, according to Blumenfeld and others, depends thirdly on establishing appropriate *policies and management*. While educational policies seem to be increasingly well aligned with the educational potentials of ICT (with the notable exception of assessment and testing, (Fishman et al 2004)), management strategies and practices have, by and large, been less responsive to change. For instance, only a comparatively small number of schools engage in the kind of strategic planning that is required to align ICT with pedagogical and organisational goals and processes (for example, Baldrige National Quality Program 2007).

An educational system needs to develop capacity in all three areas – culture, capability, policy and management – to sustain reform (McLaughlin 1987). Further, successful reform requires working on these aspects *simultaneously* to create capacity (Fullan & Miles 1992). *Systemic reform* has been proposed as a way to overcome the problem of uncoordinated or even contradictory change efforts (Vinovskis 1996). Technical innovation needs typically to be accompanied by curriculum changes, alignment of assessment requirements, and by professional development in order to stand a chance to be sustained. The argument is that, unless a reform is systemic, its *scalability* will be limited.

In summary, challenges to innovation in systemic reform can be conceptualised as located in a space formed by three axes: Culture, Capability, and Policy & Management (see Figure 1). These dimensions also underlie the survey study described in the remainder of this report.

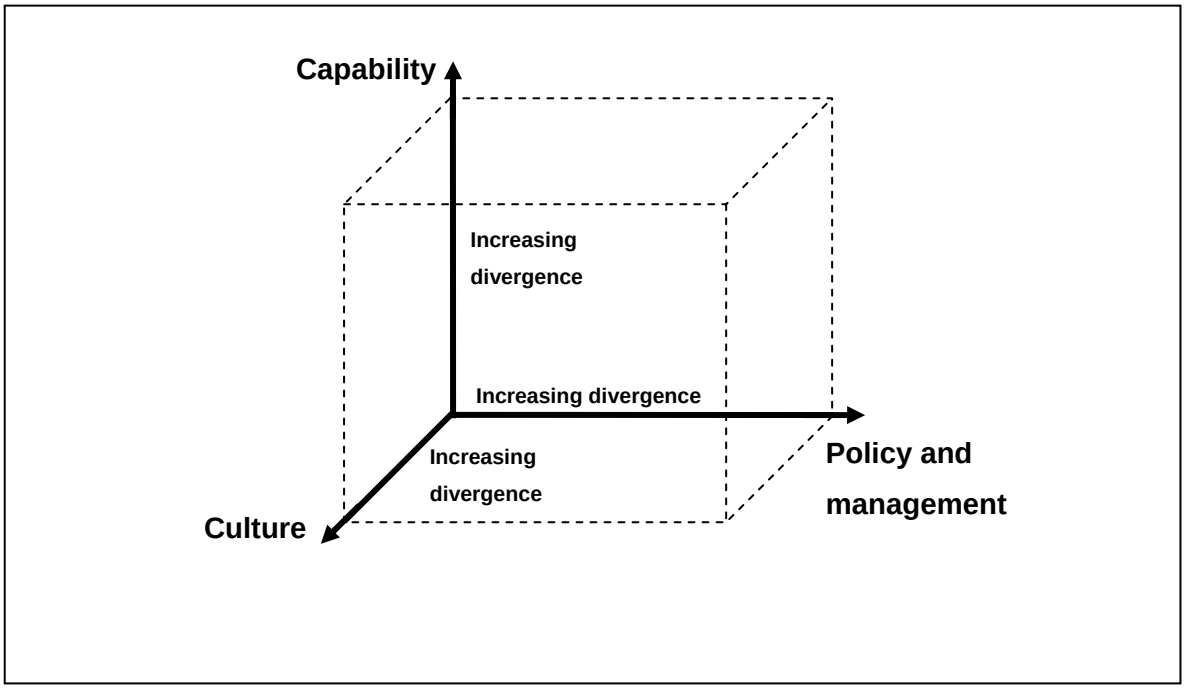

Figure 1: Dimensions of innovations in systemic reform (from Blumenfeld et al 2000, p 153)

The survey

A survey was designed for each of the four groups of respondents. These are shown in full in Appendix 1. While the core questions remained the same for each group, predictable minor differences reflected each group's location (school, regional office or head office) and functions (teaching, school leadership, curriculum development, professional development or policy formation). Each survey instrument comprised four sections:

1 Information about the respondent:
   - school or office identification
   - qualifications
   - sense of familiarity with ICT in general, with digital online curriculum, and with learning objects
   - extent of professional development in ICT generally, in use of digital online curriculum, and in use of learning objects
2 Information about the school:
   - location
   - sector
   - enrolment size
   - grade levels
   - demographics of student body
3 Information about the learning objects and digital resources currently in use:
   - number
   - names
   - year levels at which they are used
   - curriculum areas in which they are used
   - views on the learning and motivational outcomes for students
4 Information about and perception of ICT use in classrooms:
   - frequency of use of various forms of ICT
   - benefits of using ICT compared with traditional classroom activities and tools (with reference to both mainstream and non-mainstream educational settings)
   - factors affecting adoption and non-adoption of new digital technologies in classrooms

In sections 3 and 4 spaces were provided for respondents to provide written alternative answers or to expand on their responses.

The respondents

The general features of the respondents are described below, so as to give a sense of the generalisability of the findings. In three of the four groups of respondents, about two-thirds were female, the exception being the school principals group, which had a smaller proportion of women, as shown in Table 1.

Table 1: Gender of members of the four groups of respondents (total n = 1603)

	Group							
	Teachers		School leaders		Principals		Sector personnel	
	Count	*%*	*Count*	*%*	*Count*	*%*	*Count*	*%*
Male	210	26.40	169	37.90	92	54.10	51	26.70
Female	586	73.60	277	62.10	78	45.90	140	73.30
Total	796	100.00	446	100.00	170	100.00	191	100.00

In the teachers group, respondents varied in the number of years they had been in their current positions, while most of those in the other groups had been in their current positions for less than five years, as shown in Table 2.

Table 2: Distribution of respondents' years of experience in current roles (total n = 1595)

	Group							
	Teachers		School leaders		Principals		Sector personnel	
	Count	*%*	*Count*	*%*	*Count*	*%*	*Count*	*%*
1st year	20	2.5	100	22.4	31	18.3	43	22.4
2–5 years	159	20.2	340	76.1	57	33.7	144	75.0
6 –10 years	124	15.8	7	1.6	35	20.7	5	2.6
11–15 years	94	11.9			19	11.2		
16–20 years	75	9.5			14	8.3		
More than 20 years	315	40.0			13	7.7		
Total	787	100.0	447	100.0	169	100.0	192	100.0

The teachers' professional qualifications were varied, as shown in Figure 2. More than half of them had attained a four-year Bachelor of Education degree (reflecting their position as primary teachers, as shown later). About one teacher in four reported that they had completed higher qualifications, the distribution of which is shown in Figure 3.

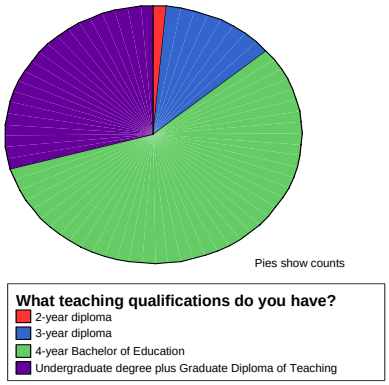

Figure 2: Distribution of respondents' qualifications (total n = 788)

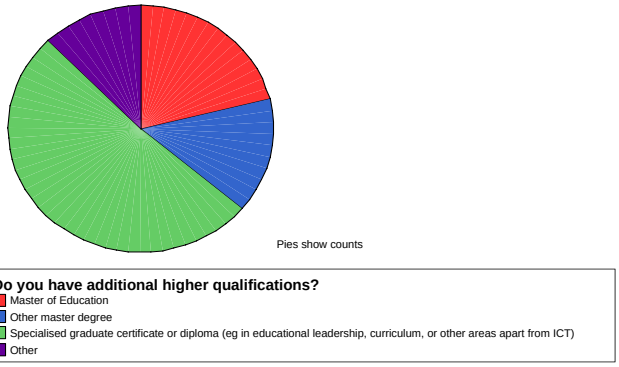

Figure 3: Distribution of respondents' additional higher qualifications (total n = 222)

Respondents' schools and districts

Respondents were located in a variety of schools across Australia and New Zealand. Table 3 presents the country, state or territory in which the respondents worked.

Table 3: Distribution of location of the sample of respondents (total n = 1602)

	Group							
	Teachers		School leaders		Principals		Sector personnel	
	Count	*%*	*Count*	*%*	*Count*	*%*	*Count*	*%*
ACT	33	4.2	11	2.4	1	0.6	10	5.2
NSW	209	26.4	90	20.0	33	19.4	27	14.1
NT	36	4.5	34	7.6	8	4.7	26	13.6
NZ	29	3.7	44	9.8	29	17.1	28	14.7
Qld	66	8.3	42	9.4	20	11.8	22	11.5
SA	15	1.9	20	4.5	3	1.8	12	6.3
Tas	172	21.7	51	11.4	17	10.0	20	10.5
Vic	127	16.0	84	18.7	37	21.8	23	12.0
WA	105	13.3	73	16.3	22	12.9	23	12.0
Total	792	100.0	449	100.0	170	100.0	191	100.0

Broadly, and in rough proportion to the populations and school sizes of these locations, response rates from the ACT, Northern Territory, Tasmania and Western Australia were higher than expected, whereas response rates from New South Wales, New Zealand and Queensland were lower than expected.

Table 4 shows the distribution of respondents according to the educational sector in which they worked.

Table 4: Distribution of the sample of respondents by educational sector (total n = 1599)

	Group							
	Teachers		School leaders		Principals		Sector personnel	
	Count	*%*	*Count*	*%*	*Count*	*%*	*Count*	*%*
Government	636	80.4	339	75.8	120	71.0	168	87.5
Independent	53	6.7	78	17.4	30	17.8	4	2.1
Catholic	102	12.9	30	6.7	19	11.2	20	10.4
Total	791	100.0	447	100.0	169	100.0	192	100.0

It can be seen that the representation of government schools is somewhat higher than would be expected on the basis of national distribution. The lower representation of sector personnel in the Independent sector is to be expected, given the more devolved nature of that sector.

Table 5 indicates the distribution of respondents according to the level of schooling in which they worked. Note that this question was not put to sector personnel.

Table 5: Distribution of schooling level of the sample of respondents (total n = 1405)

	Group					
	Teachers		School leaders		Principals	
	Count	*%*	*Count*	*%*	*Count*	*%*
Primary	414	52.5	196	43.8	103	61.3
Secondary	214	27.1	111	24.8	25	14.9
P–10/12	100	12.7	77	17.2	24	14.3
Other	61	7.7	64	14.3	16	9.5
Total	789	100.0	448	100.0	168	100.0

About half of the respondents worked in primary schools, while significant numbers of school leaders and principals were based in special schools (generally, ‘special needs’ schools, however variously labelled by their systems).

Respondents were asked to estimate the current total enrolment of the school in which they worked. Responses are summarised in Table 6. Note that this question was not put to sector personnel.

Table 6: Distribution of schools of various sizes among the sample of respondents (total n = 1378)

	Group					
	Teachers		School leaders		Principals	
	Count	*%*	*Count*	*%*	*Count*	*%*
26–100	33	4.2	16	3.6	20	12.7
101–200	65	8.3	36	8.2	27	17.1
20 –300	136	17.4	48	10.9	26	16.5

301–400	145	18.6	55	12.5	19	12.0
401–500	50	6.4	31	7.0	17	10.8
501-–700	284	36.4	112	25.5	22	13.9
701–1000	67	8.6	70	15.9	16	10.1
More than 1000			72	16.4	11	7.0
Total	780	100.0	440	100.0	158	100.0

The enrolment sizes of schools supervised by the principals in this sample are moderately well distributed from small to very large. For teachers and school leaders, however, note the comparative drop in the proportion of schools with enrolments of 401 to 500.

Table 7 shows the gender composition of the student enrolments. Note that the single-sex schools are almost all independent schools, and that this question was not put to sector personnel.

Table 7: Distribution of coeducational and single-sex schools among the sample of respondents (total n = 1400)

	Group					
	Teachers		**School leaders**		**Principals**	
	Count	%	Count	%	Count	%
Coeducational	754	95.6%	414	92.8%	158	95.8%
Single sex – female	20	2.5%	20	4.5%	5	3.0%
Single sex – male	15	1.9%	12	2.7%	2	1.2%
Total	789	100.0%	446	100.0%	165	100.0%

Of considerable interest from previous studies, including some international research studies into these issues, is the lack of any substantial correlation between measures and estimates of adoption and use, and the demographic context of the school setting. In the present study, respondents were asked to estimate the number of students in their schools who fell into the following categories: those whose language background is other than English; Indigenous / Aboriginal Australian / Torres Strait Islanders; those from low socio-economic communities; and those with special educational needs. The findings for these estimates by the teachers, school leaders and principals are shown in figures 4–7 respectively.

It should be noted that, of the four groups of respondents, more of those in the teachers group will represent the smaller (and, in the Australian setting, thereby more remote) schools than will those in the school leaders group or the principals group.

Thus, for purely statistical reasons, we would expect the teachers group to estimate higher proportions of students in these four categories. The differing estimates among the four groups of respondents for each demographic feature do not represent different estimates for the same schools or the same types of schools in comparable locations.

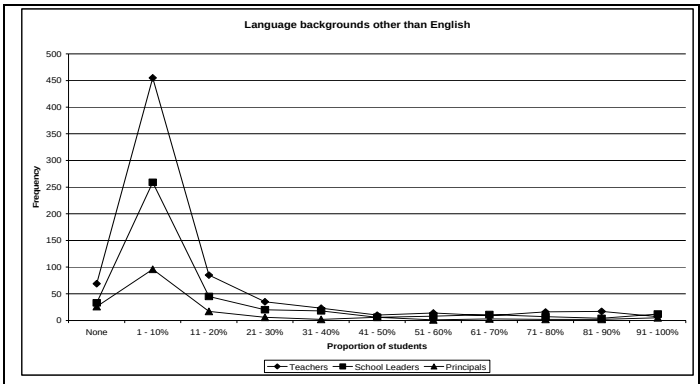

Figure 4: Distribution of respondents' estimates of the number of students in their schools who come from language backgrounds other than English

(n teachers = 738; n school leaders = 419; n principals = 163)

The fact that most respondents indicate between 1 and 10 enrolled students has come from a language background other than English reflects adequately estimates by the Australian Bureau of Statistics (2006 census) that about 20% of Australian residents speak a language other than English at home.

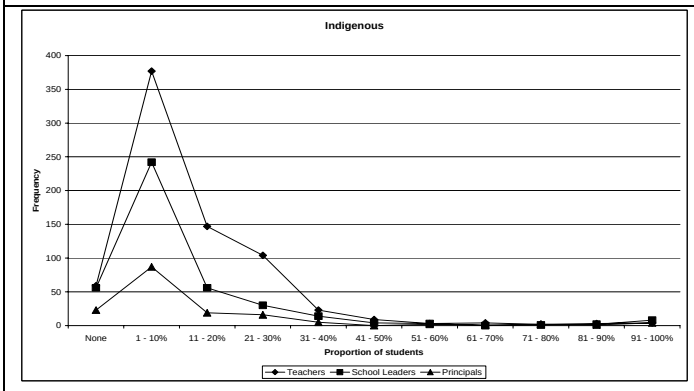

Figure 5: Distribution of respondents' estimates of the number of students in their schools who come from Indigenous backgrounds

(n teachers = 738; n school leaders = 419; n principals = 163)

Australian Bureau of Statistics (2006 census) indicates that about 2.3% of Australian residents self-identify as Aboriginal or Torres Strait Islanders.

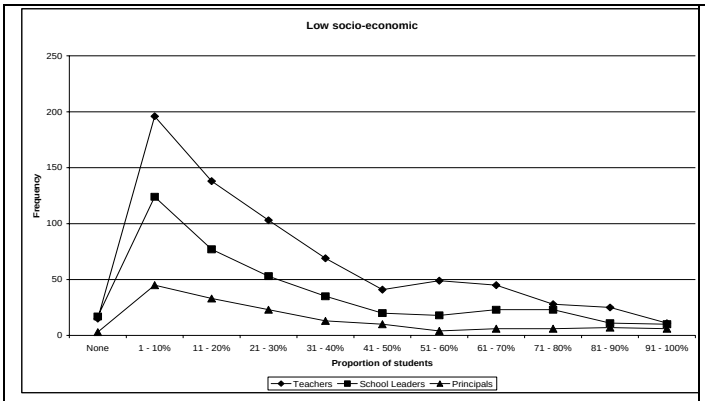

Figure 6: Distribution of respondents' estimates of the number of students in their schools who come from low socio-economic backgrounds

(n teachers = 738; n school leaders = 419; n principals = 163)

These more broadly distributed estimates indicate that many schools have substantially higher levels of low SES enrolment than they have for the other three variables.

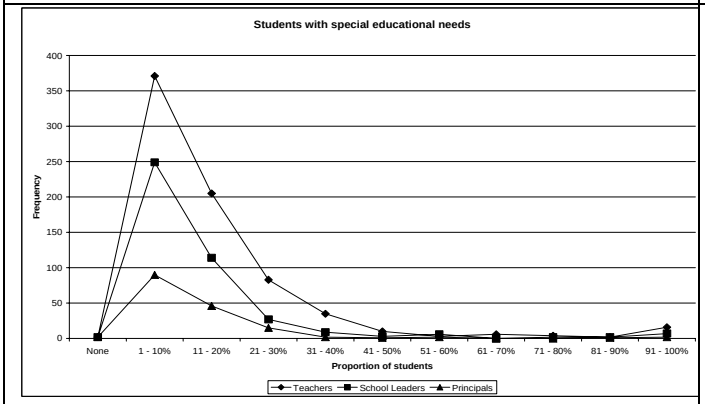

Figure 7: Distribution of respondents' estimates of the number of students in their schools who have special educational needs

(n teachers = 738; n school leaders = 419; n principals = 163)

All schools in this sample reported having some students with special educational needs. Few reported having more than 20% of enrolled students with such special needs.

These demographic estimates indicate that the school settings of the survey sample can be considered broadly representative of Australian and New Zealand schools, even though, as indicated in Table 3, the sample is not a particularly accurate representation of the these populations in terms of country, state and territory locations.

For some time there have been calls for schools to produce and implement whole-school ICT plans. Among the 168 principals in this sample who responded to the item, 17% indicated that their school did not have such a plan, and 33% indicated that

the jurisdiction in which they worked did not require such a plan. Further, the 152 school sector personnel who responded to the item produced a wide range of estimates of how many schools in their country, state or territory had an operational whole-school ICT plan, as shown in Figure 8.

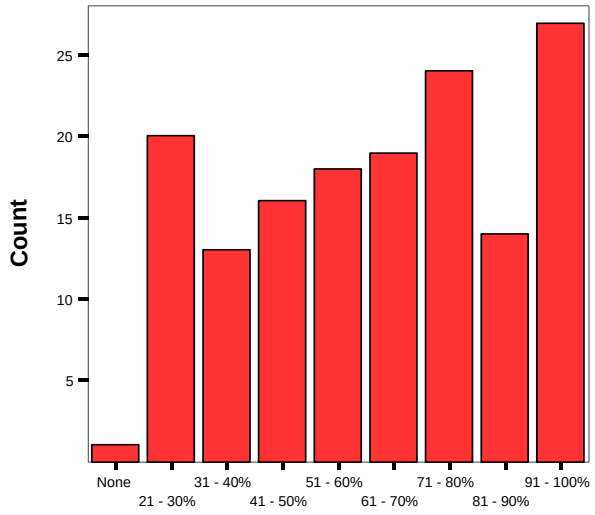

Figure 8: Estimates by 152 sector personnel of the proportion of schools in their jurisdiction that have an operational whole-school ICT policy

It is clear that, sector-wide, there are significant variations in the establishment and use of a whole-school ICT plan. This may not necessarily indicate lower usage rates or any other within-classroom variations, but it does indicate varying approaches to coordination. It also place differing degrees of pressure on systems to provide specific kinds of professional development to teachers and school leaders. The variation would have implications for the ways in which teachers could and did engage in curricular exchange and share more locally with colleagues.

Finally, a series of questions were asked of teachers concerning their familiarity with different aspects of using ICT in their teaching and concerning the extent of professional development (PD) they had engaged in with regard to each of those aspects. Results are summarised in Table 8.

Table 8: How familiar are you, and how much professional development have you had in the following aspects of ICT use (7-point scale)?

Variable	N	Mean	SD
Familiar with standard ICT applications?	796	5.49 (+)	1.44
PD on standard ICT applications?	796	4.55	1.80
Familiar with digital online curriculum?	784	5.04 (+)	1.56
PD on digital online curriculum?	774	4.26	1.81
Familiar with digital learning objects?	785	3.85	1.99
PD on digital learning objects?	789	3.22 (-)	1.90
Familiar with digital resources?	789	3.53	1.87
PD on digital resources?	793	3.08 (-)	1.84

Reported familiarity with, and professional development in, aspects of ICT use was highest for standard ICT applications and then declined progressively for digital online curriculum materials, learning objects and finally digital resources. Reported levels of professional development are lower that reported levels of familiarity, in all cases. Nevertheless, it is notable that teachers report high levels of familiarity with standard ICT applications and digital online curriculum materials.

Respondents' views of TLF materials

Respondents were asked a number of questions specifically about the TLF materials. These concerned their sense of familiarity with the materials, the professional development they had engaged in that was focused on the materials, the curriculum areas and grade levels at which they were used, and estimates of frequency of use. Responses are summarised below. Note that participants' responses to items relating to the value of ICT and the factors that enable ICT adoption are summarised in later sections of this report.

Teachers' uses of TLF materials

A number of questions called for teachers to indicate their familiarity with TLF material and the extent of their use of these materials. These are summarised in figures 9–12 (approximate number over all four questions = 660).

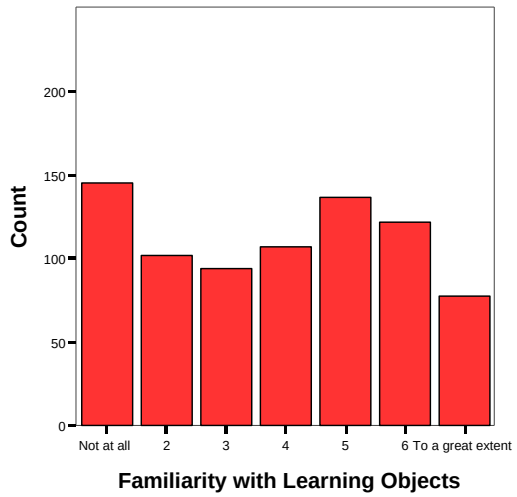

Figure 9: Teachers' responses to the question: 'To what extent are you familiar with the use of learning objects, such as those produced by The Le@rning Federation, in the classroom?'

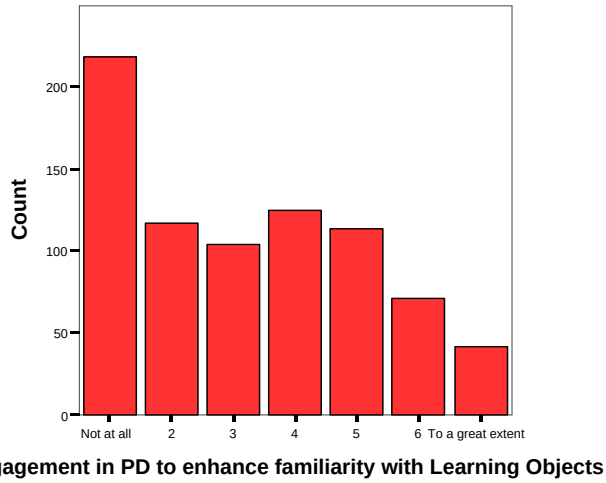

Figure 10: Teachers' responses to the question: 'To what extent have you engaged in professional development activities to enhance your familiarity with the use of learning objects in the classroom?'

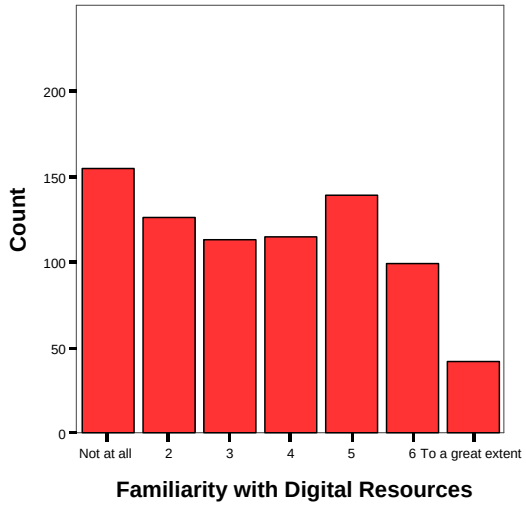

Figure 11: Teachers' responses to the question: 'To what extent are you familiar with the use of digital resources, such as those produced by TLF, in the classroom?'

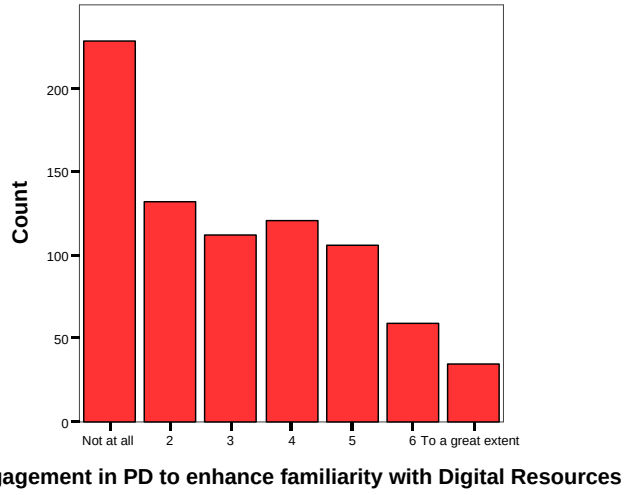

Figure 12: Teachers' responses to the question: 'To what extent have you engaged in professional development activities to enhance your familiarity with the use of digital resources in the classroom?'

It is clear that teachers vary considerably in their reported familiarity and professional development experiences with TLF materials; and report lower levels of professional development than of familiarity. About one in four or five report no familiarity and/or no related professional development with regard to TLF materials, and only a small minority report extensive familiarity and professional development. Nonetheless, these rates represent an increase over rates reported in earlier surveys (Freebody 2005; Freebody, Muspratt & McRae 2006).

Specifically on the use of TLF learning objects and digital resources, teachers were asked to offer approximations of the number of items used and the frequency of usage. Results are summarised in figures 13–16 (approximate number across all four questions = 660).

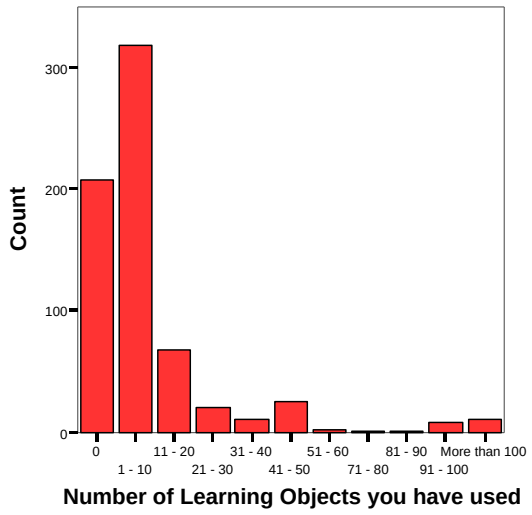

Figure 13: Teachers' responses to the question: 'Roughly how many learning objects have you used in the classroom?'

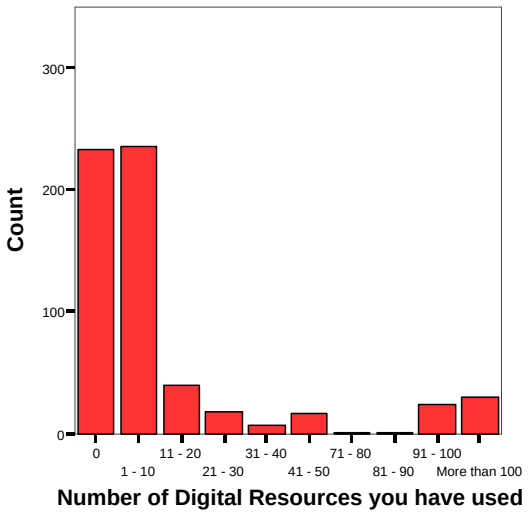

Figure 14 Teachers' responses to the question: 'Roughly how many digital resources have you used in the classroom?'

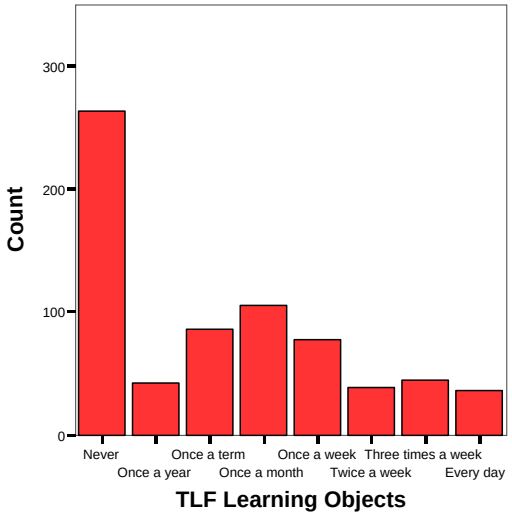

Figure 15: Teachers' responses to the question: 'How often do you use TLF learning objects in the classroom?'

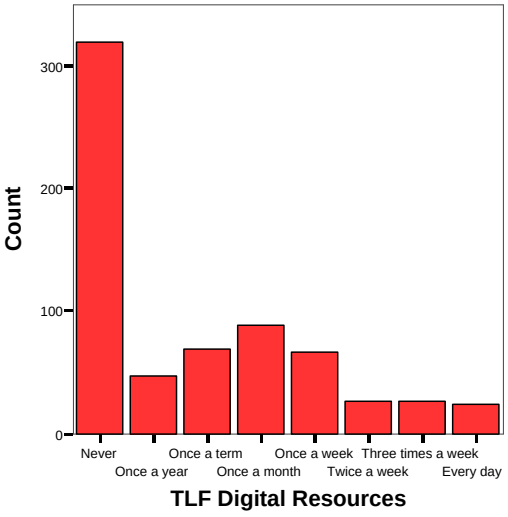

Figure 16: Teachers' responses to the question: 'How often do you use TLF digital resources in the classroom?'

Clearly, a large proportion of teachers in this sample have used a small number of learning objects and used them only infrequently. There is some evidence of a group of teachers (approximate number = 220 to 250) who use the materials between once a

term and once a week. As with the previous cluster of questions, responses represent some advance on use reported in earlier studies of TLF materials, but rates are low nonetheless.

As documented in earlier reports, usage is not equally distributed across year levels or curriculum areas, as Figure 17 and Figure 18 show.

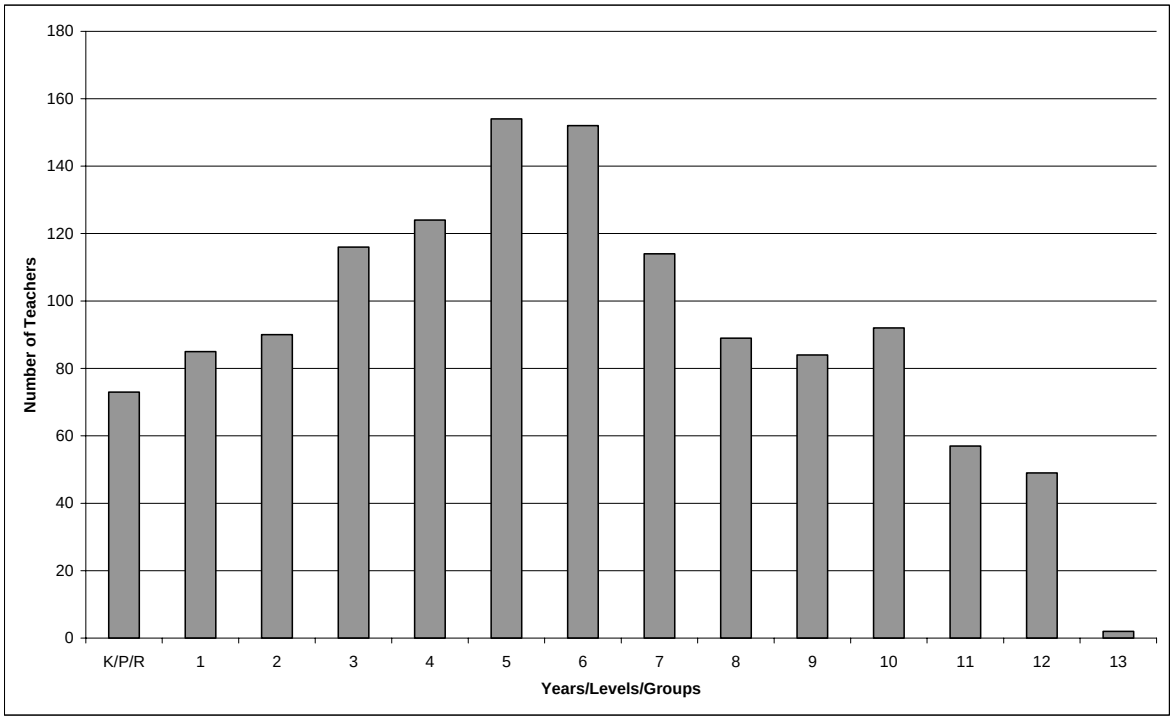

Figure 17: Teachers' responses to the question: 'At what years/levels are you currently using TLF content?'

For the most part, TLF materials are produced for use across the school years P to 10. Literacy learning objects, the exception, are specifically designated for years 7 to 9. There are, nonetheless, substantial numbers of teachers of students in years 11 and 12 who have used TLF materials, suggesting wider applicability of the materials, even though TLF has expected that syllabus expectations at years 11 and 12 are specific enough to make the use of general materials such as those produced by TLF less attractive.

Clearly, years 3–7 attract the heaviest use, but these figures need to be read alongside those summarised in figures 8–11 and 12–15, which show that overall rates of use are low.

Consonant with earlier findings, teachers in mathematics, English/literacy and science constitute the heaviest users of TLF materials, while those teaching Studies of Society

and the Environment and cross-curriculum integrated studies are now reporting higher rates than shown in earlier studies. It was shown through multilevel modelling of the teachers' responses concerning the value of the learning objects (in Freebody, Muspratt & McRae 2007) that reliable amounts of variation were associated with the individual learning object level and with the curriculum area. It was also shown that learning objects in some curriculum areas attracted higher ratings by teachers on most of the criteria. Respondents in the current sample also indicate strongly differing usage rates from one curriculum area to another, as shown in Figure 18.

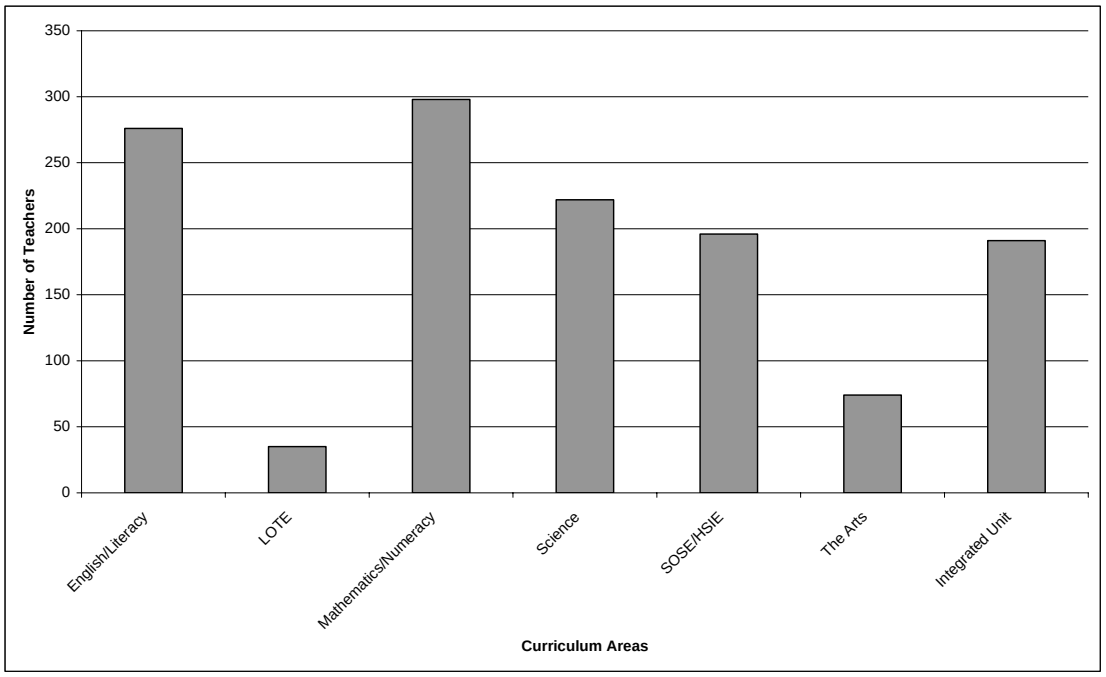

Figure 18: Teachers' responses to the question: 'In what curriculum area(s) are you currently teaching using TLF content?'

Finally we asked teachers currently using TLF materials, whether learning objects or digital resources, to give their views on the aspects of learning they found to be least and most facilitated by these materials. Results are summarised in tables 9 and 10. The grouping of items under the four subheadings shown in these tables reflects the underlying dimensions established in earlier surveys (as reported in Freebody 2005; and Freebody, Muspratt & McRae 2006, 2007a).

Table 9: Teachers' estimates of aspects of learning for which the learning object in use helped students learn (7-point scale)

Aspect of learning	N responses	Mean	SD
1 Factual/ content learning			
know key factual content	358	5.17	1.46
know about key processes	356	5.19	1.45
label parts	317	4.85	1.71
state and define ideas and processes	341	4.94	1.56
2 Conceptual understanding			
summarise and paraphrase key concepts	330	4.60	1.57
explain connections among key concepts	344	4.89	1.55
compare and contrast key concepts	323	4.66	1.55
evaluate and justify key concepts	324	4.63	1.55
3 Transfer of knowledge			
apply new ideas to new settings	348	4.82	1.51
demonstrate applications to new settings	339	4.76	1.54
design new elements by applying key concepts	316	4.50	1.69
4 Engagement			
Motivation to engage	363	5.77	1.37
task persistence	362	5.54	1.41
task enjoyment	362	5.84	1.40
collaboration with peers	355	5.18	1.55
independence in task management and completion	359	5.21	1.50

Table 10: Teachers' estimates of aspects of learning for which the digital resource in use helped students learn (7-point scale)

Aspect of learning	N responses	Mean	SD
1 Factual/ content learning			
know key factual content	248	5.10	1.70
know about key processes	240	4.86	1.68
label parts	229	4.70	1.84
state and define ideas and processes	237	4.84	1.74
2 Conceptual understanding			
summarise and paraphrase key concepts	236	4.68	1.79
explain connections among key concepts	238	4.85	1.80
Compare and contrast key concepts	235	4.73	1.80
evaluate and justify key concepts	230	4.54	1.84
3 Transfer of knowledge			
apply new ideas to new settings	235	4.70	1.74
demonstrate applications to new settings	235	4.66	1.74
design new elements by applying key concepts	228	4.50	1.82
4 Engagement			
Motivation to engage	260	5.36	1.54
task persistence	259	5.06	1.56
task enjoyment	259	5.37	1.54

collaboration with peers	257	4.94	1.67
independence in task management and completion	258	4.90	1.65

These means reflect ratings consistently above the mid-point and into the high range and, again, are compatible with earlier survey findings. Within this overall pattern, we find some advantage for the items reflecting engagement in learning and motivation to learn, over the others, and some small advantage for the items relating to factual or content learning over conceptual learning and transfer. These, however, while also consistent with earlier findings, are minor variations within the moderately high range. Those teachers who use these materials, in short, continue to report favourably on their value for students' learning and engagement.

School leaders' and principals' responses to TLF materials

Along with questions reported elsewhere in this report, school leaders and principals were asked a particular question about the use of TLF materials. School leaders' responses are summarised in Figure 19.

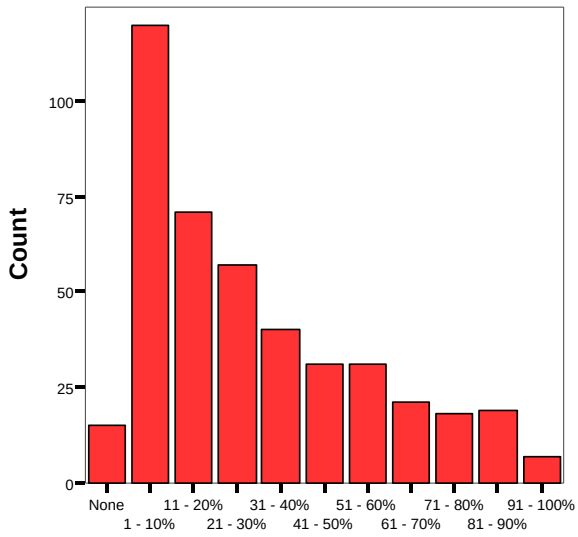

Figure 19: School leaders' responses to the question: 'Can you estimate the percentage of teachers in your school who regularly use TLF content in their classrooms?' (n = 430)

All but a few school leaders in this sample indicated some regular usage of TLF materials (with a mean, in a badly skewed distribution of 3.4 (sd = 2.6) indicating an average estimate of about 20% of teachers). This again suggests an increase in overall observed and reported use of TLF materials by teachers, assuming the consistency of

the sampling and the equivalence of its representativeness with regard to earlier sets of respondents.

Similarly, principals, whose responses are summarised in Figure 20, reported relatively high levels of overall usage of TLF materials.

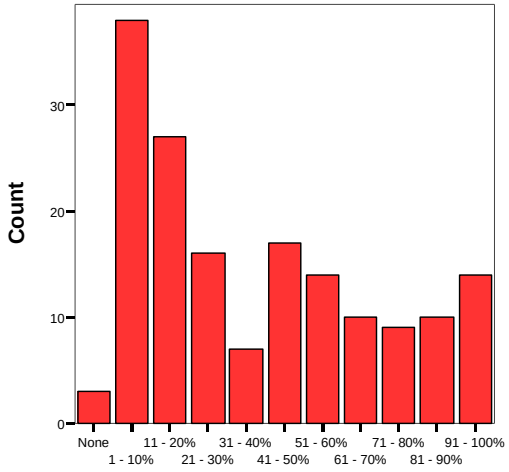

Figure 20: Principals' responses to the question: 'Can you estimate the percentage of teachers in your school who regularly use TLF content in their classrooms?' (n = 165)

This distribution of estimates (with a mean, as above in a badly skewed distribution of 4.3 (sd = 3.1) indicating an average estimate of about 27% of teachers) represents an increase in usage for this sample over those surveyed over the previous three years. In that regard, in response to the question concerning the estimated rates of increase in the use of TLF materials among school teachers, school leaders and principals provided estimates, shown in Table 11, that indicate strongly increasing exposure and usage.

Table 11: School leaders' and principals' responses to the question:

'How would you best describe the increase in adoption of TLF content in classrooms in your schools in the last three years?' (in %)

Estimated increase	School leaders (n = 435)	Principals (n = 165)
Minor	39	38
Moderate	39	32
Significant	22	30

This represents a substantial increase in the use of TLF materials, as perceived by principals and other school leaders. It is clear that, from an extremely small base in 2003–04, TLF materials are at least known by a significant proportion of Australian

and New Zealand educators, and that usage rates seem to be increasing. Again, however, these reports need to be set alongside the low number of learning objects reportedly in use and the low to moderate frequency of their use in classrooms.

Sector personnel's responses to TLF materials

A number of specific questions concerning TLF materials were asked of the sector personnel. Their responses are summarised in this section. Initial concern was with the overall level of familiarity and engagement with TLF materials among sector personnel, and the kinds of feedback reported to them from schools. Responses to questions related to these issues are summarised in figures 21–24.

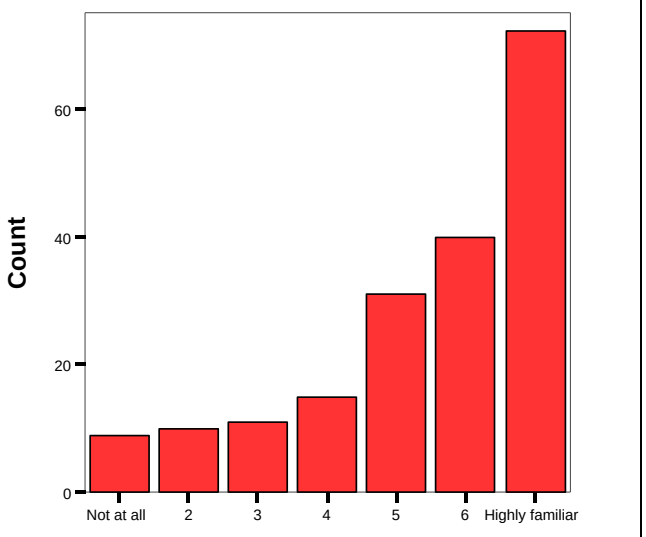

Figure 21: Sector personnel's responses to the question: 'How familiar are you with the digital online curriculum materials produced by TLF?'

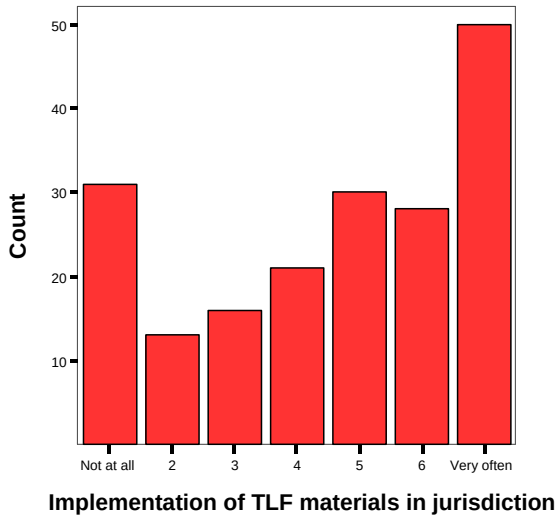

Figure 22: Sector personnel's responses to the question: 'Have you been involved in the implementation of TLF materials in schools or classrooms in your jurisdiction?'

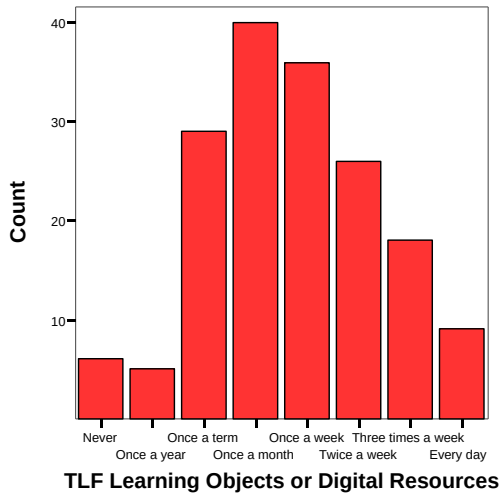

Figure 23: Sector personnel's responses to the question:
'In your jurisdiction/district, how frequently do you think TLF learning objects or digital resources are being used?'

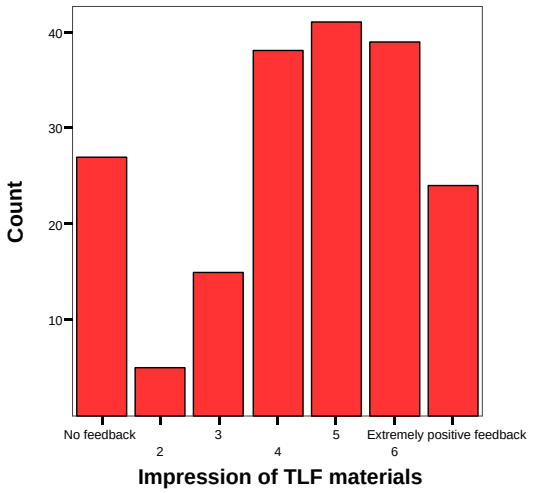

Figure 24: Sector personnel's responses to the question:
'Based on feedback from schools in your jurisdiction, what are your impressions of the quality and usefulness of TLF materials?'

Taken together, this sample of sector personnel reports high levels of familiarity and involvement with the goals of TLF, higher rates of school use than do the other three groups of respondents, and a positive view of the quality of TLF materials.

Reported uses of ICT

Below we describe how the four groups of participants responded to survey items that dealt with:

- Frequency of use of various forms of ICT in classrooms
- purposes for using ICT for teaching and learning
- benefits of using ICT in mainstream classroom settings and, separately, non-mainstream classroom settings
- factors that enable and impede the adoption of ICT in schools.

One aim of this comparison is to document empirically the nature and extent of alignments and misalignments of perceived use and benefits of ICT among the four groups.

Frequency of classroom ICT use reported by teachers

Figures 25–30 summarise the responses to this survey item. It can be seen that, apart from the primary school teachers' use of the Internet, usage rates are generally low.

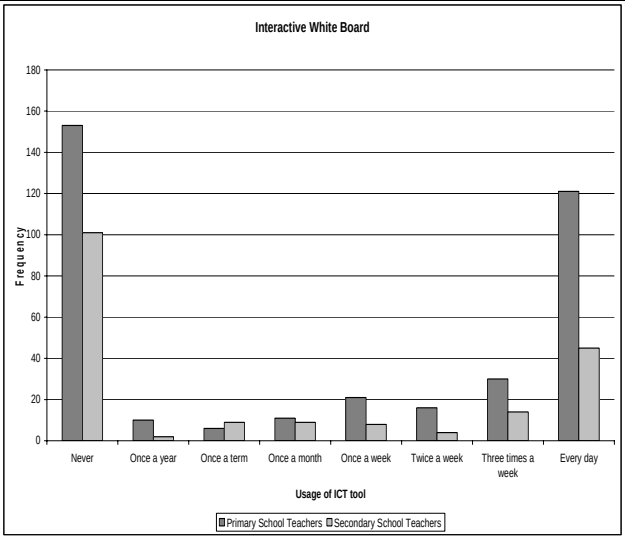

Figure 25: Primary and secondary teachers' reported use of the interactive white board in their classrooms

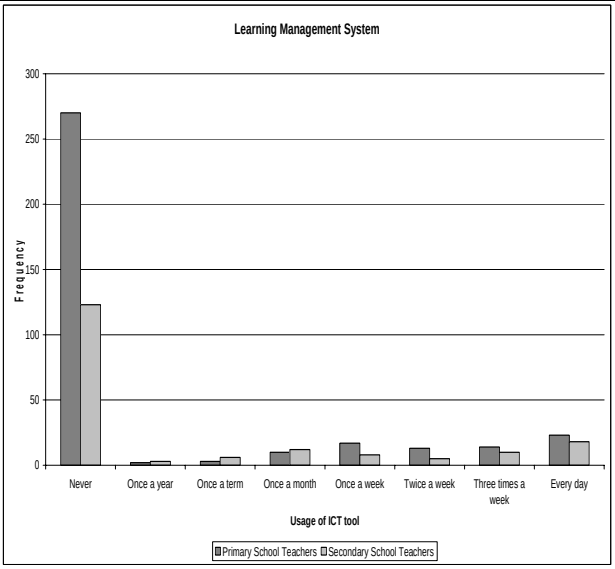

Figure 26: Primary and secondary teachers' reported uses of a learning management system in their classrooms

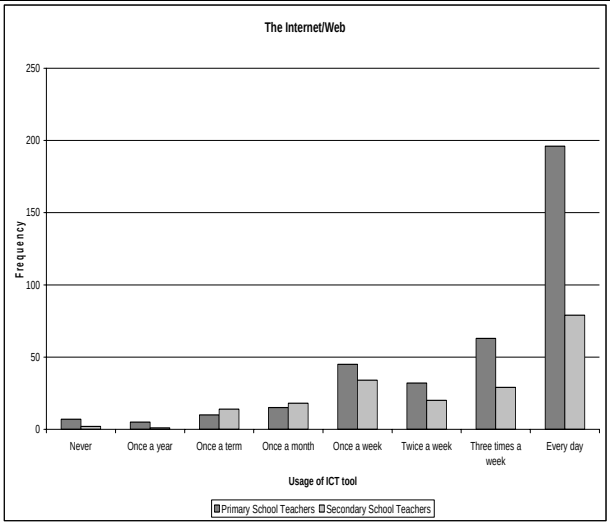

Figure 27: Primary and secondary teachers' reported use of the Internet/web in their classrooms

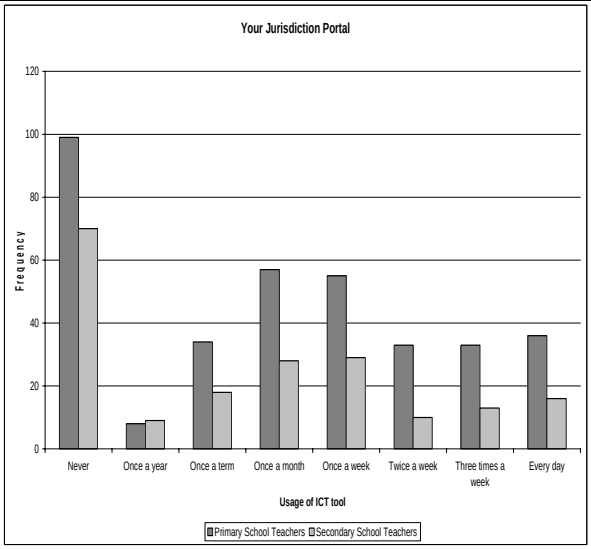

Figure 28: Primary and secondary teachers' reported use of their jurisdiction's portal in their classrooms

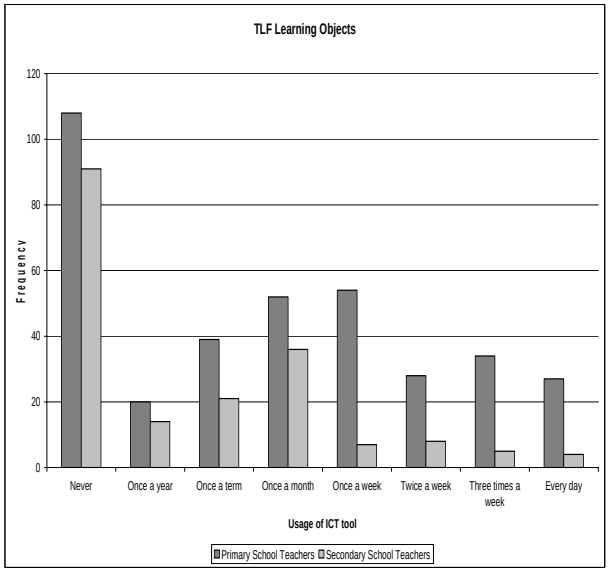

Figure 29: Primary and secondary teachers' reported use of TLF learning objects in their classrooms

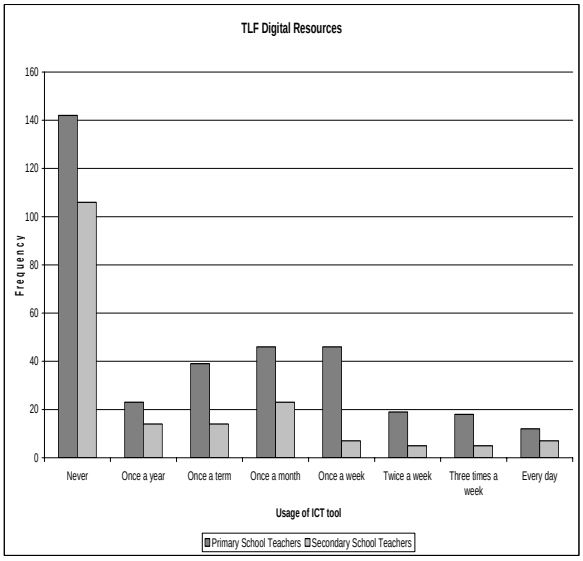

Figure 30: Primary and secondary teachers' reported use of TLF digital resources in their classrooms

Further, over all six variables, there was a highly significant multivariate difference (F(Wilks') (6, 481) = 9.87, $p < .001$, eta-sq=.11) between primary and secondary school teachers in their frequency of use. This significant difference applied to all univariate measures (p's < .01) except for the use of jurisdictional portals. Figure 31 shows that the primary school teachers in this sample reported significantly more use of all six types of ICT except for learning management systems, for which the effect was reversed.

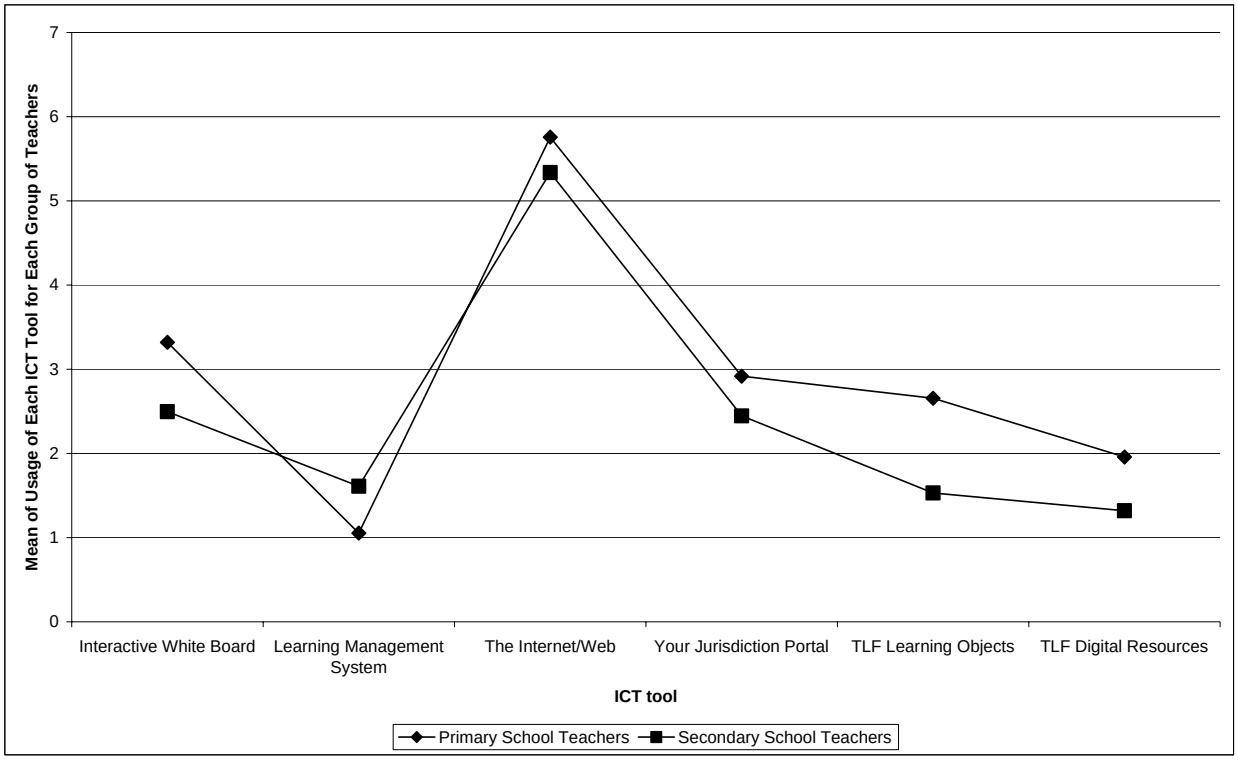

Figure 31: Reported usage rates of six types of ICT in the classrooms of primary and secondary teachers

The difference in favour of primary school teachers was most marked in the case of both forms of TLF materials – learning objects and digital resources.

Estimated frequency of classroom ICT use for particular purposes

All four sets of respondents were asked to rate the frequency of use of ICT in classrooms with respect to eight potential educational uses. These uses arose from the statements of teachers, in earlier administrations of similar surveys over the previous three years, regarding how they used ICT (see Freebody 2005). Figure 32 shows the mean scores for the four groups of respondents as they relate to these eight uses.

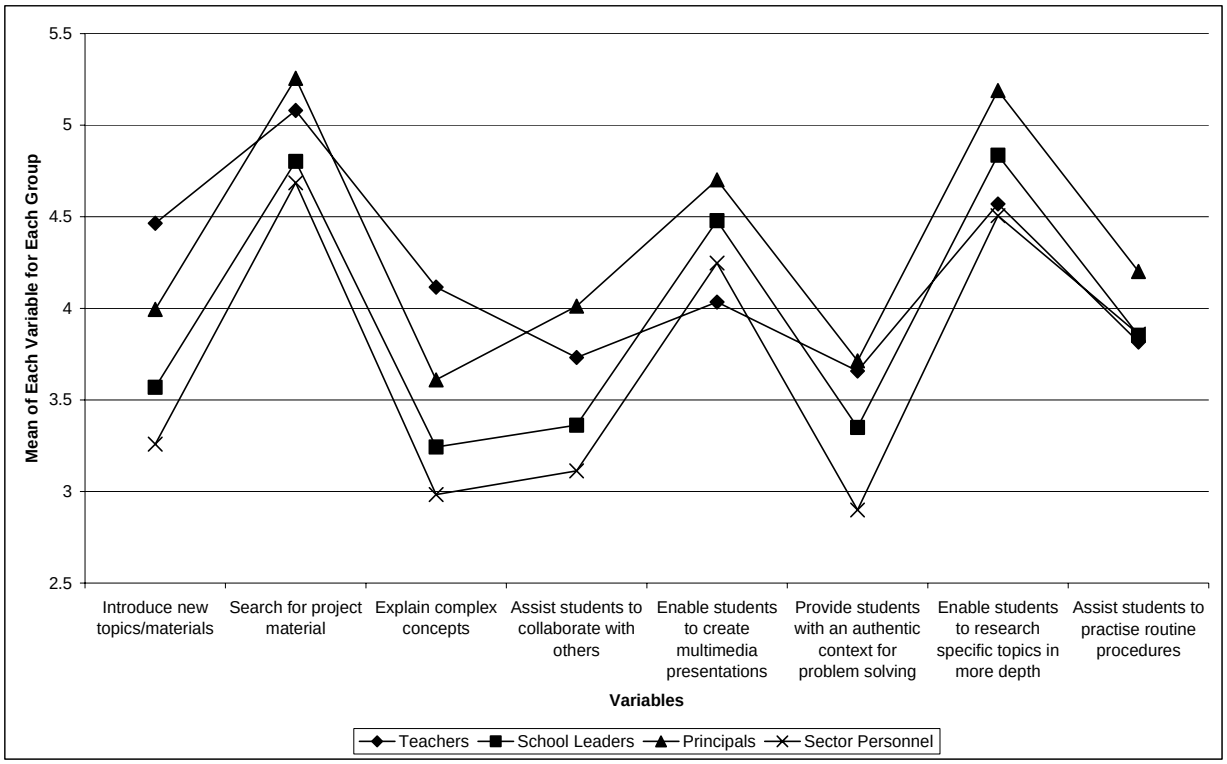

Figure 32: Means of the four groups of educators for their estimates of the frequency of usage of ICT in classrooms for eight separate purposes (7-point scale)

The factor structure (using PCA) underlying these variables was examined as a way of reducing the dimensionality of the group-wise tests for differences. One clear factor (see Figure 33) was found to account for 64% of the total variance (KMO = .89; Cronbach's Alpha = .92; weightings ranging from .62 to .92).

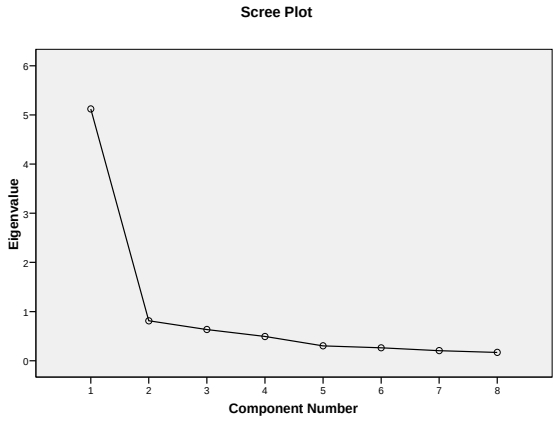

Figure 33: Scree-plot for the factor solution to eight variables indicating rates of usage of ICT for various purposes

Appling ANOVA to the factor scores from this solution revealed significant differences for the four groups of respondents ($F(3, 1432) = 7.90$; $p < .01$). Mean factor cores for the four groups are shown in Figure 34.

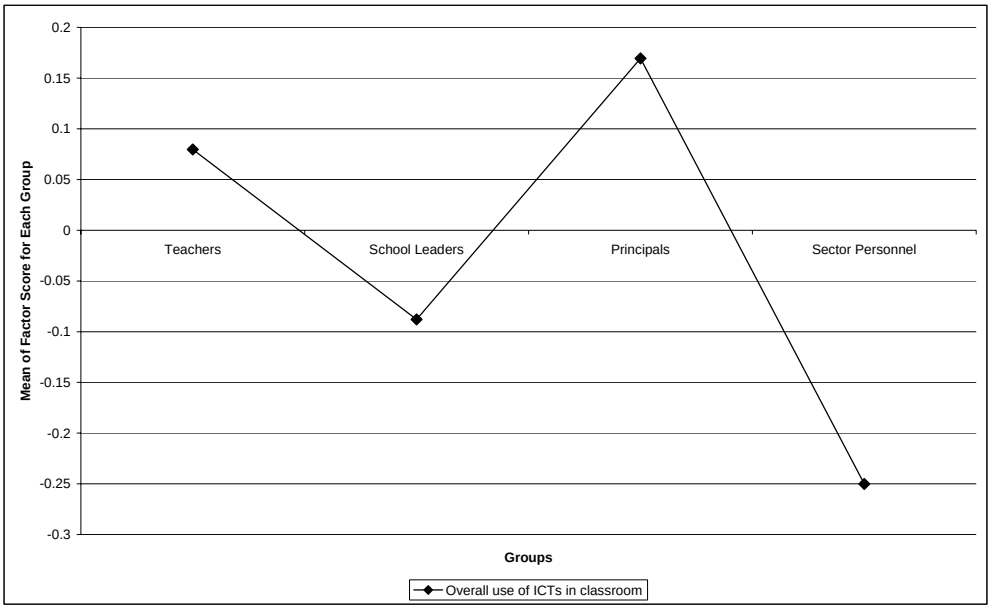

Figure 34: Means of the four groups of educators for their estimates of the frequency of usage of ICT in classrooms (single-factor standard scores)

Using Tukey's HSD test for post-hoc multiple comparisons, it was found that sector personnel estimated significantly less usage of ICT in classrooms for all purposes than did principals and teachers (all p's < .01). We can establish, therefore, that in the simply empirical matter of estimated frequency of the various purposes to which various types of ICT are put in classrooms, these groups are not in good alignment.

Perceived benefits of using ICT, compared with traditional classroom activities and tools, in mainstream classrooms

All four groups of respondents were asked to rate the relative benefits of using ICT in classrooms with respect to 13 potential benefits. Note that the emphasis in this item is on mainstream classrooms. As for the previous item, the list of 13 benefits arose from the statements of teachers in earlier administrations of similar surveys over the last three years. Figure 35 shows the mean scores for the four groups of respondents as they relate to these 13 benefits.

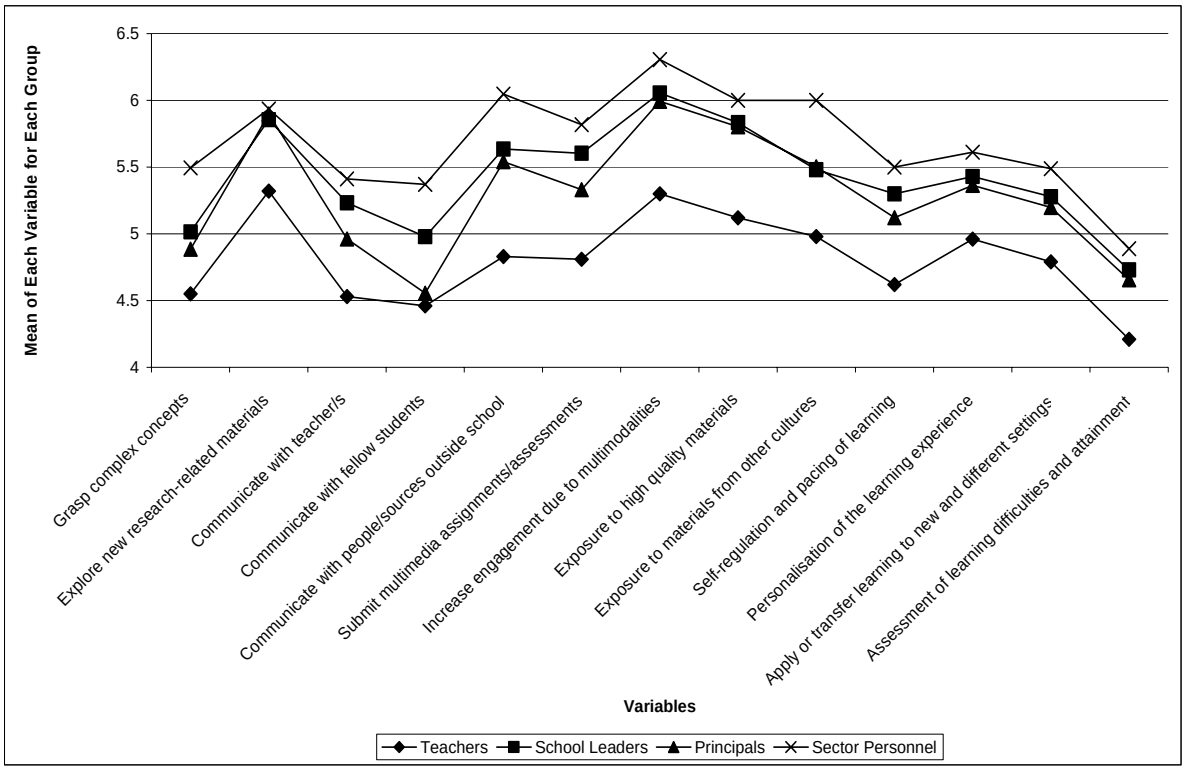

Figure 35: Means of the four groups of educators for their judgements of the benefits of ICT in mainstream classrooms on 13 separate variable criteria (7-point scale)

The factor structure (using PCA) underlying these variables was examined as a way of reducing the dimensionality of the group-wise tests for differences. Two factors showed eigenvalues > 1 (see Figure 36) and they were together found to account for 64.7% of the total variance (KMO = .94; Cronbach's Alphas = .92 and .86). The scree plot is shown in Figure 36 and the simplified factor solution is shown in Table 12.

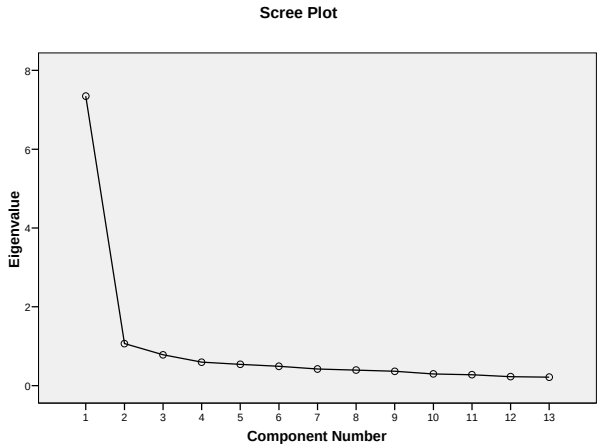

Figure 36: Scree-plot for the factor solution to 13 variables indicating judgements of benefits of ICT for mainstream classrooms

Table 12: Simple factor solution for the 13 variables indicating judgements of benefits of ICT for mainstream classrooms

	Benefits for learning and curriculum	Benefits for communication
Transfer of learning	.91	
Personalisation of learning	.85	
Exposure to quality curriculum	.85	
Self-regulation and pacing	.84	
Assessment of learning difficulties	.74	
Grasping complex concepts	.72	
Materials from other cultures	.71	
Engagement from multimodalities	.60	
Access to new research materials	.51	
Communicating with fellow students		.91
Communicating with teachers		.91
Communicating with outside sources		.77
Submitting multimedia assignments		.60

These variates (Factors 2 and 3 in the original analyses) were termed, respectively: *benefits for learning and curriculum* and *benefits for communication*. Means for the four groups on these two factor scores are shown in Figure 37.

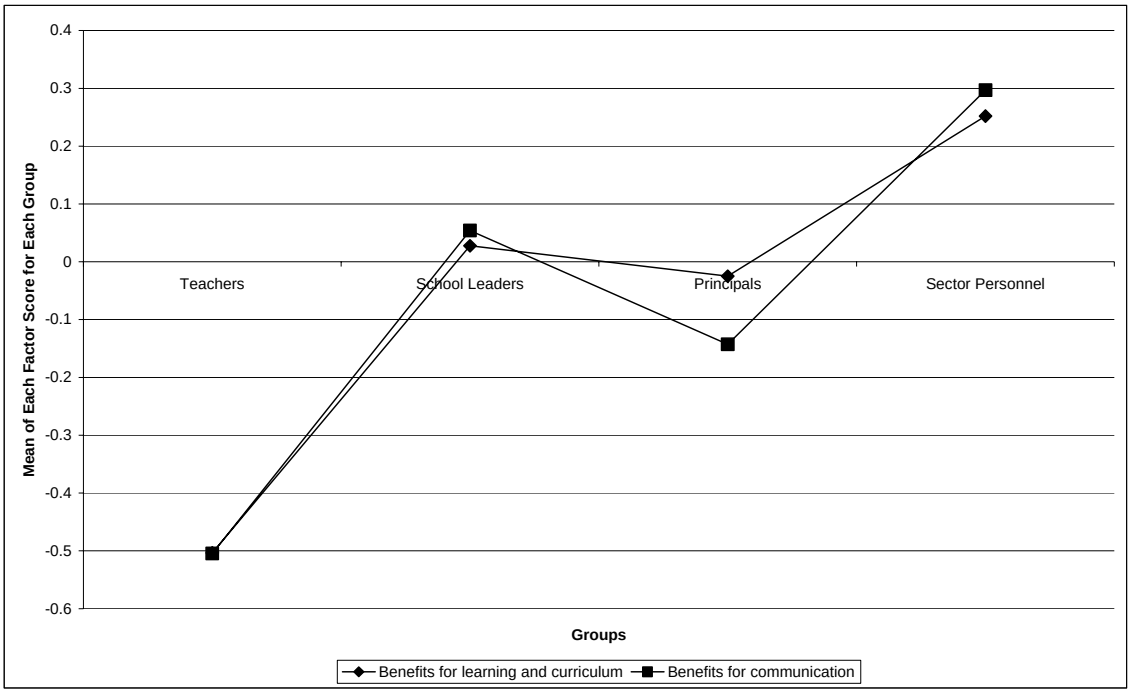

Figure 37: Means of the four groups of educators for their judgements of the benefits of ICT in mainstream classrooms on 13 separate variable criteria (two-factor standard scores)

Differences among the four groups on these two new factor scores were subjected to MANOVA and showed a significant multivariate effect (F(Wilks') (6, 1672) = 9.04, *p*

< .001, eta-sq=.031). Examination of the univariate effects shows that group differences were significant for both factors (both *p*s < .01).

Using Tukey's HSD test for post-hoc multiple comparisons, it was found (with all ps < .01) that:

- teachers estimated significantly lower levels on the factor relating to *benefits for learning and curriculum* than did the other three groups
- teachers estimated significantly lower levels on the factor relating to *benefits for communication* than did either school leaders or sector personnel
- principals estimated significantly lower levels on the factor relating to *benefits for communication* than did sector personnel.

We can establish, therefore, that on the matter of the estimated benefits of using ICT in schools – particularly their benefits for learning and curriculum access, and for communicating with fellow students, teachers and others outside the school – there are substantial and statistically reliable differences among the four groups, with teachers showing comparatively less enthusiasm generally, and sector policy personnel showing stronger enthusiasm.

Benefits of using ICT, compared with traditional classroom activities and tools, in non-mainstream classrooms?

Respondents were asked to repeat the exercise reported above – estimating the benefits of using ICT in classrooms – this time with regard to students in non-mainstream classrooms. Figure 38 shows the mean scores for the four groups of respondents as they relate to these 13 benefits.

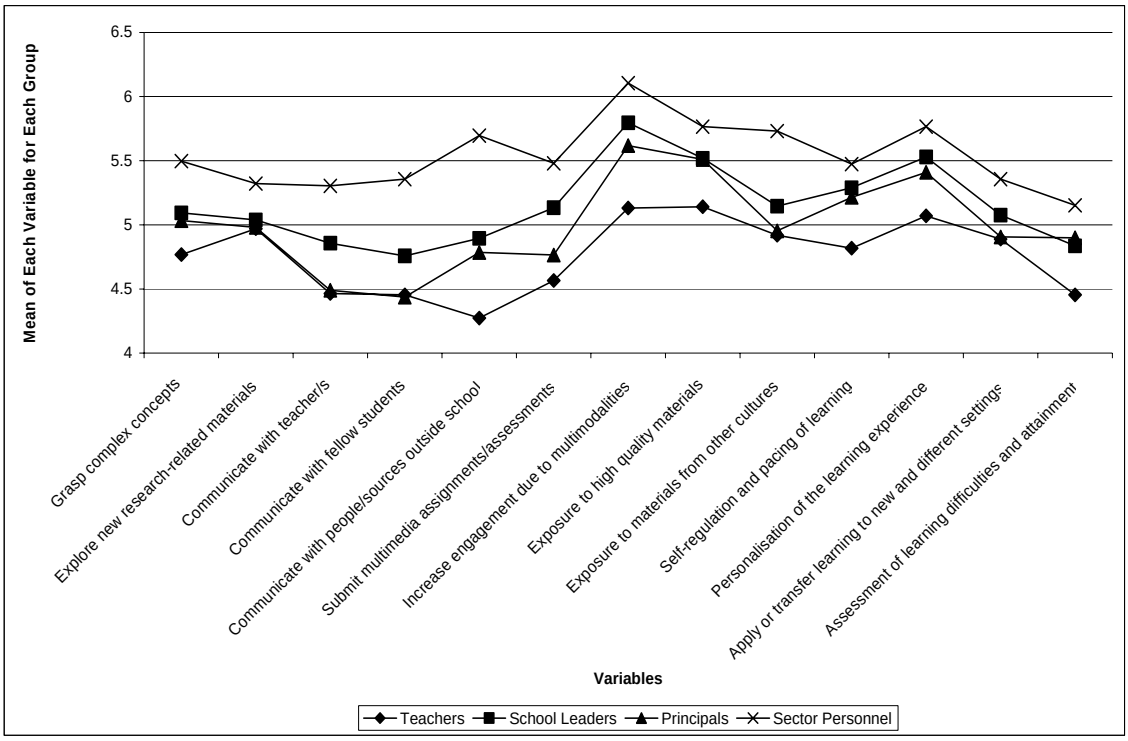

Figure 38: Means of the four groups of educators for their judgements of the benefits of ICT in non-mainstream classrooms on 13 separate variable criteria (7-point scale)

Two factors showed eigenvalues > 1 (see Figure 38) and they were together found to account for 69.8% of the total variance (KMO = .93; Cronbach's Alphas = .92 and .91). The scree plot for this two-factor solution is shown in Figure 39 and the simplified factor solution is shown in Table 13.

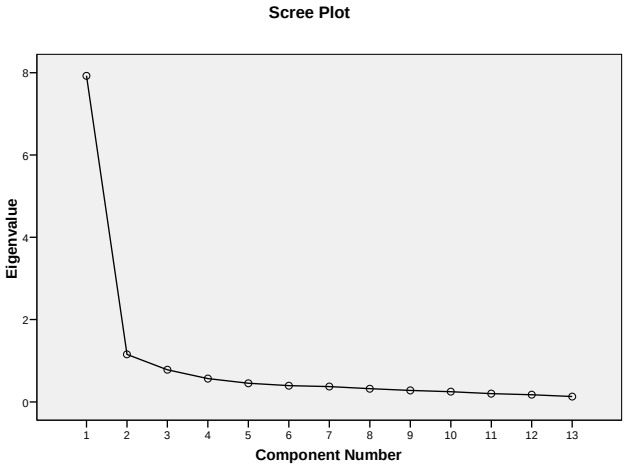

Figure 39: Scree-plot for the factor solution to 13 variables indicating judgements of benefits of ICT for non-mainstream classrooms

Table 13: Simple factor solution for the 13 variables indicating judgements of benefits of ICT for mainstream classrooms

	ICT valuable for learning	ICT valuable for communicating and exploring
Personalisation of learning	.87	
Self-regulation and pacing	.80	
Transfer of learning	.75	
Exposure to quality curriculum	.75	
Assessment of learning difficulties	.69	
Engagement from multimodalities	.67	
Grasping complex concepts	.62	
Communicating with outside sources		.85
Communicating with fellow students		.84
Communicating with teachers		.81
Submitting multimedia assignments		.74
Exploring new materials for research projects		.69
Materials from other cultures		.63

These variates (Factors 4 and 5 in the original analyses) were termed, respectively: *ICT valuable for learning* and *ICT valuable for communicating and exploring*. Means for the four groups on these two factor scores are shown in Figure 40.

Figure 38 shows that ratings are generally well above the mid-point on the scale but there are notably consistent differences among the four groups in their judgements of the level of various benefits of ICT for students with special needs and from non-mainstream backgrounds. Sector personnel register the highest ratings generally and teachers generally the lowest. Teachers gave the highest ratings to the increase in non-mainstream students' engagement in learning brought about by multimodalities (visual, animations, graphs, maps, etc), their exposure to high-quality curriculum materials, and the personalisation of the learning; and gave the lowest ratings to assessment/diagnosis.

The differences in estimated benefits nominated by all four groups of respondents for mainstream classrooms, compared with those nominated for non-mainstream classrooms are also worth noting. It is evident that, in considering students in non-mainstream classrooms, respondents reinterpreted two variables – access to materials from other cultures and access to new research materials – in terms of their communication benefit rather than their benefit for learning. It may be that students in non-mainstream settings (defined in the survey item as those with 'e.g. learning

disabilities, non-English speaking background, perceptual or intellectual impairment') are taken to need more in-school ICT-based stimulus to look for new and cross-cultural materials, or support in doing so; it may also be that respondents considered that, relative to using non-ICT-based strategies to these ends, teachers would have more difficulty especially in the case of non-mainstream students. Accounting validly for this difference is beyond the capacity of the present survey, but the difference does indicate that respondents have relatively finely tuned judgements, accurate or otherwise, about the benefits of ICT in classrooms for diverse groups of students.

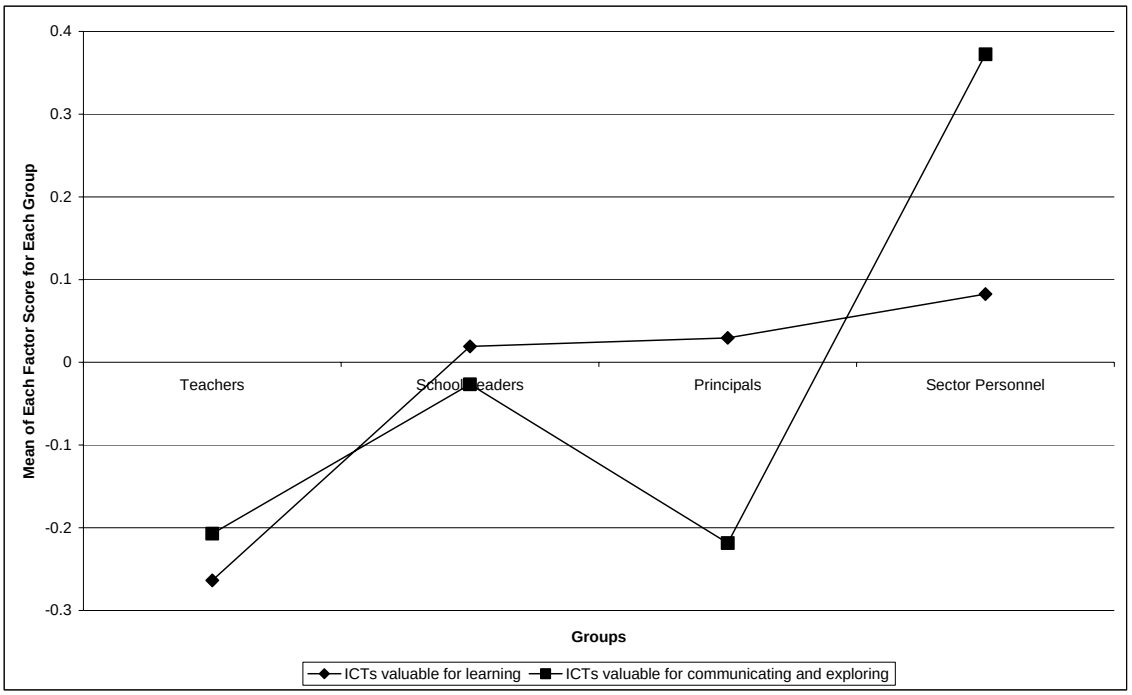

Figure 40: Means of the four groups of educators for their judgements of the benefits of ICT in non-mainstream classrooms on 13 separate variable criteria (two-factor standard scores)

Differences between the four groups on these two new factor scores were subjected to MANOVA and showed a significant multivariate effect (F(Wilks') (6, 1622) = 7.51, $p < .001$, eta-sq=.03). Examination of the univariate effects shows that group differences were significant only for the factor pertaining to communication and exploring new materials ($p < .01$).

Using Tukey's HSD test for post-hoc multiple comparisons, it was found that sector personnel reported significantly elevated estimates of benefits accruing from the uses of ICT to do with communication and exploring new materials, compared to the other three groups (all *p*s < 001). As with the previous analysis, teachers registered lower

levels of estimated benefits than did the other groups, but the difference attained significance only in the comparison with sector personnel.

Factors enabling teachers' adoption of new digital/online technologies in their teaching

Finally, respondents were asked to give their estimates of the importance of a range of factors arising from the research literature and from the case-study components of earlier evaluations of TLF materials conducted by the first author and various colleagues. Means for the four groups are shown in Figure 41.

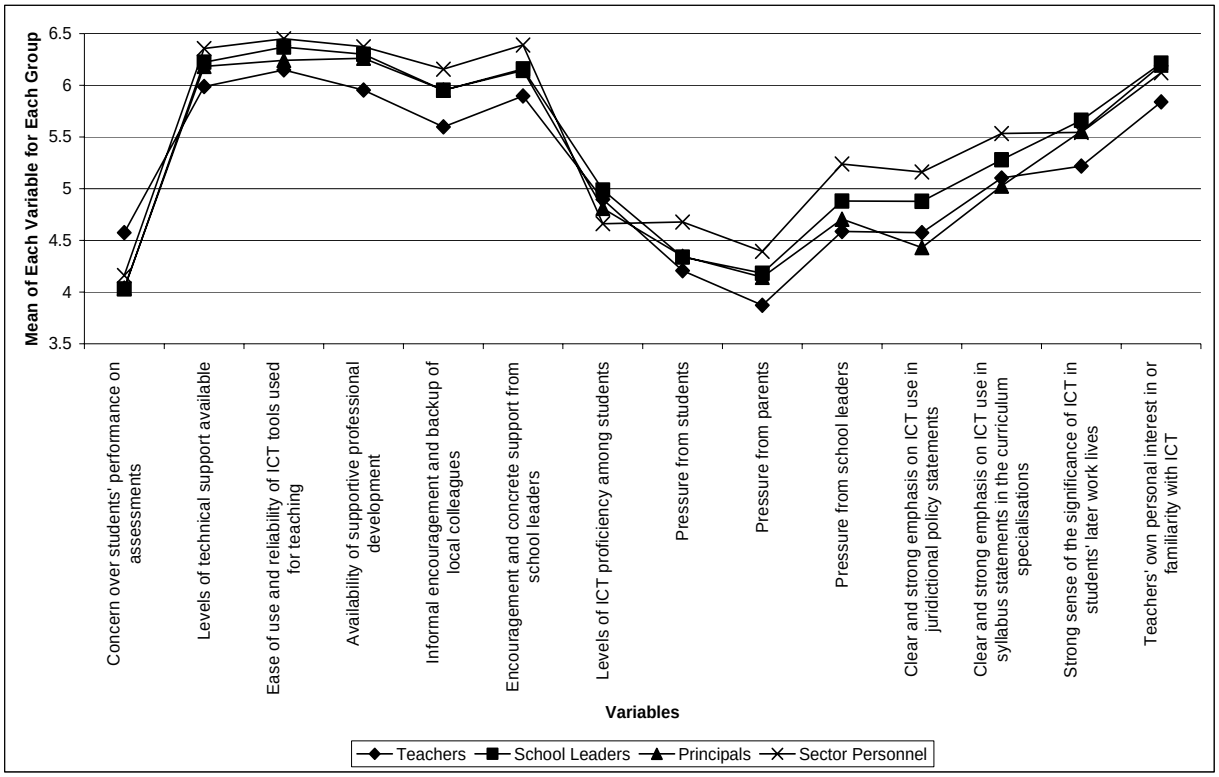

Figure 41: Means of the four groups of educators for their judgements of the factors affecting adoption of ICT in mainstream classrooms on 14 separate variables (7-point scale)

The tight comparability of the levels of emphasis is striking. Three factors[1] showed eigenvalues > 1 (see Figure 42) and they were together found to account for 67.3% of the total variance (KMO = .86; Cronbach's Alphas = .90, .84 and .79). The scree plot

[1] Note that two variables – *concern over students' performance on assessments* and *levels of ICT proficiency among students* – were omitted from the full factor solution as they did not locate reliably in the factor structure, as assessed by Cronbach's Alpha.

for this three-factor solution is shown in Figure 42 and the simplified factor solution is shown in Table 14.

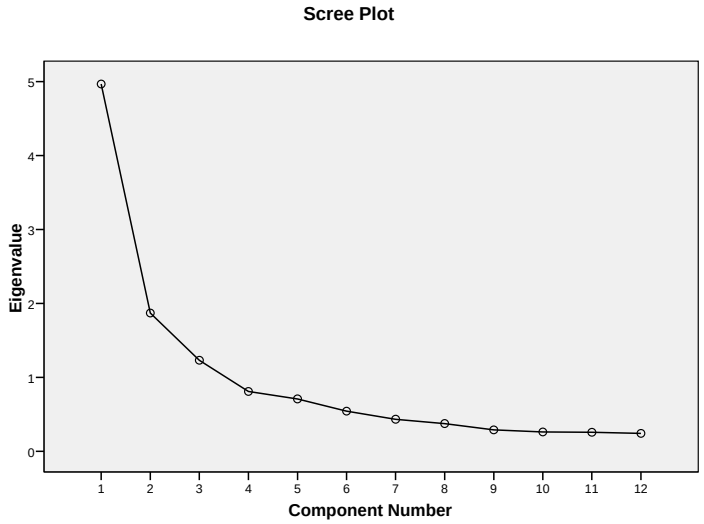

Figure 42: Scree-plot for the factor solution to 14 variables indicating judgements of the factors affecting adoption of ICT in mainstream classrooms

Table 14: Simple factor solution for the 14 variables indicating judgements of the factors affecting adoption of ICT in mainstream classrooms

	Ease of use and support in ICT	Pressure on teachers for ICT usage	Emphasis on policies and syllabuses for ICT
Ease and reliability of ICT use	.86		
Availability of professional development	.85		
Levels of technical support available	.82		
Support from school leaders	.75		
Support from local colleagues	.73		
Teachers' own interest and familiarity	.58		
Pressure from parents		.92	
Pressure from students		.92	
Pressure from school leaders		.74	
Emphasis in syllabuses			.90
Emphasis in jurisdictional policies			.84
Significance for students' later lives			.80

These variates (factors 6, 7 and 8 in the original analyses) were termed, respectively: *ease of use and support in ICT; pressure on teachers for ICT usage;* and *emphasis on policies and syllabuses for ICT*. Means for the four groups of respondents on these three factor scores are shown in Figure 43.

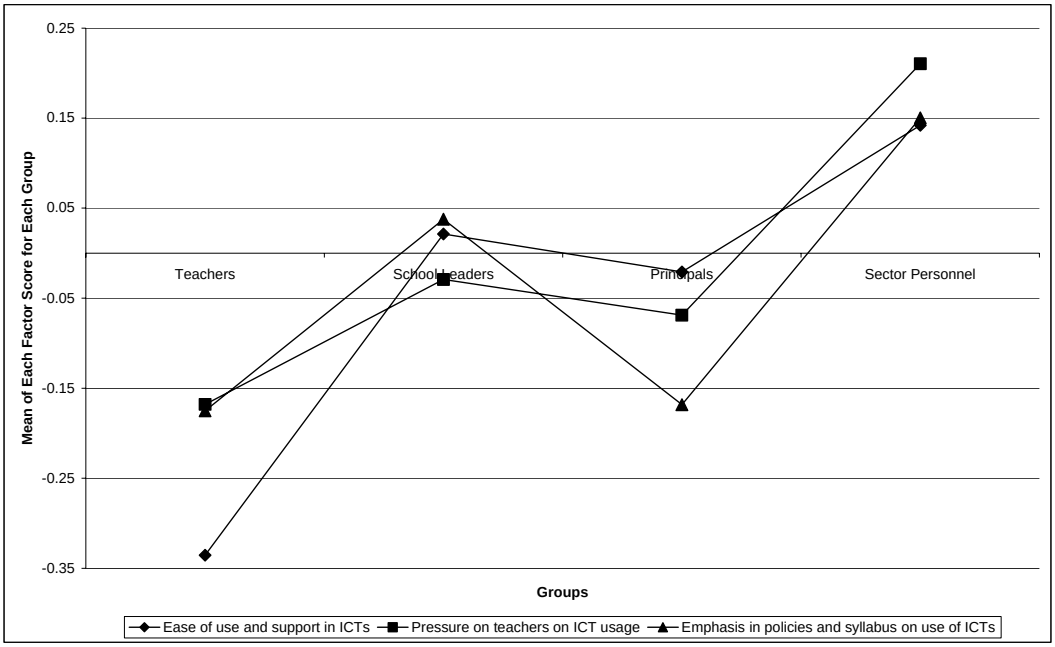

Figure 43: Means of the four groups of educators for their judgements of the factors affecting adoption of ICT in mainstream classrooms on 14 separate variable criteria (three-factor standard scores)

Differences between the four groups on these two new factor scores were subjected to MANOVA and showed a significant multivariate effect (F(Wilks') (9, 2001) = 2.98, $p < .002$, eta-sq=.011). Examination of the univariate effects shows that group differences were significant for all variates ($p < .01$). The contrasts attaining statistical reliability were that:

- teachers indicated less support for *ease of use and support in ICT* than did school leaders and sector personnel (both ps < .01);
- teachers indicated less support for *pressure on teachers for ICT usage* than did sector personnel ($p = .016$); and
- principals indicated less support for *emphasis on policies and syllabuses for ICT* than did sector personnel ($p = .019$).

Conclusions and ways forward

The results of this survey present patterns of perceptions and beliefs that need explaining. One pattern that is striking is that the vast majority of respondents from all organisational levels see TLF content as being of high quality and as helpful in bringing about learning with respect to both cognitive and motivational outcomes, and yet there is a relatively low usage of TLF content. So what impedes the more widespread use of these resources?

The main reasons for a shortfall in adoption that are characteristic of the early stages of an innovation – lack of awareness, access and basic technical skills – are no longer enough to explain the persistently low adoption rate of ICT among teachers sampled on this and previous occasions. Content is widely accessible, teachers are, by and large, aware of the resources, and technical skill gaps have been addressed through widespread professional development in relation to use of ICT in the school sector. From the survey data available to date, there is no reason to believe that teachers and/or other educational personnel have a predominantly negative attitude towards the value of ICT for learning in general, or towards TLF content in particular. It is worth noting, however, that, although still on the positive side, teachers' judgements of the benefits of ICT are significantly lower than those of the other three groups of respondents. This may be due to differences in aspiration, but it can also be due to experience, a choice that cannot be resolved by the survey data at hand.

The generally low adoption of ICT (especially in the middle secondary years) is by no means specific to Australia. It is beyond the scope of this discussion to analyse the research in detail, but the explanations range across low technological reliability, limited access, and limited bandwidth. The latter is, in many countries including Australia, regrettably still the case. Also named are alignment breaks, in particular a lack of alignment between curriculum, pedagogy, assessment of students' performance, and high-stakes testing. It is worth keeping these possible explanations in mind before over-dramatising the lack of adoption of TLF content. If anything, the situation is bound to change in Australia rapidly and dramatically over the next months due to the Australian Government's computing initiative for years 10–12.

Subsequently, perhaps slower but even more widespread adoption will arise from an increasing focus on personalised learning.

In order to address the adoption gap, we suggest a three-pronged approach:

1 *Changing focus* from sector-wide variables to details of use practices
2 *Teachers as innovators* – changing the role that teachers play in the adoption of technology
3 *Design-based research* –changing research methodology from 'at arm's length' studies to 'close-up' studies of technology and practice.

Changing focus

To go beyond explanations that rely on the 'usual suspects', we suggest considering learning objects not only as curriculum resources or as generic information technologies, but as information technology artefacts – as concrete objects in the hands of leaders, administrators, teachers and students. Looking at learning objects as artefacts invites an analytic focus on the practices of use of various groups in an educational sector. We believe that progress in analysing many aspects of educational technology in schools requires studying organisational routines and individual practices in more detail – from 'close-up' rather than 'at arm's length' – and over longer periods of time. This change in perspective is motivated by the observation that, at least in Australia where the use of ICT in education in widespread and mainstream (though not necessarily intensive), explanations for a lack of adoption need to go deeper than merely logistics or attitudes. In particular, explanations need to account for how individual and organisational practices impede or embrace technological innovation. The number of studies that focus on the way teachers interact with and make sense of learning technologies in general, and learning objects and learning object repositories in particular, is surprisingly small compared to studies of other ICT areas. As a consequence, the field of educational technology lacks knowledge of those impediments to technology adoption that are related to work practices and sense making (Weick 1995).

We can regard learning objects, like other technological artefacts, as *negotiated, embedded and sedimented sets of rules for goal-oriented action* (Masino & Zamarian 2003, p 694). This definition, which focuses on the logical function of artefacts rather

than on their symbolic or physical properties, is particularly appropriate for carefully and purposefully designed artefacts such as learning objects. It combines a cognitive perspective (Norman 1991) with an organisational perspective (Orlikowski 2000). Seen as technology artefacts, learning objects are not (only) resources for learning; they mediate people's actions. A central question, therefore, is: What role do these artefacts play in the regulation of work activities? By 'work', we refer in particular to teachers' and students' work – goal-oriented activities in the service of teaching and learning.

By and large, research that has assumed a straightforward deterministic link between ICT artefacts and organisational change has not been successful in establishing consistent findings accounted for by parsimonious theories (Robey & Bourdreau 1999). Various approaches to organisational change have been developed as alternatives, for instance, models based on structuration theory (Orlikowski 2000), institutional theory (Gosain 2004) and actor–network theory (Latour 1996). These perspectives take it that artefacts become causally effective only when used, and that only the agent's intention in the use of the artefact can give it the quality of artefact-in-use. This does not deny the independence of the artefact from human intention and use, but implies that the effective use of an artefact is the outcome of an interaction between the agent and the artefact (Volkoff, Strong & Elmes 2007).

Given the concrete nature of ICT artefacts, we need to be clear about what artefact we are talking about in the context of this study. One relevant type of artefact is the learning object, others are the learning object repository, the portal and the learning management system. Learning object repositories, portals and, in particular, learning management systems can be seen as enterprise systems, whereas the individual learning object can be seen as being a small individual application. Future research needs to be more specific in distinguishing between these categories, because they differ in nature, with respect not only to how the user interacts with them, but also to how decisions on their adoption and deployment are made.

As Norman (1991) observed, 'cognitive artefacts' have two purposes: first, they support the use of scarce cognitive resources (memory in particular) and guide the representation of problems for effective solutions. As well, artefacts have social meaning, representing '… receptacles of common experience ... shared within the

group that conceives, builds and uses them' (Masino & Zamarian 2003, p 695). Since artefacts are purposefully designed, they express organisational values.

The cognitive and social function of ICT artefacts can certainly be found in portals and learning management systems, but they are also found in individual learning objects. An individual learning object can be designed and used for structuring actions, by affording and supporting certain ways of interacting with the encapsulated content. Like technological artefacts in general, learning objects and portals come with a 'tension': on the one hand, an artefact supports cognition and rationality; at the same time, it expresses control over an agent's activities. Artefacts designed for organisational use, in particular, in incorporating an element of heteronomous control, or regulation from the outside, suggest shared ways of going about things.

Masino & Zamarian (2003) put the concept of ICT artefacts into a decision-making framework that is well suited to identifying the various points of potential misalignments of organisational and individual decisions. Their model distinguishes between *design*, *adoption*, and *use* decisions. *Design decisions* concern all the technical, operational and physical features of the artefact, thus including decisions concerning not only functionality but also the way users can interact with the artefact. DeSanctis & Poole (1994) speak of the 'spirit' of an artefact, the way it presents itself to the users.

Adoption decisions deal with how an artefact is to be integrated into the organisational structure, into business and work processes. In the case of learning objects, adoption decisions will typically be made by the teacher or, in the case of self-guided learning, the student. In the case of learning object repositories, portals and learning management systems, adoption decisions are more complex because they concern larger units, such as schools, districts or jurisdictions. In such situations, the main adoption decisions are not made by the end-users, even though the end-users may be consulted.

Use decisions concern the way end-users interact with the artefact in actual work processes, for instance, how a teacher introduces a learning object in her classroom, how deeply a student engages with a learning object in her learning. Analysing use decisions is particularly relevant because users' decisions are not necessarily aligned with the expectations of designers and adopters; the artefact-in-use can be different

from the artefact-as-designed. This is advantageous from an organisational perspective, if the artefact-in-use is an efficient or even creative adaptation to the local situation. It is disastrous when the artefact-in-use is incompatible with the organisational rationale embedded in its design. For instance, the designers and adopters of interactive digital whiteboards probably had in mind purposes different from those for which we see this artefact often being used – for example, as an expensive projection surface for slide presentations.

The manner in which these decision-making processes are related is schematically depicted in Figure 44. Design decisions concern firstly the artefact's core (A1), that is, the elements not directly connected to the users' choices because they are kept outside of users' control. Secondly, they concern the artefact's interface (A2), consisting of those elements directly under the users' control. Users appropriate the artefact through use decisions (B), the most crucial link because it is here that the artefact-as-designed can become distorted, either because of misalignments in the interpretation of the meaning of the artefact, missing alignment with the nature of the users' work, or because the artefact is perceived as a threat to the users' autonomy.

> Use decisions can be seen as a way to gain control over the work process, directly or indirectly, by controlling the way the artefact is a actually used in work activities.
>
> (Masino & Zamarian 2003, p 700).

Users also negotiate with adopters over the manner in which the artefact is embedded organisationally, for instance, over its role in workflows (D). Adoption decisions influence the artefact-in-use by suggesting, or even imposing, certain use modalities and interpretations (C1), and by influencing the artefact's interface by affecting design decisions (C2).

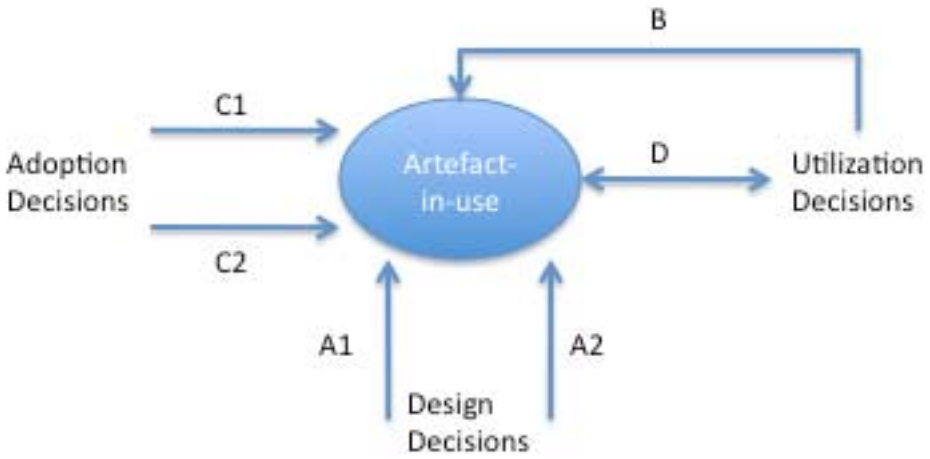

Figure 44: Decision framework for technology adoption (from Masino & Zamarian 2003)

This decision-making model, originally developed to help in understanding the processes involved when software is introduced into organisational work processes (Masino & Zamarian 2003), also provides a useful framework for the analysis of processes involved in the integration of learning objects and learning object repository/portal/learning management system technologies into schools and classrooms. The framework is readily applied to educational technologies such as repositories, portals and learning management systems, since all three share many similarities with enterprise software. The framework can also be applied, on a smaller scale, to the decision making of individual teachers regarding the use of learning objects in their teaching and learning. In this case, teachers act as adopters and as users at the same time, with more weight on the adopter role in situations where teachers select learning objects for students but do not themselves work through the learning objects.

It is worth noting that reforms and innovations can ‘go wrong’ not only because of misalignments and conflicts arising from them, but also because of a lack of specificity and a lack of development support (Cohen & Ball 1999). Specificity refers to the explicitness with which an intervention is articulated and mapped. A well-specified innovation goes beyond goal statements to suggesting specific representations of teachers’ enactments of the innovation (Blumenfeld et al 2000). In the context of decisions about artefact use, introducing teachers to an artefact-as-designed that lacks of specificity in terms of its intended use would allow many different, and potentially conflicting, interpretations of the artefact’s meaning and its

intended use. ‘Development’ refers to the well-known need to support technical innovation with curriculum and assessment materials as well as infrastructural support and opportunities for professional development.

Applied to an analysis of the adoption of learning objects, the practice-oriented analysis of learning objects as ICT artefacts-in-use suggests a focus on questions such as:

- What choices are being made with respect to the learning objects’ user interface and the integration of learning objects into teaching and learning processes?
- To what extent is the learning object supposed to act as a structuring device (Poole & DeSanctis 2004), that is, as a device to gain higher organisational control by implementing heteronomous rules (Masino & Zamarian 2003) into teaching processes?
- How is the learning object interpreted by the users, and how does it affect their work? In particular, how ‘disruptive’ a technology is the learning object vis-à-vis established ways of working and learning?
- How do the users appropriate the learning object, and how is its use negotiated with the adopters?
- What are the divergences between the intended use of the learning object, and its use when appropriated by users?
- What are the differences between the organisational changes (for example, changes in work processes, culture, climate) intended to be triggered by the learning object, and the actual changes that emerge?

Questions such as these can be raised at the various levels of an education system: at the policy level (among policy makers, adopters and users); at the school level, in the interface between district/school management (as adopters) and teachers (as users); and at the classroom level, in the interface between teachers (as adopters) and students (as users).

Teachers as innovators

Learning and teaching have been changing rapidly. In trying to move away from standardised approaches, schools are increasingly aspiring to personalise learning and to adapt instruction to the needs of sub-groups and individual students (OECD 2006).

Rather than focusing exclusively on teaching what is known, teachers are being urged to guide learner-inspired processes in knowledge building (Bereiter 2002b; Fisher, Higgins & Loveless 2006; Hargreaves 2006). To succeed in supporting students in this open and intrinsically unpredictable process, teachers cannot rely only on existing domain and pedagogical knowledge, but instead need to be knowledgeable designers and investigators of their own instructional practices (Bereiter 2002b; Hakkarainen, Palonen, Paavola, & Lehtinen 2004; van den Dool & Kirschner 2003). Teachers need to be able to create and adapt their instructional practices, to use robust methods of systematic inquiry, to engage in knowledge-building dialogues with professional instructional designers and university researchers, and to contribute to advances in their specialist knowledge domains. In other words, teachers need to work as *innovators* who design and create new pedagogical practices, as *researchers* who inquire into and assess their innovations, and as *knowledge builders* who contribute to accumulating the knowledge of their professional community.

More generally, in order for innovative technologies and innovative pedagogies to become usable and sustainable in classrooms, schools themselves must become more like innovation systems (Fullan 2005) or innovation networks (Hargreaves 2003). This requires, in particular, that teachers be committed, encouraged and supported to engage in systematic disciplined innovations and systematic inquiry into their own practices. As Markauskaite and Reimann (2008) have argued, this requires shifting the focus from developing teachers' ICT skills and putting ICT in schools, towards enhancing teachers' capacities to innovate with ICT, to engage in inquiry into their own daily work practices, and to create school-level and larger-level innovation systems. From earlier reports of the use of ICT and TLF materials in schools, which include case studies of effective practice (for example, Freebody & Muspratt 2007a), it is clear that some teachers and some schools are already well on the way towards bringing about these processes.

The capacity for innovation in education may be increased by supporting more developmental work led by teachers and schools (Bentley & Gillinson 2007; Bereiter 2002a; Hannon 2007; OECD 2004). The need for innovation is driven not only by technological developments but also by the recent shift towards personalised education (OECD 2006). As Bentley and Gillinson (2007) stated, students and parents have expectations that educational services will be tailored to their needs; and,

together with educators, they are willing to be involved in shaping these services. This cultural and social shift makes new demands that can open new avenues for classroom innovation.

The central role in educational change and innovation is typically attributed to leading teachers who innovate in their everyday practices. Foray and Hargreaves (2003), however, identify two broad issues in the structure and dynamics of professional knowledge that impede the efficiency of innovations in classrooms. First, linkages and feedback between formal research and classroom practices are weak, with professional researchers rarely drawing upon the practical knowledge of innovative practitioners. Practitioners' capacity and willingness to conduct educational experiments are also limited. Secondly, most of a teacher's practical knowledge remains tacit. Lack of knowledge codification impedes the accumulation of know-how and, as a result, information spillovers and dissemination are weak. The last few decades have seen an substantial growth in volume and interest in practitioner inquiry in education (Cochran-Smith & Lytle 1999; Dana & Silva 2003). The outputs, however, vary greatly in quality and significance. Some typical critiques of teacher–researcher approaches describe insufficient conceptual and methodological rigour, low generalisability of practice-oriented and highly contextualised outputs, and a lack of clear connection of practitioners' research goals with larger social and political agenda (Cochran-Smith & Lytle 1999).

In the traditional scientific innovation model, better outputs are typically achieved through a twofold process: by investing more in fundamental research, and by improving the efficiency of the development processes through which formal research is transformed into products that reach the market and the workplace (Bentley & Gillinson 2007). This innovation chain, however, is not so straightforward in education. As Bentley and Gillinson (2007) point out:

> Developing applications, like teaching materials, that really take note of [this] fundamental insight, may depend heavily on user testing and development, rather than just on prototyping new educational products and bringing them to market. (pp 9–10).

While basic laboratory-based research may support educational innovation, ground-breaking fundamental discoveries have a less central role; they can affect educational practices only through practitioners' acceptance, sense-making and everyday work.

As in many other service-oriented domains, most educational innovations are incremental, emerging from everyday practices in response to specific issues, rather than derived from formal experimental research (Bentley & Gillinson 2007; Bereiter 2002a, 2002b). Therefore, designing educational innovations, testing them in actual learning settings, and conducting purposeful work on improvement of designs and incremental development, can all be more important than isolated scientific experiments.

We argue that, in order to make progress with the integration of ICT in general and TLF content and technology in particular into classroom activities, teachers need to be more involved in the design of ICT artefacts, and need to be more involved in research on how students use these artefacts and what they learn from this use. We argue further that the paradigm of design-based research is a promising methodological approach to research into innovation in education, precisely because it yields knowledge that teachers can incorporate into their pedagogical decision making and practice (Markauskaite & Reimann 2008).

Design-based research

Design-based research represents an advance on the traditional choice between standard, clinic-style experimentation (which generally takes little account of the diversity and complexity of educational settings) and ethnographic or action-research descriptions (which take little account of a system's legitimate interest in finding grounds for productive generalisation and 'scalability'; see Bannan-Ritland 2003). Design-based research experiments have established themselves as productive approaches to the examination of the effects of interventions in classrooms by demonstrating both responsive management of variables and the provision of rigorous small-scale prototyping of intervention elements. Cobb, Confrey, di Sessa, Lehrer & Schauble (2003), for instance, point out that design-based research can explain why teaching and learning designs *work*, and can provide empirical bases for how they can be adapted to new circumstances.

'Design-based research' was proposed in the early 1990s by Brown (1992) and Collins (1992) as an extension of other educational research methods. Since then, it has been used in educational technology research in various forms, and in recent years

it has been the subject of extensive methodological discussions and reflections in special issues of educational journals such as *Educational Researcher* (Kelly 2003), *The Journal of the Learning Sciences* (Barab & Squire 2004) and *The Educational Psychologist* (Sandoval & Bell 2004).

Design-based research was developed to address several key issues central to research into learning, including the need to address theories of learning, to study learning in the real world, to go beyond narrow measures of learning, and to derive research findings from formative evaluations (Collins 1992). Wang and Hannafin (2005) defined design-based research as:

> a systematic but flexible methodology aimed to improve educational practices through iterative analysis, design, development and implementation, based on collaboration among researchers and practitioners in real-world settings, and leading to contextually sensitive design principles and theories. (p 6)

They identify five characteristics of design-based research. It is:

- pragmatic, that is, design-oriented and intervention-oriented
- grounded in theory and research
- interactive, iterative and flexible
- integrative
- contextual.

As Markauskaite and Reimann (2008) argue, design-based research provides a framework for research into pedagogical and technical interventions in classrooms that affords rigour with respect to the methods employed, and that gives rise to *distributed* educational research (distributed among designers, teachers, and university researchers). It thus offers a pragmatic approach to the huge demands on time and expertise that are necessary conditions of high-quality research.

While design-based research has proved to be appropriate for small-scale (classroom) and mid-level scale (school) research, it has so far not been transferred to larger-scale work at a district or system level. Markauskaite and Reimann (2008), however, have suggested that such larger-scale projects might be accomplished through building on recent developments in e-research, such as the use of Grid computing methods in the social sciences. In this report, and in related work (Markauskaite & Reimann 2008),

they suggest that, for studying uses of ICT in educational settings on a larger scale, ICT should become not only the *object* of study but also the *tool* for conducting it. They conclude that educational technology cannot continue to be confined to developing platforms and tools for teaching, learning and administration. The vision of ICT integration in schools needs to be broadened to include cooperatively conducted inquiry processes. This becomes a reality with the emergence of e-research methods and technologies (O'Brien 2005). Developers of educational technologies might gain inspiration from sectors with a longer tradition of using e-research to support systematic inquiry, such as e-science, where technological environments support a complete digital chain of knowledge creation (De Roure & Frey 2007), and e-social science, where integrated research data are embraced to support evidence-informed decision making (Philip, Chorley, Farrington & Edwards 2007). Similar e-inquiry environments with built-in research and innovation tools can scaffold all stages of teacher-led innovation processes and help integrate individual innovations into larger knowledge-creation systems.

So focusing future research on critical aspects of teachers' and students' practices in the use of TLF content and ICT more generally, combined with an extension of teachers' roles in the evaluation process and a research approach that includes designers, adopters, teachers and students in intervention studies, can lead to insights into the complexities of innovation adoption and appropriation that go beyond the scope of studies that report only outcomes and reports of practice.

Summary recommendations

Learning objects, and ICT more generally, need to be seen as both curricular and technical interventions into classrooms. In that regard their use poses challenges to teachers and students that are cognitive, attitudinal, technical and practical. Studying their adoption, adaptation and sustained use therefore means building up detailed knowledge from a variety of case sites, targeting practices and outcomes in close-up design-based interventions in which everyday practices – initiations, modifications, challenges, responses and outcomes – are documented and disseminated. The development of such a corpus of research findings can then allow the collection of repertoires of successful pedagogical practices in which teachers have adopted, integrated and coordinated their uses of learning objects and ICT generally. In these

ways, actual knowledge of practice can form the basis or a more nuanced view of the extent of system-wide alignment.

This is important because there is currently no well-developed sense of the extent to which misalignments of ICT policy and practice among educators constitute a strength or a weakness of a sector or system. This issue has considerable significance for our understanding of the uses of TLF and other ICT-based online materials, and on actions to be taken on the basis of that understanding. It is impossible to resolve this issue through conducting one definitive research study. Rather, resolution requires a patient and focused set of collaborative research efforts over extended periods of time, and the support of educational jurisdictions with enough confidence to invest in such efforts.

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Appendix

The surveys administered to each of the four groups of educators are provided below as separate files in PDF format:

Survey of teachers	TLF Survey_Teachers.pdf
Survey of school leaders	TLF Survey_School Leaders.pdf
Survey of principals	TLF Survey_Principals.pdf
Survey of sector personnel	TLF Survey_Sector Personnel.pdf