# Creating efficiencies in teaching:
# where are the right resources when you need them?

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## Structured abstract

**BACKGROUND**
Early career engineering academics are encouraged to join and contribute to established research groups at the leading edge of their discipline.  This is often facilitated by various staff development and support programs. Given that academics are often appointed primarily on the basis of their research skills and outputs, such an approach is justified and is likely to result in advancing the individual academic's career. It also enhances their capacity to attract competitive research funding, while contributing to the overall research performance of their institution, with further potential for an increased share of government funding.

In contrast, there is much less clarity of direction or availability of support mechanisms for those academics in their role as teachers. Following a general induction to teaching and learning at their institution, they would commonly think about preparing some lecture materials, whether for delivery in a face-to-face or on-line modality. Typically they would look for new references and textbooks to act as a guide for preparing the content. They would probably find out how the course has been taught before, and what laboratory facilities and experiments have been used. In all of these and other related tasks, the majority of newly appointed academics are guided strongly by their own experiences as students, rather than any firm knowledge of pedagogical principles. At a time of increased demands on academics' time, and high expectations of performance and productivity in both research and teaching, it is essential to examine possible actions to support academics in enhancing their teaching performance in effective and efficient ways.

**PURPOSE**
Many resources have been produced over the years in engineering schools around the world, with very high intellectual and monetary costs. In Australia, the last few years have seen a surge in the number of ALTC/OLT projects and fellowships addressing a range of engineering education issues and providing many resources. There are concerns however regarding the extent to which these resources are being effectively utilised. Why are academics still re-inventing the wheel and creating their own version of teaching resources and pedagogical practice? Why do they spend so much of their precious time in such an inefficient way?

**DESIGN/METHOD**
A symposium examining the above issues was conducted at the AAEE2012 conference, and some pointers to possible responses to the above questions were obtained. These are explored in this paper and supplemented by the responses to a survey of a group of engineering education leaders on some of the aspects of these research questions.

**RESULTS**
The outcomes of the workshop and survey results have been analysed in view of the literature and the ALTC/OLT sponsored learning and teaching projects and resources.  Other factors are discussed, including how such resources can be found, how their quality might be evaluated, and how assessment may be appropriately incorporated, again using readily available resources. This study found a strong resonance between resources reuse with work on technology acceptance (Davis, 1989), suggesting that technology adoption models could be used to encourage resource sharing.

**CONCLUSIONS**
Efficient use of outstanding learning materials is an enabling approach. The paper provides some insights on the factors affecting the re-use of available resources, and makes some recommendations and suggestions on how the issue of resources re-use might be incorporated in the process of applying and completing engineering education projects.

**KEYWORDS**
Learning resources, resources re-use, technology enabled learning, student centred learning

## Introduction

At a time of increased demands on academics' time, and high expectations of performance and productivity in both research and teaching, it is essential to consolidate efforts and maximise efficiency. In their research work, newly appointed engineering academics are encouraged to join established research centres working at the leading edge of their discipline in conjunction with their colleagues. However, developing those same academics' skills in teaching and pedagogy often does not seem to follow a similar collaborative pattern.

After a general induction to their institution's teaching and learning policies and practices, and possibly some foundations in pedagogy and curricula design through an internal program such as a Graduate Certificate in Higher Education, a new academic who is given the responsibility to teach a course unit might commonly think about preparing lecture materials, whether for delivery face-to-face or on-line. Typically they would look for new references and textbooks to act as a guide for preparing the content. They would probably find out how the course unit has been taught before, and what laboratory facilities and experiments are available and have been used previously, and they may seek previous students' results and unit evaluations. More often than not, they will follow their consideration of content by the design and preparation of the all-important assessment. In all of these tasks, many newly appointed academics are guided strongly by their own experiences as students, rather than any firm knowledge of pedagogical principles.

An established academic assigned the responsibility of teaching a new course, would probably follow a similar process, perhaps spending less time on locating appropriate teaching resources such as textbooks. Driven in part by underlying disciplinary knowledge bases and in part by accreditation processes, the majority of the curricula within course units in undergraduate engineering programs across the world's universities are very similar. The major differences lie in how material is packaged within different subjects or courses. Every academic has some known (and many unknown) colleagues who have been teaching the same content for many years, and have prepared extensive teaching materials, resources, assessment items, etc. Much of the preparation time referred to earlier is therefore duplicating others' work, rather than making effective use of existing resources and ensuring the best possible learning for students in their local context, or knowingly advancing the practice of teaching.

This study found a strong resonance between resources reuse with work on technology acceptance. It also suggests that technology adoption models might be used to more effectively encourage resource sharing.

## Background

Many engineering educational resources have been produced over the years, representing an enormous intellectual and monetary investment. In Australia, the last few years have seen a surge in the number of ALTC/OLT projects and fellowships addressing various engineering education issues and developing resources. It would be hoped that such resources, covering both content and educational processes, would become widely adopted. Many of the guidelines for university or national learning and teaching grants require applicants to address dissemination of outcomes and indicate how project outcomes and deliverables will be used beyond the lifetime of the project. However, despite significant planning and good intentions by both the applicants and funding bodies, there is little evidence of substantial uptake and utilisation of these resources. Despite this lack of uptake, there is a long history of research exploring the benefits that arise from the reuse of resources, with a significant increase in attention to this area as the Internet increasingly facilitated shared access. For example, Littlejohn (2003) discusses the benefits that arise from reuse of educational resources, and considers the various models that facilitate sharing of resources. Similar work has been carried out more recently by Downes (2007) and Perkins (2007), where the focus has been on models for making resources accessible.

Narrowing the focus somewhat, other authors have considered specific institutional issues.

Yuan, MacNeill and Kraan (2008) provide some useful insights into the type of resources which might be shared, but also highlight key drivers and inhibitors of sharing – though largely from the perspective of the institution making the resources available rather than those making use of the resources. Work such as this highlights a significant issue with much of the current work in this area – that there is often a tacit assumption that if resources can be made available for sharing then the inherent benefits will automatically mean that potential users of those resources will choose to adopt them. This is, however, often not the case and there is, unfortunately, only limited insights within the literature as to how to encourage the use of shared resources once they are available or why such use is so sparse.

Warwick, Terras, Huntington and Pappa (2008) gave substantive consideration of the use of Internet resources. They describe outcomes of their study of the Log Analysis of Internet Resources in the Arts and Humanities. Whilst focused in the humanities rather than engineering, this "*identifies factors that may predispose a digital resource to become used or neglected in the long-term*". A particularly interesting aspect of the research was consideration as to why 'neglected' resources were not being used. Whilst many of the results are still somewhat speculative, the research does provide an interesting set of recommendations related to aspects such as availability, nomenclature, access interfaces, and resource quality. A number of other studies (e.g. McMartin et al, 2008; McNaught et al, 2003) also consider the issues that affect the use of online resources. Generally these studies emphasise that this is a complex problem that involves both individual motivations and organisational drivers.

In a quantitative study of organisational factors affecting knowledge sharing, Costa and Monteiro (2012) surveyed 162 university teachers from Management, Psychology and Economics departments in Portuguese public universities. They applied exploratory factorial analysis to validate the knowledge sharing scale on their sample. They report that effective organisational commitment has a positive and significant impact on knowledge sharing behaviour. Although this study did not target engineering academics specifically, it points to factors beyond the individual academic that might affect their attitude towards sharing and using knowledge. It is not clear however whether this can be extended to the utilisation of readily available resources.

In their book "*Raising the stakes*" Coaldrake and Stedman (2013) devoted a chapter to analysing the success or otherwise of educational initiatives aimed at making course materials freely available to students, and academics. They showed that such ventures can be very costly, and at least in some cases, require up-front investment. Such investment is based on certain assumptions about the uptake that may not materialize. They also observe that such initiatives may prove to be unsustainable. Interestingly, they indicate that course materials associated with prestigious universities have often successfully attracted significant exploration, not only from students but also from academics. In the latter case it is unclear if this was driven by academics' desire to determine whether they could be used either directly or indirectly in their own teaching.

In contrast to the above, Marjanovic (2013) investigated the sharing and reuse of innovative teaching practices in the business analytics discipline. This was part of a project that aimed at enhancing teaching practices and making improvements to knowledge sharing and reuse of innovative practices. To do so, they describe a three-layer repository model, considering instructional resources, learning designs that are specific to certain disciplines, and instructional design patterns. However, the applicability and effectiveness of such a model to engineering education requires further investigation.

Whilst the above studies are useful, it is also interesting to note the work by Kemp and Jones (2007), who argue that there are significant disciplinary differences in the factors that affect reuse. From this we can hypothesise that the issues within Engineering might be significantly different from the issues within, say, science or the humanities – and hence we need to take care in drawing conclusions related to Engineering from studies in other areas. It also emphasises the importance of studying the issues specifically within Engineering.

This paper is an attempt to answer questions such as: why academics involved in Engineering education are still re-inventing the wheel and creating their own version of everything? Can we find better ways forward? What is stopping us? What could assist us?

## Available resources

Over the past six years, an estimated $7M has been spent by Australian government agencies (typically the Australian Learning and Teaching Council, its predecessor the Carrick Institute for Learning & Teaching in Higher Education, and its successor, the Australian Government's Office for Learning & Teaching) on about 40 specific fellowships and projects to improve university engineering education. The participating universities have usually matched this investment through their investigator's time and other resources.

An early project was a national review of engineering education led by the Australian Council of Engineering Deans (ACED) to set a general framework for improvement (King, 2008). Its broad recommendations stressed the need for engineering academics to improve their pedagogical knowledge, engage with active learning, and *share educational resources*. Over 2008-13, the ALTC funded a network for educators in Engineering and ICT to support some of this work, including annual meetings of Associate Deans (Teaching and Learning), workshops on teaching and learning, and a website, http://www.arneia.edu.au, in which summaries of projects and exemplars of good practice may be found. Another useful site maintained by AAEE – http://aaee-scholar.pbworks.com – maintains links to many other useful sites such as SPARK, Peerwise, Teamwork and Communication skills, Research Skills, Ethics, Sustainability, Adaptive e-learning Tutorials, Intercultural competencies, Calibrated Peer Review and many more. These linked sites contain either substantial repositories of shared resources, or are portals to other resources.

The nationally funded fellowships and projects are typically awarded competitively against discipline-independent criteria and, almost without exception, have multiple university partners. Generally the projects, whilst focused on an Engineering context, address concepts that are broadly applicable across most disciplined. Only a minority are engineering topic specific, such as mechanics, or confined to a specific engineering discipline. Rather, they cover cross-disciplinary educational issues, such as students' learning styles, project and group work, specification of graduate attributes and learning outcomes, and threshold concepts, amongst other topics. All of the projects and fellowships have produced material outputs and change, particularly amongst their participants. But their focus may not be perceived by many engineering academics to relate to the function they consider central to their roles: teaching content-rich material in a pre-defined curriculum.

The take-up of outcomes from broadly aimed national projects even within the participating universities has not, to the authors' knowledge, been examined systematically. Dissemination by publication is generally insufficient to ensure wide adoption by others, without other initiatives such as workshops and external drivers. The most critical external driver for curriculum change in Australian engineering has been accreditation. The AQF (Australian Qualification Framework) (AQF Council, 2013) has also been influential recently, and TEQSA will surely bring further requirements. Since 2008, AAEE and the Engineers Australia Accreditation Centre, with funding support from ACED have run annual workshops on curriculum mapping and alignment for the revised-outcomes based accreditation system (Engineers Australia, 2013), that have generally been regarded as valuable by the leaders of the engineering education community'. These activities have the potential to also encourage greater adoption of resources, though there is little data on the level of the resulting impact.

## Investigations

This section presents the outcomes from two activities over the last year: a symposium at AAEE2012 and a poll of academics in an attempt to better understand these complex issues.

### A.      Outcomes of the discussions at AAEE2012 Symposium

At the AAEE2012 conference, the authors conducted a symposium entitled: "The "not

invented here syndrome: Breaking the resources re-use barrier." With recognition that there are many resources currently available and accessible via the Internet, including published courseware by some prominent international universities, the symposium aimed at seeking practical answers to questions such as: Why is it that academics are still re-inventing the wheel and creating their own version of everything? Why do academics spend so much of their precious time in such an inefficient way? Is this due to the "not invented here" syndrome"? Can we find better ways forward? What is stopping us and what could assist us? Discussions identified some useful resources in Australia and from the international community (see earlier). The discussions coalesced in two main areas: *barriers* to changing current practices of academics creating their own resources; what needs to change? And *enablers* for resources reuse. These are summarised below.

## A.1    Barriers to change

**Learning development (technology) staff are not available:** Often academics require the support of qualified learning developers to help them adopt and adapt available resources. The lack of access to such support was seen as a barrier to resources re-use.

**Too many choices plus how to organise all this material:** At the opposite extreme from not finding any useful resources, having to choose from too many options was seen as a barrier to those who actually know of the availability of the resources. Here we note that some academics face the barrier of choice (a smaller group), and others face the barrier of not knowing about suitable resources (the greater proportion of academics).

**Research vs teaching demands:** The tension between these two areas of academic endeavour is becoming stronger. University's expectations of higher performance in research are placing extra demands on academics' time, with the potential of reducing their investment in teaching. Here, it is this same lack of time that is seen as preventing academics from investing in finding and adapting available resources.

**Need to trust the correctness of the resources:** A point raised was the need to verify the academic integrity of the resources. When this is not possible to achieve, useful resources do not get used.

**Need to learn other materials:** Often times, academics find themselves needing to learn other materials in order for them to be able to use certain resources. This could be a special interface, or even conventions used in the design of some software packages.

**Academic identity is tied up with the teaching role:** Some see a strong connection between the produced resource and the identity of the academic who produces it. For example, lecture notes carry, at least in some cases, what academics see as their own signature and credibility, which they want to maintain.

**Reputational issues:** Resources produced by academic institutions carry their brand. This raises a question regarding how the use of a resource branded by another institution would affect an institution's academics' and students' identities. Some see that there may be need for rebadging, and this might require university-level processes, which individual academics may be unable to put into effect. This could act as a barrier for resources re-use.

## A.2    Enablers

**Use MOOC resources supported by drop-in tutorials:** There are increasing numbers of freely available materials available online. These can be combined with in-class support and online assessment to create a flexible and efficient learning environment. However, the online resources are not necessarily easy to extract from a MOOC offering, although some cross-licensing is beginning in the US, where materials developed for MOOCs are being licensed to other universities, eg Gerrior (2013).

**Use site visits, visiting lecturers, adjunct professors, etc, to add value:** The issue of identity and reputation has already been mentioned. Students want to know what extra value they get from studying at university X when their learning materials are generated elsewhere. One way of adding value is through unique experiences such as site visits, guest industry

lecturers, research and industry-based projects, to add value beyond what can be delivered through standard texts, websites, etc. In fact, we believe that this is the future of engineering education. The online learning resources will be available everywhere, just as textbooks are today, and academics will add extra value through engagement with the real world.

**Computer-assisted tutorial support and assessment provides a customized learning environment to each student as well as real-time data collection for academics:** There is a large unmet potential in providing students with access to online tutorial and assessment tools. With these tools, students can test themselves as often as desired and an online tutorial and assessment tool can give each student a customised experience. Students can progress at their own rate, repeat material when needed and, finally, master the material. They could take the final exam when they are ready. The tools also provide academics with real-time data on student progression so that they can follow up as appropriate. This is really student-centred learning.

**Collaboration: Make my life easier:** Perhaps at the heart of this problem is the need to build collaborative groups of academics in subject areas. One of the challenges identified above is that academics don't know what resources are available. Further, although academics would like to modify resources, few of them have the time to do so. One possible approach would be to have peer networks – e.g. a Statics Club, where the 40-50 (perhaps more) academics who teach statics in Australia could collaboratively develop the materials and assessments that would be used across the country and potentially overseas. The use of shared assessment would allow each university to see how they are performing on a national scale. In this process, each academic would provide a better service to their students, to their managers and to the government as funders of the enterprise.

**OLT sponsorship:** Such a collaborative approach is also attractive to the Office for Learning and Teaching because the national community is acting as one body rather than as 35 separate universities. One would hope that Deans would see it in their best interests to fund such developments as well, once benefits, such as peer support, improved quality and reduced costs, were realised.

## B.      Results of a poll of engineering leaders
A poll of 27 engineering education leaders was conducted to explore their opinions on the use of educational resources.  The poll was intended to stimulate discussion and to also find out whether there were diverse views or general agreement on certain aspects of the resources re-use issue. The poll questions are listed below, and their responses are shown in Figure 1.

*(a) Do you think that sharing teaching resources is useful?*
*(b) Do you think that there are readily available resources that are useful?*
*(c) What is your estimate of academics using these resources, as is?*
*(d) What is your estimate of academics using these resources, but after modifying them?*
*(e) For those who are not using those resources, what do you think the reason is?*
*(f)  What do you think would help academics use these resources?*

As Figure 1(a) shows, the majority supported the view that sharing resources is useful. However, participants were divided about whether available resources are useful. There is much to unpack in these responses. For example, from the discussions that followed the poll, the definition of what is meant by resources seemed to vary among the participants. Some saw these as software packages, video recorded lectures, Internet operated lab exercises, or programs such as Engineers Without Borders. Some still spoke of learning resources supplied by publishers and available to students when they acquire textbooks. These variations need to be taken into consideration as we discuss the remaining results of the poll. The possible variations in interpreting what is meant by "resources," could explain why the responses to the second question showed that the same group was almost equally divided on whether there are available resources that are in fact useful. The question can be thought of as consisting of two parts; first, that resources exist, and second, that these resources are useful. This means that if one's opinion is, based on their understanding of what is meant by "resources," that such resources do not exist, then they would have responded in the

negative.

Assessing the usefulness of resources is far from being a simple task. If a resource is made available for academics to use, the rate of uptake could be an indication of its quality, provided that it is equally discoverable by the prospective users. The other point to consider is whether such a resource takes into consideration students' evaluation of the resource's effect on their learning. The response to the following four questions provided a wider spread of opinions among the participants. Questions (c) and (d) aimed at exploring, in the opinion of the participants, how the decision to use certain resources is affected by the need to modify them before use or not. In regards to using the resources without modifying them, 80% of the participants estimated that 10% of academics do so. However, only 46% of participants thought that 10% of academics use resources, after modifying them. This seems to suggest that a greater number of academics tend to modify the resources they use. The questions did not make any distinction between the resources in terms of whether they are used in early parts of the engineering program, or in the later years. It is to be expected that courses in the
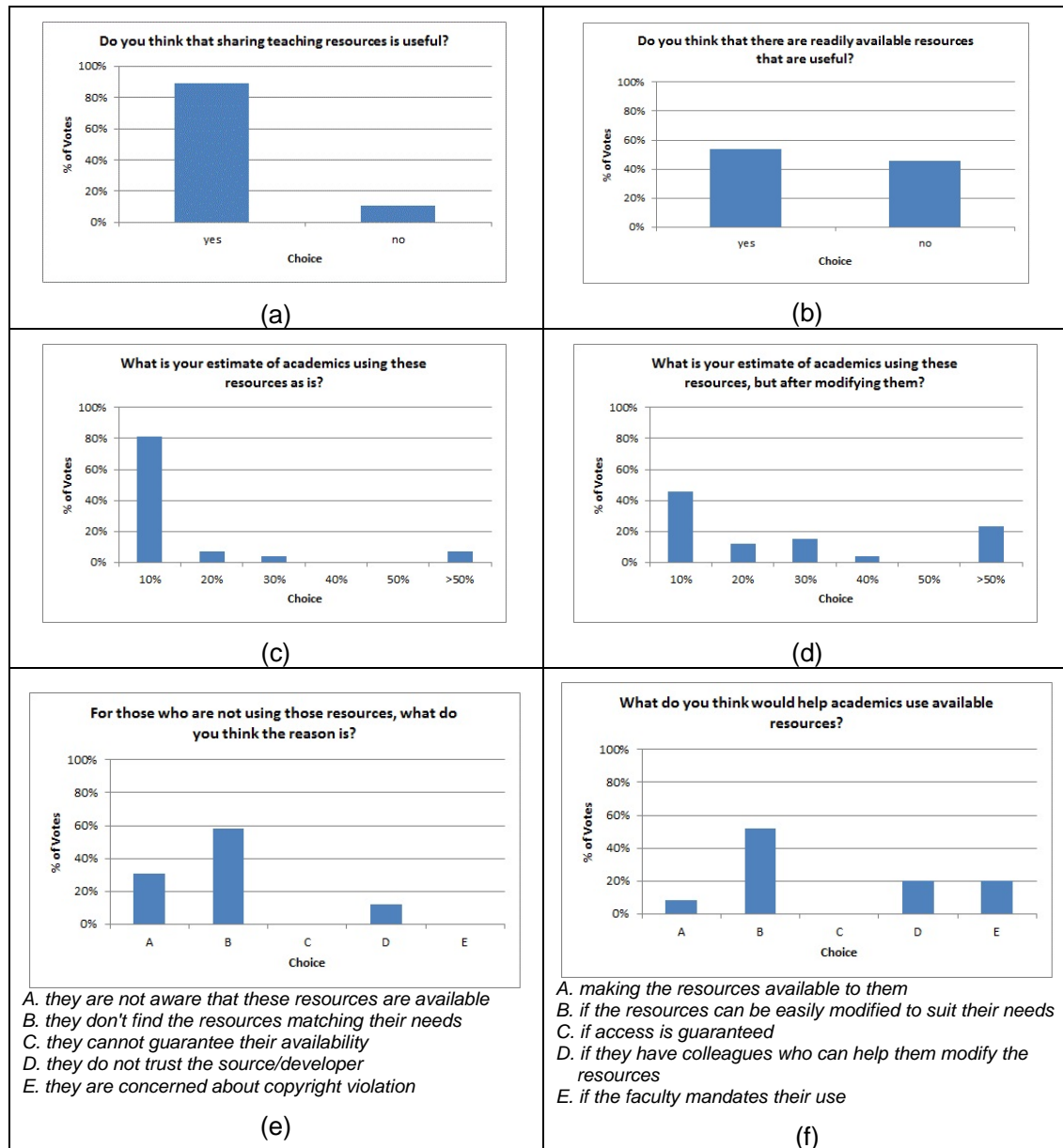


Figure (1) Opinion survey results

first year, for example, would have fewer variations between institutions, as these would be foundation courses. Third and final year courses are expected to vary in content and emphasis between institutions, though the smaller numbers of students can also mean greater benefits from sharing. This would mean that academics would need to do more in adapting available resources to suit their particular program. This point became evident during discussions with the participants, as the resources they identified as being used by academics at a greater percentage, were in fact targeting first year students.

Engineering programs include final year capstone projects; each year more than 10,000 such projects are run in formative Bachelor's and Master's degrees. Surely there are opportunities to find specific resources that address certain aspects of a project and that can be adapted for the specific focus of a final year project. This might be an interpretation of the increase in the percentage of users (figure 1, d), in the opinion of the participants, considering the use of resources after modifying them. The last two questions (shown in figure 1, e and f), sought to explore the participants' opinion on what could be barriers for resources re-use, and also factors that might assist or encourage academics to use available resources.

One of the possible barriers for resources re-use that was identified in the symposium we held at AAEE2012, as well as in (Kortemeyer, 2013) is the issue of discoverability of the available resources. That is, how would academics know of the existence or availability of certain resources? Figure 1 (e) shows that in the opinion of the survey participants, 85% of academics do not use available resources because they are either not aware of their existence or that they find they need to be modified before they can use them. Only a small percentage would not be using resources because they do not have confidence in the resource or who produced it.

This shows that, in the opinion of the participants, a great barrier to resources re-use is the lack of knowledge of the availability of the resources. However, the final question of the poll indicates that, in the opinion of the participants, the real barrier lies in the difficulty in modifying available resources, more so than making the resources available (this is different from the issue of discoverability of the resources). While the ease or otherwise of modifying available resources is identified as an important factor, help from colleagues and their leaders emerged as valued ways of encouraging and supporting resources re-use. Clearly, this poll did not address all aspects of the resources re-use issue. It did however provide a snap shot of a sample of views on how the current scene is perceived. Some of the views expressed were consistent with those identified at our AAEE2012 symposium.

## Discussion and conclusion

Much of what these investigations have uncovered has a strong resonance with work on technology acceptance, despite the fact that we are exploring adoption of resources rather than technologies. For example, the early work on TAM (Technology Acceptance Model) (Davis, 1989) focused on two key drivers for adoption: perceived ease of use; and perceived usefulness. Subsequent work (such as that by Venkatesh, 2003) provided more complex models, but was grounded in similar concepts.

The concept of perceived ease of use relates strongly to our discussion above on "does it make my life easier" and the time taken to adapt the resources for local use. Similarly, perceived usefulness relates to the extent to which academics might feel that the shared resources will benefit them and their students ("what's in it for me?"). We can potentially learn from this analogy, and use these technology adoption models to more effectively encourage resource sharing. Further research would however need to consider how these approaches could be adapted to the University context. Of particular interest would be a consideration of issues that are regularly identified in studies of factors affecting academics' motivations, such as time scarcity and the emphasis that is placed on research versus teaching.

To address the resources re-use issue, Brownfield and Oliver (2003) indicated that there is a need for processes and strategies supporting the discovery and recovery of these resources through the use of metadata. However, discovery is just one part of the problem. Adaption

and adoption remain obstacles.

Perhaps it is time that we, as a community, chose to standardise on the content and form of engineering fundamentals courses, so that the adaption problem could be tackled once rather than 35 times. Could we not settle on standard online courses in Statics, Dynamics, Fluid mechanics, Thermodynamics, Circuit Theory, etc., and concentrate our energies on project-based learning to support students in the application of these skills to real situations?

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