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# Australian Academic Leaders' Perceptions of the Teaching–Research–Industry–Learning Nexus in Information and Communications Technology Education

*Tanya McGill, School of Engineering and Information Technology, Murdoch University, Murdoch, WA, Australia*

*Jocelyn Armarego, School of Engineering and Information Technology, Murdoch University, Murdoch, WA, Australia*

*Tony Koppi, Faculty of Informatics, University of Wollongong, Wollongong, NSW, Australia*

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## ABSTRACT

*Strengthening the teaching-research-industry-learning (TRIL) nexus in information, communications and technology (ICT) education has been proposed as a way of achieving improvements in student learning (Koppi & Naghdy, 2009). The research described in this paper builds on previous work to provide a broader understanding of the potential outcomes associated with the TRIL nexus in relation to ICT education. It presents the results of a survey, of Australian ICT academic leaders, designed to clarify the outcomes associated with the TRIL nexus, and to investigate how the synergies associated with it can be better exploited. The results show that the benefits of strong relationships between aspects of teaching, learning, research and industry are recognized and emphasized in Australian universities, but that further action is needed to strengthen relationships with the industry component of the TRIL nexus. Recommendations to help achieve this are made.*

*Keywords: Industry Involvement, Information Communications and Technology (ICT) Education, Student Learning, Teaching–Research–Industry–Learning (TRIL) Nexus, Teaching–Research Nexus*

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## INTRODUCTION

Koppi and Naghdy (2009) introduced the concept of the teaching-research-industry-learning (TRIL) nexus in information, communications and technology (ICT) education. This concept brings together research on the teaching-research nexus in higher education (e.g. Healey, 2005b; Marsh & Hattie, 2002) and the many small individual initiatives to integrate aspects of research and/or industry into ICT education that have been described. Koppi and Naghdy (2009) propose that synergies are achievable by strengthening the connections between industry, teaching, learning and research in ICT education.

The vast majority of ICT education studies related to aspects of TRIL have been reports of individual initiatives by those who carried them out (e.g. Pilskalns, 2009; Schilling & Klamma, 2010). While these provide excellent ideas for ICT academics who hope to further integrate research and/or teaching into their academic offerings, they are generally too piecemeal to really guide attempts to strengthen the TRIL nexus, and do not provide a higher level perspective of the importance of TRIL to universities. White and Irons (2009) moved towards this latter goal by comparing ICT academics' beliefs and experiences relevant to the relationship between research and teaching. Grant and Wakelin (2009) added the role of consultancy to the teaching-research mix, and explored the perceptions of ICT academics about the nexus. The relationships involved in the TRIL nexus in ICT education have been further explored in an extensive meta-analysis of published literature on TRIL related initiatives taken by ICT academics and ICT departments (McGill, Armarego, & Koppi, 2012). Based on the studies analyzed, McGill, Armarego and Koppi (2012) also provided recommendations to support those attempting to strengthen the TRIL nexus in ICT education. The research described in this paper builds on previous work to provide a broader understanding of the potential outcomes associated with the TRIL nexus. It considers how

ICT academic leaders perceive the outcomes associated with the concept, including the nature of potential improvements in learning associated with a strengthened TRIL nexus. It also explores how ICT academic leaders perceive the synergies associated with it can be better exploited.

## BACKGROUND

The relationships between teaching and research have been comprehensively examined, both in general (e.g. Healey, 2005a; Neumann, 1992; Robertson, 2007) and in various disciplines including ICT (e.g. Grant & Wakelin, 2009; White & Irons, 2007). The many ways in which the relationships between research and teaching have been strengthened in ICT degrees have been summarized by McGill, Armarego and Koppi (2012) and include faculty teaching students about the research of both themselves and others, augmenting the curriculum with research projects, and complete curriculum redesign to integrate research throughout. Healey (2005a) has categorized approaches to integrating research into learning and teaching as having students as audience or participants, and the research focus being on the process of research or research as content. This categorization helps to represent meaningfully the wide variety of approaches.

Whilst the empirical evidence is not overwhelming (Marsh & Hattie, 2002), the consensus of opinion is that compelling benefits can flow from strengthening the relationships between research and teaching and learning. These benefits are believed to include: enhanced knowledge currency; enhanced staff credibility; increased student enthusiasm and motivation; and a strengthened sense of professional identity (Healey, Jordan, Pell, & Short, 2010; Hunter, Laursen, & Seymour, 2007; Lindsay, Breen, & Jenkins, 2002). In ICT education the following additional possible benefits have been highlighted: increased likelihood of students pursuing graduate degrees; increased student

confidence; and expanded student awareness of both discipline and career opportunities (Barker, 2009).

There have, however, been some reports of possible negative impacts on student learning associated with extensive staff involvement in research, in particular regarding a lack of staff availability (Healey, et al., 2010; Lindsay, Breen, & Jenkins, 2002; Trowler & Wareham, 2008). These concerns are mirrored within the ICT specific literature (Strazdins, 2007). Strazdins (2007) also noted that not all students can cope with ICT education that has a strong emphasis on research.

The relationships between industry and teaching have not been examined as extensively as those relating to research, and Thompson (2010) has noted that, with the exception of student projects, few of the interactions between academia and industry are ever formally documented and evaluated. However the relationships between universities and industry are being seen as increasingly important (Meek & Davies, 2009), with ICT graduates, faculty and industry urging for greater industry involvement in ICT education (Koppi & Naghdy, 2009).

Whilst some reservations have been noted about the benefits of industry involvement in some academic disciplines (Billett, 2001), ICT is not one of them. The consensus in the literature appears to be that developing and maintaining industry links is associated with positive benefits for all involved. Increased involvement of industry in the activities of ICT departments in universities can include: provision of courses to industry; the establishment and use of industry advisory boards; and consultancy and/or industry-based research activity (McGill, Armarego, & Koppi, 2012). To students the benefits of greater involvement with industry are believed to include opportunities to engage in authentic work activities with experienced co-workers, and opportunities to reinforce skills (Billett, 2001). Benefits to academics include maintaining the currency of their knowledge and the potential for applied research projects.

## THE STUDY

In order to explore further perceptions of the nature and value of the TRIL nexus in ICT education, the opinions of ICT academic leaders in Australia were sought. The study described below was part of a broader Australian Teaching and Learning Committee (ALTC) project on improving ICT education. Only those aspects relating to the TRIL nexus are included in this paper.

The academic leader of ICT in each Australian university with membership of the Australian Council of Deans of ICT (ACDICT) was contacted to participate in a survey on several aspects of ICT education. ACDICT was formed in 2008 to represent the range of disciplines comprising ICT in all Australian universities, and has 36 member universities. Its mission is 'To promote and advance ICT education, research and scholarship on behalf of Australian universities' (ACDICT, 2008). This population was chosen in order to obtain opinions representative of all ICT offerings in Australia, including computer science, information systems and computer engineering. The survey was administered in four consecutive forms over several months in order to maximize the number of responses: paper-based by mail; phone; email attachment; and, finally, an online version, with several weeks between each approach made to the ICT academic leader. The official ACDICT representatives were encouraged to consult with leaders of learning and teaching across the spectrum of ICT offered at their institution.

The survey items relevant to the TRIL nexus were designed to clarify the outcomes associated with the nexus, and to investigate what more Australian universities believe they could be doing to exploit synergies associated with the TRIL nexus in ICT education. Seven items presented outcomes associated with the research component of the TRIL nexus (see Table 1 for a list of the items), and eight items related to benefits associated with the industry component of the TRIL nexus (see Table 2 for a list of the items). Respondents were asked to

rate their agreement with each of these statements on a 5-point Likert scale ranging from 'Strongly Disagree' to 'Strongly Agree'. Two Likert scale items to capture perceptions of synergies were also included:

- 'Universities should be doing more to take advantage of synergies between industry, research and teaching and learning'
- 'There is a synergy between teaching, research, industry and learning'.

An open ended question that asked 'What more should universities be doing to take advantage of synergies between industry, research and teaching and learning?' was also included in order to provide participants with the opportunity to contribute strategies for achieving and exploiting synergies. All questions were developed specifically for the study.

## RESULTS AND DISCUSSION

Ultimately 22 responses were received from 18 of the 36 universities (four universities provided responses from different ICT areas, thus representing a 50% university response rate). Hence, from the perspective of those leading the discipline and guiding the development and teaching of ICT academic offerings in Australia, the responses are taken as providing a representative view of perceptions regarding the nature and value of the TRIL nexus in ICT education.

Overall the ICT academic leaders believed that there is a synergy between teaching, research, industry and learning. Eighty six percent agreed or strongly agreed and no respondents disagreed with the notion that such a synergy existed. Their general beliefs are consistent with the general beliefs about the value of integrating research into teaching and learning in many disciplines (e.g. Healey, 2005a; Neumann, 1992; Robertson, 2007), and also consistent with calls from industry and various peak bodies for universities to establish greater links with industry (Koppi & Naghdy, 2009). Details of their perceptions of the outcomes associated

with the research and industry components of the TRIL nexus are provided below.

### Research Component of the TRIL Nexus

Much has been written about the benefits of enabling ICT students to have more involvement with research (e.g. Grant & Wakelin, 2009; McGill, Armarego, & Koppi, 2012). The majority of the ICT academic leaders who participated in this study concurred with these benefits, but they were mindful of the possibility for very research-oriented staff to perhaps disengage from student learning concerns.

As shown in Table 1, the potential positive impacts on learning associated with involvement in research include: improvements in research skills; increases in interest and enthusiasm; and increased understanding of subjects. Almost all of the ICT academic leaders (95%) agreed that involvement with research improves student's research skills. In addition to direct outcomes related to research, 91% also agreed that involving students in research stimulates their interest and enthusiasm, while 86% of the ICT academic leaders agreed that involving students in research increases their understanding of subjects. The benefits, therefore, go beyond research skill into improved engagement with and learning of the curriculum. There was however weaker consensus that faculty research, in and of itself, leads to better student learning, with only 64% agreement with this notion. This lack of unanimous consensus about the achievement of benefits implicitly acknowledges that there is a need for active efforts to integrate discipline-based research into learning and teaching. It may also result from concerns about research detracting from teaching and learning.

As has been noted, there have been some reports in the literature of potential negative impacts on student learning associated with high staff involvement in research, in particular lack of staff availability (Healey, et al., 2010; Trowler & Wareham, 2008). Participants in this study were divided over whether academics who are focused on research may be less interested

*Table 1. Outcomes associated with the research component of the TRIL nexus given as counts (responses range from Strongly Disagree (SD) to Strongly Agree (SA))*

	<b>Total Number</b>	<b>SD</b>	<b>D</b>	<b>N</b>	<b>A</b>	<b>SA</b>	<b>% Agreement</b>
Involving students in research improves their research skills	22	0	0	1	7	14	95%
Involving students in research stimulates their interest and enthusiasm	22	0	0	2	10	10	91%
Involving students in research increases their understanding of subjects	22	0	1	2	11	8	86%
Discipline-based research in the school leads to better student learning	22	0	1	7	9	5	64%
Academic staff who are focused on discipline-based research are less inclined to be interested in learning and teaching	22	5	5	3	6	3	41%
The emphasis on research by academic staff involved in discipline-based research may have a negative impact on student learning	22	7	6	3	4	2	27%
The lack of academic staff involved in discipline-based research in the school has had a negative impact on student learning	19	1	4	10	0	4	21%

*Table 2. Benefits associated with the industry component of the TRIL nexus given as counts (responses range from Strongly Disagree (SD) to Strongly Agree (SA))*

	<b>Total Number</b>	<b>SD</b>	<b>D</b>	<b>N</b>	<b>A</b>	<b>SA</b>	<b>% agreement</b>
Involving students with industry increases their awareness of the problems and issues faced in the industry	22	0	0	1	12	9	95%
Learning by our students is helped by their connections with industry	22	0	0	2	12	8	91%
Involving students with industry stimulates their interest and enthusiasm	22	0	1	1	13	7	91%
The research in this school would be better if we had more connection with industry	22	1	1	1	13	6	86%
Industry connections formed by academic staff help student learning	22	0	0	4	9	9	82%
The school should have more connection with industry	21	1	2	1	11	6	81%
Students would learn better if they had more connection with industry	22	0	2	3	11	6	77%
Involving students with industry increases their understanding of subjects	22	1	2	3	10	6	73%

in teaching and learning, and whether this may have a negative impact on student learning. Forty percent agreed and 45% disagreed that academic staff focused on discipline-based research are less inclined to be interested in learning and teaching. Twenty seven percent agreed that the emphasis on research by academic staff involved in discipline-based research may have a negative impact on student learning and 59% disagreed with this statement. This seems to indicate that, in general, over involvement in research is not perceived as a serious problem for student learning: the positive aspects identified appear to outweigh the concerns. However, in around a quarter of the universities included in the study these concerns exist. These may be universities where any redistribution of staff resources is difficult to cover. Alternatively, these findings may be related to the maturity of the academic unit. Yet another reading suggests concerns mask an underlying conflict: teaching and research roles are motivated by different reward systems (Coate, Barnett, & Williams, 2001).

### Industry Component of the TRIL Nexus

Table 2 presents the responses relating to the industry component of the TRIL nexus. As can be seen, the majority of participants felt that their school needed more connections with industry (77%) and that research in their school would be improved by making more connections with industry (86%). Only a very small proportion of participants disagreed with these sentiments. Disagreement could reflect satisfaction with existing strong connections and hence no perceived need for further development of connections.

Respondents believed that student learning benefits both directly from associations with industry, and indirectly via staff connections. Direct student connections with industry include activities such as work placements and industry-related projects as well as obtaining

industry certifications. Twenty of the ICT academic leaders (91%) agreed that their students' learning is helped by these kinds of connections with industry and none disagreed. They also believed that industry connections formed by academic staff were important for student learning, confirming what has been suggested in the literature (Koppi & Naghdy, 2009). The kinds of connections that have been previously reported can include provision of courses to industry, the establishment and use of industry advisory boards, and consultancy and/or industry-based research activity. Eighteen of the ICT academic leaders (82%) agreed that these kinds of connections with industry help student learning, and none disagreed. One participant did however comment on the need for universities to maintain control in determining course content:

*Universities should be taking the lead in determining what constitutes the core body of knowledge in the discipline rather than be driven by industry demands, which tend to 1) emphasize generic skills and 2) change over time.*

The nature of potential improvements in learning associated with industry connections was further explored in several questions. The vast majority of ICT academic leaders believed that involving students with industry in various ways increases their awareness of the problems and issues faced in the industry (95% agreement), and stimulates their interest and enthusiasm (91% agreement). The majority of participants (73%) also agreed that involving students with industry increases their understanding of subjects. Some participants (14%) did however disagree, perhaps conveying concerns that too much focus on involving students with industry may crowd the curriculum, and therefore reduce the time available for covering required content. This could support concerns expressed in the non-ICT literature about the need for recognition of the differing goals of universities and industry (Thompson, 2010).

## What More Should Universities be Doing to Take Advantage of Synergies Between Industry, Research and Teaching and Learning?

The majority of ICT academic leaders (82%) believed that universities should be doing more to take advantage of synergies between industry, research and teaching and learning. Participants were asked to elaborate on this and describe what they felt universities should be doing to take further advantage of these synergies.

The responses to this open ended question were classified into general themes representing different approaches to achieving the potential advantages from synergies between industry, research and teaching and learning. The themes were permitted to emerge from the data. A multiple classification scheme was used so that each remark could be coded into more than one category if appropriate. Table 3 lists the themes that emerged. It was interesting to note that all but one suggestion related exclusively to the industry component of the TRIL nexus.

The predominant theme of the recommendations was that universities should provide more support for making connections with industry (6 comments). The nature of the support proposed varied between participants, with all the following mentioned: resources (unspecified); money; administrative support; small grants; and sabbaticals. Typical comments included:

*Actively seek connections with industry. Provide administrative support to staff making such connections.*

*Small grants and sabbaticals for industry engagement.*

*Provide more resources at grassroots for such activities. That is the key.*

Two participants recommended that universities should help industry more actively, presumably believing that this support would lead to reciprocal benefits for teaching, learning and research in universities in the future:

*Being proactive in the nurturing/incubation of ICT companies in regional areas.*

*Engaging with industries, identify problems that they are trying to solve. Help them think about different ways of solving problems.*

The final suggestion on approaches to increasing connections with industry was that peak ICT academic bodies should encourage industry to support university initiatives to increase engagement with industry:

*Make sure that the ACDICT convinces Industry to help.*

Only one participant made a suggestion that related to the research component of the TRIL nexus. This recommended that students should obtain practical experience with applied

*Table 3. Major themes in responses representing different approaches to achieving the advantages from synergies between industry, research and teaching and learning*

Themes
Universities should provide more support for making connections with industry (6)
Universities should more actively help industry (2)
Peak ICT academic bodies should encourage industry to support university initiatives (1)
Students should obtain practical experience with applied research (1)



research, thus embracing both the research and industry aspects of the TRIL nexus:

*Undergraduate students in my opinion should take at least 1 unit which is research based working in teams for Academia and Industry researchers in a 3 year UG degree. This should not be in the 3rd year but probably in the second (early).*

## CONCLUSION

The research described in this paper has provided a broader understanding of the potential outcomes associated with the TRIL nexus. It has considered how ICT academic leaders perceive these outcomes, including the nature of potential improvements in learning associated with a strengthened TRIL nexus, and how they believe the synergies associated with it can be better exploited.

McGill, Armarego and Koppi (2012) catalogued the diverse range of connections that have been reported between ICT teaching and learning, and research and industry. The present study has confirmed that a substantial number of these connections are acknowledged in Australian universities, and that ICT academic leaders believe that these connections are valuable. The results of the study show that ICT academic leaders greatly value the role that research plays in enriching student learning, and the various ways it does so. These include improving students' understanding of subjects and stimulating their interest and enthusiasm. The ICT academic leaders were, however, conscious that some academic staff may focus on their own research to the detriment of their teaching. However, in general they believed that the positive aspects outweigh the concerns. The ICT academic leaders also valued the contributions that different kinds of industry involvement can make to student learning and to research. This suggests that, despite Thompson's (2010) finding that there has been little evaluation of the outcomes of engagement with industry in ICT education, there is a strong belief in its value.

It is interesting that despite strong recognition of the benefits of integrating both research and industry activities and connections into ICT teaching and learning, the ICT academic leaders were more cognizant of the need to strengthen the industry component of the TRIL nexus than they were of the need to strengthen the research component. The area in which the ICT academic leaders most desired change related to industry interactions. They recommended that universities should be establishing more connections with industry. They strongly believe that there are important benefits to students and staff from strengthening the industry component of the TRIL nexus, with both university research and student learning improved through more connections with industry. Increased support from universities for achieving this was the common thread of recommendations from the ICT academic leaders. This emphasis on the industry component of the TRIL nexus may reflect the fact that research is (and has always been) an integral part of academic life and that many academics have already taken steps to enable the learning undertaken by their students to benefit from both their own research and that of others. The connections with industry are, however, less well embedded in universities. Whilst there have been some published examples of successful strengthening of these links, ICT academic leaders clearly believe that more is required.

In considering the implications of this study it should be noted that whilst the opinions obtained from the survey of ICT academic leaders relate to half of the universities in Australia, they primarily reflect the views of the academic leaders. The beliefs and actions of all academic staff are important and future research should explore these.

In order for ICT students, ICT academics and the ICT industry to fully achieve the benefits associated with strengthening the TRIL nexus, action is required. The literature contains a number of suggestions to help others undertake initiatives to strengthen aspects of the TRIL nexus. A summary of these recommendations has been provided by McGill, Armarego and Koppi (2012). While the results of this study

have reinforced many of those recommendations, several additional avenues designed to provide guidance to those seeking to achieve the benefits associated with strengthening the industry connections in the TRIL nexus have emerged. In particular, the importance of universities actively seeking problems and unsatisfied needs from industry and helping to address them was highlighted. Also, the potential role of industry associations and professional bodies in helping to form and sustain connections should be noted. Participation in these bodies should be encouraged and opportunities to work together through these organizations embraced.

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*Tanya McGill is an Associate Professor in the School of Engineering and Information Technology at Murdoch University in Western Australia. Her major research interests include information technology education, e-learning, and technology adoption. She is the author of over 100 journal articles, book chapters, and articles in conference proceedings. Her research has been published in various journals including Behaviour and Information Technology, Decision Support Systems, Computers & Education, Journal of Computer Assisted Learning, Journal of Computing in Higher Education, and Journal of Organizational and End User Computing.*

*Jocelyn Armarego is a Senior Lecturer in the School of Engineering and Information Technology at Murdoch University in Western Australia. Her areas of research interest include competency mapping between the profession and the curriculum, non-traditional higher education learning and distributed collaboration for systems development. She has worked in the software industry and been involved in managing a project to support Engineering and ICT academics engage with theoretical aspects of learning.*

*Tony Koppi has been involved in recent years as Project Manager of four higher education learning and teaching projects funded by the Australian government, and part-time Executive Officer of the Australian Council of Deans of Information and Communications Technology (AC-DICT: [acdict.edu.au](http://acdict.edu.au)). Earlier he was Director of the Educational Development and Technology Centre at the University of New South Wales in Australia with responsibility for staff development and projects concerned with educational technology, and for establishing and supporting an eLearning system for the university. Prior to that he was at The University of Sydney in a similar educational and technology development leadership role. Extensive experiences include leadership, change management, science, education and technology innovation, and working with various academic and industry partners.*

# Do Open Educational Resources and Cloud Classroom Really Improve Students' Learning?

*Chia-Wen Tsai, Ming Chuan University, Taipei, Taiwan*

*Pei-Di Shen, Ming Chuan University, Taipei, Taiwan*

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## ABSTRACT

*More and more educational institutions are using educational technologies and online learning materials to help students achieve satisfactory learning effects. However, not all teachers are able to prepare and design digital learning materials for students. This research attempted to empirically demonstrate the effects of applying open educational resources (OERs) and a cloud classroom developed by Ming Chuan University, which comprises access to related software and online learning materials, to enhance students' computer skills and also improve their scores on certification examinations. The researchers conducted an experiment that included 114 undergraduates from two class sections – the first section received OERs in a cloud classroom in addition to their traditional classroom instruction (OER group, n=61), and the other learned in the traditional classroom without OERs (non-OER group, n=53). The results show that students who received OERs had significantly higher grades than those without in the PowerPoint module; however, the difference is not statistically significant in the Excel module. The authors further discuss the implications and unexpected results in this paper.*

*Keywords:* Application Software Education, Cloud Classroom, Educational Technologies, e-Learning, Online Learning Materials, Open Educational Resources (OERs)

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## INTRODUCTION

E-learning applies electronic technologies in educational environments with a special emphasis on learning through the web (Guri-Rosenblit & Begoña, 2011), one aspect of which is the use of OpenCourseWare. OpenCourseWare is generally supplied by prestigious educational institutions allowing learners to use the same learning materials available to those institutions' students in a structured process without the demands of professors, institutions or financial

obligations (Atkins, 2007; Lowman, 2009). The MIT Open Courseware (OCW) project aims to share knowledge through making educational materials available for learning via the Internet. The concept of OCW was born from discussions of a study group close to MIT's Council on Educational Technology and includes educational material such as lecture notes, course outlines, reading lists and assignments for virtually all MIT courses across the Institute's entire curriculum (Su & Yu, 2011).

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In addition to OCW, there is increasing interest in various forms of school-based modes and in using the tools offered by new information and communication technologies (ICT), including open educational resources (OERs), for large-scale provision to potential learners (Moon, 2007). The recent advent of open content or OERs, a global intellectual resource of learning materials, offers a significant breakthrough for teachers and students (Thakrar, Zinn & Wolfenden, 2009). OERs may include text, images, audio, video, interactive simulations, problems and answers, and games that are free to use and re-use in innovative ways by anyone around the world (Baraniuk, 2007). OERs can provide the catalyst for different forms of learning, linking formal and informal aspects and splitting up the functions of content, evaluation, support, and accreditation (McAndrew, Scanlon, & Clow, 2010).

As for the practical applications and implementation, YouTube is a well-known website that is simultaneously ‘a high-volume website, a broadcast platform, a media archive, and a social network’ (Jarrett, 2010). Many academics and institutes are now using YouTube for recording and transferring course lectures. These videos on YouTube may be valuable when instructors are away or for students who miss the classes (Pasquali, 2007; Kousha, Thelwall & Abdoli, 2012). With regard to the overall influence of YouTube on academic publications, it seems that YouTube videos are being used by a small but increasing number of researchers to support discussions (Kousha, Thelwall & Abdoli, 2012). For example, when searching videos related to smoking on YouTube, one can find clear messages from those both for and against, but also a wide range of scenarios in which messages about smoking are delivered, which can enhance or disarm any argument (Freeman & Chapman, 2007). Learners could independently find many useful materials among the free videos and websites, and learn at their own pace and convenience.

Online learning covers a myriad set of applications and processes that may be helpful as long as teachers are able to make good use of them in the curriculum. What is most significant

about the method and application is that it ensures faster learning at comparatively reduced cost and gives access to more learning resources (Sarma & Majumder, 2010). The relationship between educational ideas and technological capabilities may ensure the successful use of instructional technology in higher education (Garrison & Akyol, 2009). However, this challenges teachers who do not have the skills to adopt e-learning and educational technologies (e.g. building up a course website, recording digital learning material). In this regard, the authors adopted OERs and cloud classroom and explored whether they could improve students’ learning in this study. The cloud classroom is a concept that has been developed by the authors’ university, which comprises a virtual collection of necessary software and learning materials for students to review and practice what they have learned in regular classes. This could include access to both related OERs and materials specific to the course at hand.

## LITERATURE ABOUT OPEN EDUCATIONAL RESOURCES

OCW is a revolutionary approach to sharing educational resources. It freely and openly presents the core academic content, including lecture notes, syllabi, assignments and exams, to support formal and informal learning around the world (Ocw.mit.edu, 2012). OCW provides opportunities to view classes taught in well-established universities worldwide (Yang & Sun, 2011). Some studies have started to explore the effectiveness and phenomenon related to the MIT OCW. Due to the fast advancement in portable technologies such as smart phones and reading devices, it is indicated that OCW will play an essential role in ubiquitous synchronous and asynchronous learning in the future (Su & Yu, 2011).

In addition to OCW, OERs are “technology-enabled, open provision of educational resources for consultation, use and adaptation by a community of users for non-commercial purposes” (UNESCO, 2002). OCW and OERs have great potential for providing access to

knowledge for the global public, including isolated and underprivileged students in developed and developing countries who are otherwise excluded from higher educational opportunities (Morgan & Carey, 2009). Educators might find supplemental materials among OCW that they can refer their students to (Haiti OCW site tour 2012, 2012). It is indicated that learners were able to gain vocabulary knowledge by simply viewing an OCW lecture once (Yang & Sun, 2011). It is also found that students have primarily strong positive attitudes toward the OCW program, the faculty who post materials, and other educators who reuse OCW materials (Kanchanaraksa, Gooding, & Yager, 2011).

Senior managers, staff, and students recognize the potential benefit of OER for students, staff, institutions, self-learners, and those with no or limited access to higher education (Nikoi & Armellini, 2012). In Taiwan, the Opensource Opencourse Prototype System (OOPS) was established for Chinese-speaking users to benefit from this global education movement (Huang, Lin & Shen, 2012). However, there are few studies that discuss the effects of OERs on the development of students' computing skills. To address this gap, the authors in this study attempted to use OERs and explore their effects on developing students' computing skills, and passing certification examinations.

## The Empirical Study

### *Subjects*

The subjects in this study were 114 freshmen from two class sections taking a compulsory course titled 'Information Technology: Office Applications' in Taiwan. Students in the first class section came from the Department of Economics (OER group, n=61); the other came from the Department of Accounting (non-OER group, n=53), which served as the control group.

The two involved classes in this research were taught by the same teacher and used the same course website built based on Moodle, an open-source Learning Management System. The teacher in this study announced that students in the OER group would receive specific teaching

methods and materials from OER. The gender breakdown was 51 males and 63 females, while the mean age of students was around 18 years old. Moreover, none of the students majored in information or computer technology.

### *Experimental Procedure*

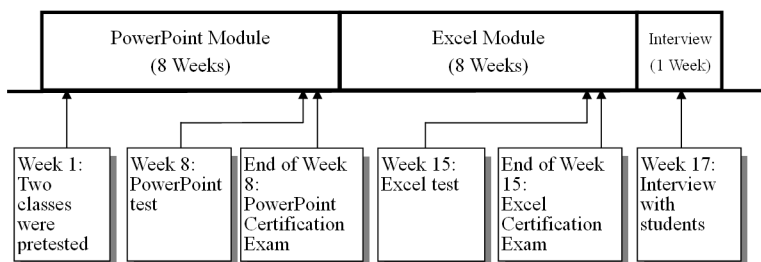
In this course, there were two modules, Microsoft PowerPoint and Excel. At the end of each module, students were tested, and a certification examination was held within a week after the test. The PowerPoint test and certification examination were administered in the eighth week, and those for Excel in the fifteenth week. After that, eight students from the OER group were randomly chosen to be interviewed in the seventeenth week (see Figure 1).

### *Intervention for the OER Group*

The experiment in this study was designed to examine the effects of OERs on improving the computing skills of non-computer majors. The teacher first surveyed the appropriate learning material on related websites and found two suitable websites with clear videos and illustrations in sequence. Then, the teacher announced and provided open learning materials and the address of the two websites in the Course Discussion and Announcement Boards of the course website for the OER group students' use and reference. In addition, the authors' university has also developed and provided a cloud classroom that includes the necessary software and learning materials for students to review and practice what they have learned in regular classes.

In the first week of the course, students from the OER group were told they could use the open, free learning materials to help them learn, review, and practice after classes. Students could log into the cloud classroom and listen to the OER materials at their convenience. On the contrary, students from non-OER group just received teacher's lecture in the classroom, without specific access to the open learning materials or directions for using the cloud classroom.

Figure 1. The schedule of course and examinations in the experiment



## Evaluation

In the eighth and the fifteenth week of the semester, respectively, the examinations for certificates in PowerPoint and Excel were conducted. On the examinations of PowerPoint and Excel, there were two or three main problems, which each consisted of 5 to 8 sub-problems. A student's grade came from her/his completeness and correctness of problem solving. A student could earn professional certification using slides or spreadsheet if her/his grade was higher than 70. Finally, the authors tested the effects of OERs on students' computing skills in using PowerPoint and Excel.

At the beginning of each course, the teacher first conducted a pretest to check whether students had learned PowerPoint or Excel. In the pretest, the scores showed that students' computer skills were uniformly low. It means that the difference of students' skills in using PowerPoint and Excel between the two groups was not statistically significant when they began this course. Therefore, the researchers could rule out initial differences as a plausible alternative explanation for any differences found after learning through OERs (Gibbons & Herman, 1997).

In addition to the quantitative data, qualitative data were also collected in this study. In the seventeenth week, the teacher randomly chose eight students from the OER group for interview. A semi-structured interview was conducted with the group, which lasted approximately one hour.

The interview was recorded, transcribed, and subsequently analyzed.

## Results

### Quantitative Data Collected

The independent samples t-test is used to compare students' computing skills between the OER group (that received open educational resources and teacher's lectures) and the non-OER group (that received only teacher's lectures in the classroom). The results in Table 1 show significant difference in PowerPoint scores of OER group students' computing skills (95.98) compared with those in non-OER group (90.00).

In addition, the data shown in Table 2 indicate an unexpected result. That is, on the examination of Excel, the average score of OER group students' computing skills (84.49) is lower than those in non-OER group (92.70), though non-significantly. The authors discuss the potential factors that may have caused this unexpected result in the section 'Discussion and Conclusion'.

### Qualitative Data Collected

Besides the statistical quantitative data, qualitative data were also collected through interviews with students. Among those who received the OERs, one student described his learning experience with physical textbooks and digital learning files:

Table 1. Comparison of PowerPoint grades: OER group and non-OER group

Group	n	Mean	S. D.	F	t-value	df	p
OER group	61	95.98	7.70	17.75	-2.09	112	0.039 *
non-OER group	53	90.00	20.78				

\* $p < 0.05$

*The content in the textbooks is all description in text. The digital learning materials provided by our teacher on our course website are videos about the processes of problem-solving. The combination of textbooks and digital learning materials is helpful for our learning.*

In the interview, a student without a textbook described how he learned the computing skills with OERs:

*As I did not buy the textbook, I relied so much on the digital learning materials provided by our teacher. When I reviewed and practiced the computing skills at home, I got to watch the videos (digital learning materials) and prepare for the examination.*

However, in addition to the OERs, one of the students also indicated the need for teacher's illustration:

*I think the videos (digital learning materials) are useful in the PowerPoint module, but not very useful in the Excel module. Because there were many difficult functions and formulas when we solved problems in the Excel module, it was hard for me to understand the purposes and processes of problem-solving when watching the videos. Without teacher's illustration, the*

*videos in the Excel module did not seem to be as effective as those in the PowerPoint module.*

Another student agreed, and further expressed her thoughts as follows:

*When I practiced and solved a harder problem, I would watch and listen to the online digital learning materials. However, the materials (in the Excel module) did not provide clear illustration of the functions or formulas used in the problems. I thus felt confused when I watched the videos. I think it was better when I listened to teacher's lecture and illustration in the classroom, then watched the videos when I practiced at home. .... I watched all the videos before the examination.*

Based on both the quantitative and qualitative interview data, it is believed that OERs contributed to students' development of computing skills and to higher scores on the certification examination. Nevertheless, the interview data also indicated that students may need teacher's initiation and illustration, while the OERs may serve as auxiliary material in the learning modules that are complicated and require more thinking and understanding. Students may not necessarily benefit from OERs when learning complex computing skills.

Table 2. Comparison of Excel grades: OER group and non-OER group

Group	n	Mean	S. D.	F	t-value	df	p
OER group	61	84.49	32.91	18.69	1.68	112	0.096
non-OER group	53	92.70	14.44				

\* $p < 0.05$



## DISCUSSION AND CONCLUSION

Skillful teaching requires appropriate application and integration of specific moves and activities, based on knowledge and understanding and on the application of professional judgment (Ball & Forzani, 2009). In this research, the authors provided and integrated OERs to enhance students' computing skills and their certification examination scores. This research may contribute to e-learning theory in three different ways. First, this empirical study examines the effects of OERs on improving students' computing skills. Second, this research highlights and indicates the importance of teachers carefully using OERs in different computing modules (e.g. PowerPoint versus Excel). Finally, this study also indicates that teachers who do not have the knowledge and skills for building course websites and preparing digital learning materials could survey appropriate OERs first and provide these resources for students.

The findings in this study report that teacher's adaption and provision of OERs for students can significantly improve students' computer skills in using Microsoft PowerPoint. As the data in Table 1 shows, students who are directed to OERs (OER group, mean = 95.98) have significantly higher levels of computing skills in using PowerPoint than those without (non-OER group, mean = 90.00) ( $p = 0.039$ ). Moreover, students also expressed their appreciation for the digital learning materials in the PowerPoint module. Thus, it is believed that teacher's survey, adoption, and provision of OERs could help improve learning effects and computer certification examination scores of the students.

The findings of the present research are similar to Clifton and Mann's (2011), and Kousha, Thelwall and Abdoli's (2012) studies. With teacher's survey, filtering, and provision of appropriate OERs, students could review and practice what they learned in class. Students who missed classes could also learn via the online learning materials at their convenient time and pace. Therefore, it is suggested that teachers who

do not have the knowledge or skills to build a course website or record digital content could also provide existing online complementary learning materials for their students to improve learning effects.

However, it was found that there was no significant difference in the scores of examination of Microsoft Excel between the two groups. Based on the data from Table 2, it is found that students who received OERs (OER group, mean = 84.49) had lower levels of computing skills in using Excel than those without (non-OER group, mean = 92.70), though non-significantly ( $p = 0.096$ ). The authors attempted to find deeper understanding through the collected qualitative data. In the interview, students expressed their needs for teacher's illustration and initiation when learning functions and formulas in Excel module. As there were more difficult and complex functions and formulas in the Excel module than in the PowerPoint module, students may need teacher's lecture and illustration in the classroom. That is, the OERs may serve as a backup when students review or seek solutions if they face problems.

Furthermore, the teacher in this study and fellow researchers also reflected on and discussed the unexpected result of students' learning effects in the Excel module. A potential reason for the lower scores in the OER group may be that students had gotten accustomed to use the OERs provided instead of listening carefully to the teacher's illustration. They may have been distracted in the classroom and tended to believe that they could learn the functions and formulas from the online learning materials. However, the OERs on YouTube of computing skills in Excel did not provide clear illustration. Students could not understand the purpose or why the particular functions were used. They usually just memorized the processes of problem-solving without clear understanding. If there were more than three functions used in a single problem, there should be additional clear explanation. However, when students learned from the OERs without clear illustration, they may have suffered from confusion as to why and how to use the functions. In this

learning climate and situation, students may have lower learning outcomes than those who did not receive OERs.

In conclusion, to achieve effective learning in online courses, teachers should reconsider their students' specific needs and provide an exquisite course design with appropriate teaching methods and materials (Tsai, 2011). In this study, the authors conducted an empirical experiment and found that teachers could survey, filter, and provide OERs from educational and other websites (e.g. YouTube) to help students achieve better learning effects in Microsoft PowerPoint module. Finally, the authors suggest that teachers could appropriately adopt OERs to help students learn, even if teachers do not have to skills of building course websites or designing digital learning materials.

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*Chia-Wen Tsai is an associate professor in the Department of Information Management, Ming Chuan University. Dr. Tsai is one of the Editors-in-Chief of International Journal of Online Pedagogy and Course Design, and International Journal of Technology and Human Interaction. He is also the Associate Editor of Cyberpsychology, Behavior, and Social Networking. He is interested in online teaching methods and knowledge management.*

*Pei-Di Shen now works as Director of the Teacher Education Center and professor of Graduate School of Education, Ming Chuan University, Taipei, Taiwan. Professor Shen is one of the Editors-in-Chief of International Journal of Online Pedagogy and Course Design. Her primary interest areas are E-learning, Knowledge Management, Virtual Community, and Management Information Systems. Her research focus is the distance education in higher education.*

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