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Articles
Engineering Education in the 21st Century: Roles, Opportunities and Challenges

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Abstract

The World has faced a wide myriad of problems for many centuries, the list being quite similar today. Almost all of them have - in some way or manner - to do with engineering and engineering solutions. These problems and the fact that we live in a highly communicated, ‘globalized”globe, requires new sets engineering capacity, competencies and professional skills to address them as well as to further enhance technology and innovation as critical foundations to develop and sustain knowledge economies. Engineering education has a very important role in society, bridging the gap between the world of today and education and addresssing local, regional and global challenges. This paper describes the challenges engineering and engineering education faces in the 21st Century as well as describe the role and opportunities engineering educators have to respond to these challenges. world.

Keywords: engineering education, globalization, curriculum innovation, professional skills, assessment.

INTRODUCTION Other World Challenges

Across history, there have been many reports and publications that describe the world’s major problems. The list usually includes: Population, water, food, energy, health, environment, terrorism/conflict, climate change and sustainability. Most if not all of these problems have had, or will have an engineering dimension (creating, solving, involving). A most recent highly quoted report focused on engineering problems published by the US National Academy of Engineering lists fourteen engineering grand challenges (NAE, 2008) all, if not most of them, again related to engineering, technology and science, namely:

1. Make solar energy economical
2. Provide energy from fusion
3. Develop carbon sequestration methods
4. Manage the nitrogen cycle
5. Provide access to clean water
6. Restore and improve urban infrastructure
7. Advance health informatics
8. Engineer better medicines
9. Reverse-engineer the brain
10. Prevent nuclear terror
11. Secure cyberspace
12. Enhance virtual reality
13. Advance personalized learning
14. Engineer the tools of scientific discovery

The list seems unsurmountable, yet, humankind cannot survive if it does not address these problems with urgency and effectiveness. Solving these problems will require, as Stanford University President John Hennessey says: “deep collaboration and intensive investment.”

In addition to the grand challenges listed above, the world of today and tomorrow confronts other challenges an ever changing technology landscape and information, knowledge production, the result of faster, efficient and new modes of communication and interconnectednes. The following chart demonstrates instant global internet connections, which demonstrate, the world can communicate constantly across space and time.

This world interconnectedness, or ‘flatness’ as Thomas Friedman so brilliantly describes in his book (Friedman, 2007), the lowering of trade and political barriers and the exponential technical advances of the digital revolution have made it possible to do business, or almost anything else, instantaneously with billions of other people across the planet. In other words, we are facing a new world order, where new communication schemes have allowed the development of new business models (outsourcing, near sourcing, off-shoring, etc), which in turn, are requiring a new set of professional skills and competencies in the workforce, and of course, in university graduates.

The new professional not only needs to be knowledgeable in his/her own discipline, but also needs a new set of soft, professional skills and competencies.

But, what are these skills? There are many engineering professional societies’ surveys, accreditation criteria, which have listed the engineering professional skills and competencies of the engineering graduate. Nevertheless, what the new world order and local/regional challenges require are quite novel.
Using an exciting combination of insights from foresight as well as systems and design thinking, Bob Johansen, President and CEO of the Institute for the Future Johansen (Johansen, describes the essential skills leaders must use to thrive in a world of volatility, uncertainty, complexity and ambiguity. In this world, he states, there will be danger as well as opportunity, thus leaders must learn new skills to address these and make a new future. Most of the skills he envisions for the 21st century technology professionals described in Table 1 do not yet appear in the dictionary!

The critical questions are: Are universities and colleges of engineering around the globe preparing the engineering/technology professional with the required skills? Are they aware of the need to develop these and actively responding by innovating curricula and the learning experience? Or does it look like the gap between the professionals universities are graduating and the needs of society and private/public enterprises is wide open and roadmaps to close it have yet to be created? What can higher education and engineering education do to address this gap, this opportunity to better serve society?

The answer to these questions is critical, urgent and unavoidable by all stakeholders involved.

What is Going on Around the Globe?

As a result of the world’s interconnectedness, new and successful business models and strong leadership and multi stakeholder alignment, developing countries and regions have realized that giving priority to knowledge and knowledge management will enable their economies faster to be able to globally compete. They are making significant investments in science and technology, innovation and ITC infrastructure. Many countries are following the pointedly suggestions of the World Bank Institute to develop knowledge economies (WBI, 2007), namely: education and training; ICT infrastructure, policies, and innovation/R&D. Clear examples of how countries are following these guidelines with success (of course, before the global financial situation of 2009) are:

- **Singapore** - the ‘economic miracle of the Asian region, with its focus on innovation, and IT infrastructure and government policies
- **Ireland** – transitioned from a poor, largely agricultural country whose young people were leaving it has become one of the most dynamic knowledge-based economies in Europe investing in education and bringing foreign investment.
- **South Korea** – which evolved to become one of the most vibrant countries in the region… a manufacturing powerhouse that has virtually eradicated poverty, malnutrition & illiteracy and finding its place in the global economy.

Nowadays, Brazil, Russia, India and China (“BRIC” countries) are capturing the world news with their economic development achievements. For example, en August 15, 2010, China surpassed Japan as the second world largest economy (Barboza, 2010).

> “China is still a developing country. It has a lot of room to grow. And China has the biggest impact on commodity prices — in Russia, India, Australia and Latin America.”
> ~ Wang Tao, economist at UBS in Beijing, 2010

China and other countries are capitalizing on their resources and people to compete, recognizing the relationship between education and economic strength, just as the US and other developed countries have (See Figure 2). In the US states where education attainment is high (Massachusetts, New Jersey, Connecticut, Maryland), the per capita income is high as well.
Table 1: Technical Leaders 21st Century Skills (Johansen, 2009)

<table>
<thead>
<tr>
<th>Skills</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mobability</td>
<td>ability to work in large groups; talent for organizing &amp; collaborating with many people simultaneously</td>
</tr>
<tr>
<td>Influency</td>
<td>ability to be persuasive in multiple social contexts &amp; media spaces; understanding that each context &amp; space requires a different persuasive strategy &amp; technique</td>
</tr>
<tr>
<td>Ping Quotient</td>
<td>responsiveness to other people’s requests for engagement; propensity &amp; ability to reach out to others in a network</td>
</tr>
<tr>
<td>Multi-Capitalism</td>
<td>fluency in working with different kinds of capital: natural, intellectual, social, financial, etc.</td>
</tr>
<tr>
<td>Protovation</td>
<td>fearless innovation in rapid, iterative circles</td>
</tr>
<tr>
<td>Open Authorship</td>
<td>creating content for public consumption &amp; modification</td>
</tr>
<tr>
<td>Emergensight</td>
<td>ability to prepare for &amp; handle surprising results &amp; complexity</td>
</tr>
<tr>
<td>Longbroading</td>
<td>thinking in terms of higher-level systems &amp; cycles</td>
</tr>
<tr>
<td>Signal/noise</td>
<td>filtering meaningful information, patterns &amp; commonalities from massively multiple streams of data</td>
</tr>
<tr>
<td>Cooperation Radar</td>
<td>the ability to sense, almost intuitively, who would make the best collaborators on a particular task.</td>
</tr>
</tbody>
</table>

Figure 2: Relationship between the education levels of the population and per capita personal income (2009)

Global Investments in Science and Engineering Talent and Innovation

In addition to capital, labor and land, knowledge is becoming a primary factor of production. In fact, many economists now argue that knowledge has become the most important component of production. The belief is that a knowledge economy will lead to improved quality, reduced costs, better response to consumer needs, and innovative products. Since knowledge resides in human resources, talented individuals are key to start the virtuous cycle that catalyzes economies.

The direct relationship between science, engineering/technology, innovation and economic development and sustainability is reported in the OECD Science, Technology and Industry Scoreboard (OECD, 2007, 2009). Countries like China, Korea, Sweden, Germany, and Finland are producing science and engineering graduates show healthy economies. And those that are investing significant amounts of their GDP in R&D and innovation are world economic leaders (Sweden, Finland, Japan, Korea, and Switzerland). The number of doctoral graduates, another key another indicator, shows that this talent
trained to conduct research, invents solutions and contributes to the diffusion and use of knowledge and new business creation.

But unfortunately, science and technology investments and the number of science/engineering graduates do not necessarily mean quality or obtaining desired outcomes. Evidence points to the fact that the world’s most valuable resource - a well qualified talent pool - is getting harder and harder to find. In fact, finding talented people is the single most important managerial preoccupation around the globe, according to a 2007 McKinsey survey.

Why is qualified talent difficult to find?

One possible reason may very well be because there is wide gap between what universities are producing and what companies need (Frymire, 2006; McKinsey 2008). It appears that the skills and competencies of university graduates are not aligned with the needs of the public and the private sectors. New university graduates indicate a country’s capacity to absorb, develop and diffuse knowledge and to supply the labor market with highly skilled professionals. Results from the 2008 McKinsey survey of 83 worldwide executive interviews demonstrate a very low hiring rate in engineering and other professions. For example, if executives had 100 engineering positions to fill, they could hire only 13, 10, 25 and 10% of the engineers in Brazil, Russia, India and China, respectively. This could be due to many factors, but most certainly, related to out-dated curricula and lack/poor development of the skills and competencies needed in the workforce are certainly a strong factor, as stated in previous section.

The following question arises: Are traditional curricula preparing students well for their professional challenges?

The overwhelming response across the world is, no (Becker 2009). While working techniques, teamwork, methods/systems know-how, hands-on know how, communication/presentation, foreign language, negotiation and leadership skills are considered very important/important for the job, they are not considered as well taught in the university. There’s a clear disparity between knowledge taught at universities and know-how required at the workplace.

Faced with this serious gap between, what can engineering educators do? The answer to this question is URGENT, CRITICAL and UNAVOIDABLE. For every day that goes by, society loses and nobody wins.

HOW CAN ENGINEERING & ENGINEERING EDUCATION RESPOND AND ADDRESS LOCAL, REGIONAL & GLOBAL CHALLENGES?

If technology and knowledge form the basis for meaningful economic development, and, given that globalization is radically accelerating the pace of change and raising the long-term stakes, it is clear that success in knowledge-based economies depends largely on the capabilities of people who are credentialed in meaningful and consistent ways. Furthermore, the kind of knowledge countries need to develop is key: first, literacy of the general population, and then educating problem-solvers who can build the technical infrastructure for sustainable change. Engineers are the ideal problem solvers. When you consider that economic studies conducted before the information-technology revolution show that as much as 85 percent of measured growth in U.S. income per capita was due to technological change (US NAE, 2005), a strong case can be made for seeing engineers as the key knowledge workers for capacity building and sustainable economic growth in emerging economies.

Thus, one can safely conclude that engineering and engineers are key to developing and growing knowledge-based economies. For no profession unleashes the spirit of innovation like engineering, few professions turn so many ideas into so many realities and few professions have such a direct and positive effect on people’s everyday lives.

But engineering is a demanding and tough discipline. It requires intensive discipline and motivation and hard work. And in view of technology industry executives, it also requires more than textbooks, exams and theories.

“...for students to succeed as engineers, they must acquire skills that go far beyond theories, simulations and exam-taking... there is absolutely no substitute for the hard edged technical and business skills that are required to bring products and projects to market.”

~ Bernard M. Gordon, founder of NeuroLogica Corp., founder & former chair of Analogic Corp., and co-founder of Epsco Inc.

So, what can engineer education stakeholders and leaders (deans, faculty, students, administrators, industry, government agencies, professional associations and others) do to reduce this enormous gap? The author suggests five (5) principal actions, namely:

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1. Innovate, reform the engineering curriculum AND the learning experience
2. Focus on learning (not on teaching)
3. Foster creativity and innovation across the ecosystem
4. Implement continuous assessment and accreditation to drive excellence
5. Educate the engineering professor of the future

Innovate, Reform the Curriculum and the Learning Experience

High-quality and pertinent engineering education are imperatives for creating a knowledge-based economy. Engineering education must respond to local challenges as well as global opportunities.

During the past 10 to 15 years there have also been significant amounts of resources spent worldwide innovating engineering curricula. In the US for example, some of the most prominent initiatives occurred during the mid 90’s when NSF funded the Engineering Coalitions; for example: www.gatewaycoalition.com; www.synthesis.org; www.succeed.ufl.edu). These focused primarily on engineering curricula innovation, integrating outcomes assessment, using complementary technology and implementing new learning strategies. One of the authors of this paper - together with colleagues from Penn State University, the University of Washington and Sandia National Labs - also participated in a somewhat smaller but successful partnership called the Learning Factory, which received the US NAE Gordon Prize in 2006 for innovation in engineering education (Lamancusa, et al, 2008). Although these efforts were successful, they have not permeated the engineering education ecosystem the way the sponsors and participants thought they would. The engineering education culture – the model for training the next generation of engineers – is still the same.

Notwithstanding the current global economic crises, the fact remains that the economic progress and achievements of US and many other nations are rooted in their science and engineering talent. Why, then, has the engineering education model not evolved at the pace that science and technology have? How has top-tier science/engineering developments continued if students are not appropriately prepared? The workplace demands new engineers to be technically qualified, flexible, and dynamic thinkers, but their classrooms are not necessarily and systemically supplying them with these tools.

Perhaps the lack of attention to the educators themselves is the key oversight in this system. Evidence of this perceived lag can be seen in Figure 1. About 50% of industry and academia respondents in an Engineering 2020 survey dissent from the assertion that the current undergraduate engineering education is sufficiently flexible to adequately meet the needs of 21st century engineers.

Figure 3: Responses to Question: “Current undergraduate engineering education is sufficiently flexible to adequately meet the needs of the 21st century engineers” (US NAE, 2004)
Therefore, the author strongly believes that in order to innovate and reform engineering education, the engineering education leadership requires a systemic, integrated approach. Why not apply the engineering problem solving approach engineers are experts on, to innovate the curriculum? Engineering educators could take the following steps:

1. Define educational objectives/desired outcomes
2. Plan the education process (content, skills, competencies, experiences)
3. Measure outcomes (outcomes, learning, process)
4. Share results/discuss with stakeholders
5. Make decisions (to improve, not punish)
6. Re-engineer/re-form

One first critical action to be undertaken in this process is to understand the elements, components and variables that characterizes the ‘educational ecosystem’. The author’s description of a university, college or engineering program is similar to a chemical reactor: a system existing in a location/city/country/region and which mission is to provide educated citizens, generate/augment the pool of knowledge and serve its community (the three-pronged mission of universities). It receives students from the secondary system of education with certain skills and competencies and through its education/experiences processes, generates outcomes of value to society. Each university, college or program has ‘unique variables’ that define the system and help achieve desired outcomes (like a chemical reactor). The unique combination and value the system places in these variables gives the distinctive nature of the program. These ‘variables’ include curriculum, faculty qualifications, student experiences, textbooks used, labs and infrastructure, and others.

So, the Chemical Engineering (ChE) program at the University of Puerto Rico at Mayagüez is not equal to any other ChE program around the world. Why, because it exists only in Puerto Rico, serves the Puerto Rican society (although its graduates are recruited from several parts of the world!), and the institution has certain specific goals and values that makes it one of a kind. Yes, there may be things that are somewhat the same among various institutions (courses, textbooks, credit-hours, etc), yet each one has distinctive attributes.

In order for a university or engineering program to be of value to society, it has to understand its needs. What are the city/country/region economic development and human resources needs now and in the future? Where in the value chain the city/country/region wants to be in the future (innovation, manufacturing, marketing, all)? What are the technology niches it wants to nurture or develop? Once these questions are answered by all stakeholders in consensus, the program can then define the skills, competencies and values of its graduates, which in turn will define curricula AND student experiences needed to achieve educational goals.

A key step in this process is the definition of the engineering graduate profile, the skills and competencies s/he must possess to be successful as an engineer. Engineers face problems as a way of life. Engineers must not only be knowledgeable about science and technology but also have the skills, competencies and values to address problems and opportunities in effective and creative ways.

But herein lays the problem: engineering education has not traditionally concerned itself with the development of skills and competencies needed in the job market and workplace.

According to Richard M. Felder, co-director of the U.S. National Effective Teaching Institute, “We’re teaching the wrong stuff (Felder, 2006)” He argues that since the 1960s, the United States has concentrated almost exclusively on equipping students with analytical (left-brain) problem-solving skills, and that a) most jobs calling for those skills can now be done better and or cheaper by either computers or skilled foreign workers (and if they can be, they will be), and b) American workers with certain right-brain skills will continue to find jobs in the new economy. (For example, researchers, designers, entrepreneurs as well as other self-directed people, and people with strong interpersonal, cultural awareness and language skills.) Felder questions whether the U.S. education system is helping students develop the attributes they will need to be employable in the coming American and global engineering job market.

Another important element in this process understands the principal stakeholder: the engineering student. The 21st century student is creative, mobile, collaborative, multi-tasking and producer. He/she was born with technology and uses it freely. Educators should understand their motivations, how they spend their time, their challenges, their expectations for the future and their perceptions and expectations of the education they are receiving.

For engineering education to be effective, it needs to innovate both the curriculum AND the learning experience taking into consideration the needs of society and the learner.

**Focus on Learning (not on Teaching)**

Few engineering professors are taught how to teach (in fact, few higher education professors, in general, are educated in pedagogy). Adults have special needs when it comes to learning and few higher educators are aware of them. Only few understand that humans have
preferred learning styles and that professors like to teach the way they learn. At most, what engineering professors start their academic careers, they replicate/adapt the teaching style of their professors, which resembles an 18th century classroom. But teaching is too complex and too important a profession to let people do it with no training or experience (Felder, 2004). According to Felder, most engineering instruction in the past few decades has been heavily biased toward intuitive, verbal, reflective, and sequential learners, although relatively few engineering students fall into all four of these categories. The result is that most engineering students are taught in a manner at least partially mismatched to their learning styles, which could hurt their performance and their attitude toward engineering as a curriculum and career. For engineering education to be effective it has to focus on the learning not on the teaching. Educators need to integrate diverse classroom (and out of classroom) techniques, like cooperative learning, active learning, visuals, etc. to address the learning styles of all the students.

**Foster Creativity & Innovation**

"Innovation is the specific instrument of entrepreneurship... the act that endows resources with a new capacity to create wealth." Peter Drucker

Innovation (and its outcomes) is one of the foundations of knowledge-based economies. Innovation is driven by processes that succeed only where organizational conditions foster the transformation of knowledge into products, processes, systems, and services. In order to catalyze and sustain economic development, innovation has to be ingrained in the culture of people; it has to be a mindset that drives people to make better everything around, including personal life all the time. Innovation also allows education stakeholders to be open and accept others' ideas. For innovation to occur and to have economic and societal impact, all sectors of society have to be involved to both solve local problems and be globally competitive.

According to the World Economic Forum (2008), the 'magic formula' for innovation is:

- 2 universities (one strong in sciences/engineering, other in liberal arts + management)
- Large corporations
- Sister city w/mature economy
- Sector growth
- Plus, rule of law, infrastructure, culture, society embracing mobility, tax policy

For engineering education to be effective, it needs to consider developing the innovative engineer, one who invents new processes and ideas and some even take risks starting new businesses (entrepreneur).

**Implement Continuous Assessment & Accreditation to Drive Excellence**

Higher education institutions and engineering programs need to collect of data to be able to understand and interpret the institution/program, make intelligent decisions about current operations, develop plans for the future and improve the efficiency and effectiveness of the system. Data also provides a mean to understand internal operations and the effectiveness with which leaders and others are using their resources. Universities and programs need to engage in serious institutional research in order to provide information which supports planning, policy formation, and decision making. Finally, there’s the need to be accountable to society.

There are various definitions to outcomes assessment, but a widely accepted one is: outcomes assessment is a process to improve the quality of an academic program, student learning, and student success based on real evidence. It is a continuous process that involves planning, assessing, data analysis, feedback, and making programmatic improvements. Outcomes assessment also involves documentation, stakeholder input and sharing of results. Integrating outcomes assessment and continuous improvement into academic programs have become a major goal of every engineering educational institution (McGourty, 1999). Moreover, with the new ABET accreditation criteria (www.abet.org) established in the US in 2000, the push is for outcomes assessment across the globe.

If education, in general and engineering education in particular, is key foundation for society, all institutions and programs should strive for excellent through continuous quality assessment (internal driver for excellence) and through accreditation (external driver for excellence). The quest for excellence through internal and external drivers begins with strategic planning, which establishes the roadmap that responds to various intertwined contexts with the ultimate outcome of influencing change. In order to make sound, validated decisions based on actual data, planning, executing, assessment and feedback are critical for decision making.

Engineering program accreditation as mentioned above is a widely used external driver of excellence.

"Accreditation is a process of external quality review created and used by higher education to scrutinize colleges, universities and programs for quality assurance and improvement.” Judith S. Eaton, President, US CHEA
In many regions around the world that undergo engineering program accreditation either voluntarily or mandated, the process brings the following benefits: assures quality in education, allows access to external (federal) funds, provides a means for ease transfer of courses and programs and lastly and very important to those hiring engineers, accreditation provides employer confidence.

For engineering education to improve, it has to integrate internal and external drivers of excellence through planning, continuous outcomes assessment and accreditation.

Educate the Future Engineer Professor

Most reports on engineering education tend to emphasize “what” needs to be changed. “How” the change should be driven and “who” should drive the change have generally not been as fully addressed, both of which largely determine how quickly and how well change occurs and how it is sustained (Morell, 2010).

Most fundamentally, many engineering education reports fail to reach the base: absent are guidelines for the engineering professor looking for best practices and roadmaps to become a better educator and professional. Many may argue that the ideal engineering graduate of today and tomorrow has already been described ad nauseam and that - as a result - millions of dollars have been invested to innovate and reform engineering education. But the fact remains that the engineering education ecosystem has not developed in the way expected and required.

In spite of all these efforts, still the same questions remain unanswered: What is the problem with engineering education, and why has the profile of the engineering professor been ignored in this discussion? Why the continuing problems of recruitment and retention of engineering students with all of the resources devoted to curriculum development? Why the lag, as previously described, between the advancement of science and technology vis-à-vis the evolution of the engineering education model? Why are so many worried that the profession will not be able to serve society and support and sustain economic development as it has in the past?

The answer may very well be, because, there’s been little systemic effort to change/educate the ‘catalyzer’ of engineering education: the engineering professor! A 2009 survey undertaken by the author and the President of the Student Platform for Engineering Education Development (SPEED) aimed at describing what the profile and general characteristics of the ideal engineering professor (Morell, 2010). Figure 4 describes the major findings of this global, multi-stakeholder survey.

The engineering professor of today and tomorrow needs to be a blend of the two professions, engineer and educator. He/she must be an individual who:

- Is competent in his/her own discipline, engineering fundamentals and problem solving
- Is current in his/her research, publishes, networks, communicates effectively and keeps up with trends in his/her discipline; and does all of the above with an entrepreneurial spirit.
- Is an effective teacher, knows about learning and outcomes assessment, facilitates learning using learner-centered strategies, keeps up with developments in engineering education, studies and uses the effectively, cares about the students and their learning, enjoys being as a mentor.
- Understands the role that the profession has in society both locally and globally, practices it as part of his/her career development as well as leads, serves and participate in forums to promote policy making and excellence in engineering education and research/innovation.
- Aims at developing the skills and competencies engineers should possess through practice and experience in order to better serve society and be a role model for students.

At Hewlett Packard Laboratories (HP Labs), Open Innovation 1 is a core element to augment and accelerate knowledge creation and tech transfer. Projects underway include joint research with universities worldwide, collaborations with customers and partners and research and internship/postdoc programs co-funded by governments. Engagement with government agencies in the US, UK and selected strategic geographies has helped broaden HP Labs’ reach and ability to conduct critical IT research and host a number of interns and postdocs, a unique opportunity for the development of future generations of scientists and engineers to grow the critical skills for future product and service innovation. Programs of this nature lay the foundations for future partnerships with universities and newly qualified researchers, as well as being a vital investment in the future health of the innovation ecosystem.

1 Henry Chesbrough defines Open Innovation as “the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively. This paradigm assumes that firms can and should use external ideas as well as internal ideas, and internal and external paths to market, as they look to advance their technology…”
In 2009, HP Labs - with the support of several other corporate research labs – led the creation of a pilot program at the US National Science Foundation (NSF) to allow corporate labs host engineering postdocs. In 2010, the Industrial Research Innovation Post Doc Fellowship Program run by the American Society of Engineering Education (ASEE) provided 40 top US engineering post docs to work with corporate scientists (Morell, 2010). The program posted 160 research positions by 47 companies (only 40 filled) and over 450 candidates responded. HP Labs hosted five (5) of these postdocs working on cutting-edge research in areas such as next-generation displays, nanotechnology and information management with very positive results.

These kinds of opportunities provide future professors to experience engineering and research/innovation for a purpose beyond publishing a paper, obtaining external funds and supervising PhD thesis. They become aware of technology/science frontiers, business constraints and the need for special skills in the workplace (like working in multidisciplinary multi-geography, multi-stakeholder team projects) so innovating engineering curriculum accordingly be a natural for them.

For engineering education to be effective, it must plan to develop and educate the engineering professor, one that is experienced in the profession as well as knowledgeable of the learning process.

CONCLUSION

Higher education, in general, is responsible for formally preparing the next generation of leaders, technical professionals, government officials and educators. Engineering education, in particular, plays a central role in our increasingly technology-based societies. The education of engineers must prepare them for the multi-disciplinary nature of the problems they will face developing a new set of skills and competencies. The author lists five things engineering education can do to better respond to society’s needs: innovate, reform the engineering curriculum AND the learning experience; focus on learning (not on teaching), foster creativity and innovation across the ecosystem, implement continuous assessment and accreditation to drive excellence and educate the engineering professor of the future. These may seem impossible to accomplish, but not as difficult as the grand challenges the world is facing and will continue to face in the future. There are many good benchmarks and good practices around the world. It takes leadership to plan and allocate the right resources. But change only starts when individuals change first.

REFERENCES


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Support for Innovation, Organizational Learning, and Organizational Innovation in Vocational High Schools: a Taiwanese Perspective

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Abstract

Many studies have shown that support for innovation positively influences organizational innovation. Organizational learning is closely related to organizational innovation. However, there is a lack of studies examining the direct and indirect effects of organizational learning on organizational innovation. The purpose of this study was to examine the role of organizational learning as a mediator variable between support for innovation and organizational innovation. Samples for this study were randomly selected from 32 vocational high schools in Taiwan. The final sample included 421 participants in the full sample which accounted for 70.35% of the sample. The study concluded that support for innovation was an important determinant of organizational innovation in vocational high schools. Organizational learning had a positive relationship between support for innovation and organizational innovation.

Keywords: organizational learning, support for innovation, organizational innovation.

INTRODUCTION

The present educational environment has become increasingly competitive. To keep up with rapid changes, schools need to foster interaction between the principal and teachers to promote organizational innovation (Hsiao, Chang, & Tu, 2009). The goal of vocational high schools is to equip students with skills in industry. The education at vocational high schools in Taiwan offers students a variety of vocational and technical courses to gain practical experience alongside theoretical learning in the classroom.

However, school principals can act in both formal and informal ways to build commitment towards the organization. The principals can interact with supervisors, teachers, parents and students in a loose organizational structure (Catano & Stronge, 2007). The teaching and learning process is the foundation of education. In order to achieve educational goals, the school administrators should endeavor to influence teachers (Olaleye, 2008). Principals are expected to exhibit leadership and improve schools to enhance teaching and learning in the school. It is their responsibility to have a positive influence on teacher organization.

Organizational learning in schools in the context of education is regarded as a learning community (Imants, 2003). Argyris and Schön (1978) provided that it enhances the organization’s innovative capacity. Most studies regarding organizational learning associate it with organizational innovation (Hsiao et al, 2009; Weerawardena et al, 2006). Some studies found that support for innovation may have an influence on organizational innovation (Gumusluoglu & Ilsev, 2009; Scott & Bruce, 1994). However, there is a lack of studies examining whether the support for innovation has a direct effect. Empirical studies have not examined the mediating role of this contextual factor while investigating the relationship between organizational learning and support for innovation. Based on the above, this study aimed to explore the impact of support for innovation on organizational innovation and the role played by organizational learning as a mediator variable. Figure 1 shows the model developed for this purpose.

![Figure 1: The Proposed Model](image)

THEORETICAL BACKGROUND AND HYPOTHESES

Support for Innovation and Organizational Innovation

Gumusluoglu and Ilsev (2009) concluded support for innovation has a moderating role between transformational leadership and organizational innovation. From their results they concluded that transformational leadership and external support for innovation had a significant effect on organizational innovation, but there was no clear evidence for internal support for innovation. Jung, Chow and Wu (2003) used a multisource approach to investigate 32 Taiwanese companies, showed that transformational leadership had a significant and positive influence on organizational innovation when mediated by empowerment and support.
for innovation.

$H_1$: Support for innovation positively influences organizational innovation

**Support for Innovation & Organizational Learning**

Organizational learning has been regarded as one of the strategic means of achieving long-term organizational success (Senge, 1990). Organizational learning can be considered as a process of change in thought and action both shared and individually, which is affected by the organization of the institution (Vera & Crossan, 2004). Jung, Chow, and Wu (2003) argue that when an organizational culture values initiative and innovative approaches, employees are more likely to take calculated risks, accept challenging assignments, and derive intrinsic enjoyment from their work. Administrative support for innovation is critical both inside and outside the organization (García-Morales, Llorens-Montes & Verdú-Jover, 2008; Burningham & West, 1995). This support for innovation defines expectations, approval, and practical support of attempts to introduce new and improved ways of doing things in the work environment. Thus:

$H_2$: Support for innovation positively influences organizational learning

**Organizational Learning & Innovation**

Organizations can learn through collective experience, perspective, and capabilities of individuals (Rait, 1995). If innovation is to emerge, organizations need to develop highly effective strategies to improve organizational learning (Glynn, 1996). Previous research has shown that organizational learning affects organizational innovation. Hsiao et. al. (2009), examined 418 teachers of vocational high school teachers in Taiwan. They found that the public school teachers’ perception of higher organizational learning having significant influence on organizational innovation was greater than private school teachers. Liao and Wu (2010) selected samples based on Common Wealth Magazine’s Top 1000 manufacturers and Top 100 financial firms in Taiwan. They came to the conclusion that organizational learning was significantly and positively related to organizational innovation. Weerawardena, et. al. (2006) examined 1,000 firms in Australia. Their results found that the more organizational learning, the more organizational innovation. Based on these findings, organizational learning and organizational innovation were closely related. Therefore:

$H_3$: Organizational learning positively influences organizational innovation

From review of literature, organizational learning will affect support for innovation (García-Morales et al, 2008). This has a positive influence on organizational innovation (Gumusluoglu & Ilsev, 2009; Scott & Bruce, 1994). Organizational learning may be an important mediator variable. This study proposes:

$H_4$: Organizational learning mediates the relationship between support for innovation and organizational innovation

**METHOD**

**Samples**

Samples from this study were randomly selected from 32 vocational high schools in Taiwan. The final sample included 421 teachers in the full sample which accounted for 70.35% of the sample. There were 203 male (48.2%) and 218 female (51.8%) teachers. The average age of subjects in the sample was 30.36 years with a range of 28–50 years. Subjects in the sample were well educated: 53.4% held bachelor degrees, 44.7% had master degrees and 1.9% had PhDs. 23.3% had job tenure below 5 years, 20.2% with job tenure of 6–10 years, 15.7% with job tenure of 11–15 years and 21.1% with job tenure above 21 years. The statistics for samples are listed in Table 1.

<table>
<thead>
<tr>
<th>Table 1: Statistics of samples</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Descriptive statistics</strong></td>
</tr>
<tr>
<td>Gender</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Education</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>In charge of Administration</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Job tenure</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
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<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>n = 421</td>
</tr>
</tbody>
</table>

**Procedure**

The purpose of this study was to investigate the relationship between organizational learning and organizational innovation. The role of support for innovation was a mediator variable. Based on literature review and previous research, hypotheses were formulated and tested. The first section consists of demographic information about the teachers among the 32 vocational high schools in Taiwan. The second section consists of 16 items within 3 scales. All scales were composed of 5-point Likert-type items. The average time for completing each questionnaire was 10–15 minutes.

**Measures**

**Support for Innovation**

The Support for Innovation Scale (SIS) was developed on the basis of many relevant studies (Scott & Bruce,
Organizational Learning Scale (OLS) measured in this study was developed on the basis of relevant studies (Kale, Singh & Perlmutter, 2000). Internal consistency was measured with Cronbach’s alpha (α = .90). A confirmatory factor analysis (CFA) of a one factor model, reflected acceptable goodness-of-fit indexes (χ²/df < 4, GFI = .997, AGFI = .986, RMSEA = .024, ρc = .84, AVE = .56).

Organizational Innovation

The Organizational Innovation Scale (OIS) was measured with five items adapted from Friedman (2003). It was suggested that one item from OIS be removed on the basis of an exploratory factor analysis (EFA), due to high structure coefficients loading above 1 (Hair, Black, Babin, & Anderson, 2010). Cronbach’s alpha reflected a good level of internal consistency (α = .87). A CFA test of one-factor model, resulted in suitable goodness-of-fit indexes (χ²/df < 2, GFI = .994, AGFI = .972, RMSEA = .056, ρc = .87, AVE = .72).

Organizational Learning Scale (OLS) measured in this study was developed on the basis of relevant studies (Kale, Singh & Perlmutter, 2000). Internal consistency was measured with Cronbach’s alpha (α = .90). A confirmatory factor analysis (CFA) of a one factor model, reflected acceptable goodness-of-fit indexes (χ²/df < 4, GFI = .993, AGFI = .963, RMSEA = .070, ρc = .89, AVE = .68).

Organizational Innovation

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Data Analysis

In response to the research questions, correlation analysis was used to find the relationship between support for innovation, organizational learning, and organizational innovation. Moreover, structural equation modeling was used to test the complex relationship and direct/indirect effects.

RESULTS

Descriptive Results

Means and standard deviations of SI, OL, and OI are represented in Table 2. All mean scores were > 3.0, ranging from 3.76 to 3.81. This indicated an overall positive perception.

Table 2: Statistics and reliability coefficient for each subscale

<table>
<thead>
<tr>
<th>Subscale</th>
<th>Number of items</th>
<th>Mean</th>
<th>SD</th>
<th>α</th>
</tr>
</thead>
<tbody>
<tr>
<td>Support for Innovation(SI)</td>
<td>4</td>
<td>3.76</td>
<td>.64</td>
<td>.87</td>
</tr>
<tr>
<td>Organizational Learning(OL)</td>
<td>4</td>
<td>3.81</td>
<td>.68</td>
<td>.90</td>
</tr>
<tr>
<td>Organizational Innovation(OI)</td>
<td>4</td>
<td>3.79</td>
<td>.65</td>
<td>.87</td>
</tr>
<tr>
<td>n = 421</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Correlation Analysis

The bivariate correlation analysis is presented in Table 3. Organizational learning had a significant and positive correlation for support for innovation (r = .710, p < .01), and organizational innovation (r = .701, p < .01). Support for innovation had a significant and positive correlation with organizational innovation (r = .703, p < .01). Variable correlations are shown in Table 3. Teachers who had positive perception in support for innovation were also likely to lead to more positive experience in organizational innovation. It seems that teachers who had more frequently in organizational learning behaviors tended to engage more frequently in organizational innovation. Organizational learning is increasingly becoming recognized as a crucial organizational function. However, teachers who had positive perception toward support for innovation had a better tendency to practice organizational innovation.

Table 3: Correlation coefficients for pairs of variables

<table>
<thead>
<tr>
<th>Subscale</th>
<th>SI</th>
<th>OL</th>
<th>OI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Support for Innovation(SI)</td>
<td>.710</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Organizational Learning(OL)</td>
<td></td>
<td>.701</td>
<td></td>
</tr>
<tr>
<td>Organizational Innovation(OI)</td>
<td></td>
<td></td>
<td>.703</td>
</tr>
<tr>
<td>n = 421</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>p &lt; .01</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Analysis model

Using organizational innovation as the endogenous variable, and support for innovation and organizational learning as exogenous variables, each path in the model was tested. The first goal was to estimate the predictive power of the set of independent variables on organizational innovation. As the focus of this study was on direct and indirect effects of organizational learning on organizational innovation, the strength of predictor variables on the dependent variable was assessed. All the indices were in line with recommended benchmarks for acceptable fit (χ²/df < 2.165, GFI = .958, AGFI = .936, and RMSEA = .053). The total explained variance in organizational innovation was 69.2% (R² = .692). Table 4 illustrates the fit indices for the proposed research model.

Table 4: Summary of goodness-of-fit indices (df = 51)

<table>
<thead>
<tr>
<th>Fit index</th>
<th>Recommended level of fit</th>
<th>Proposed research mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>n = 51</td>
<td>n.s at p &lt; .05</td>
<td>110.392</td>
</tr>
<tr>
<td>2/df</td>
<td>&lt; 5</td>
<td>2.165</td>
</tr>
<tr>
<td>AGFI</td>
<td>&gt; .90</td>
<td>.936</td>
</tr>
<tr>
<td>NFI</td>
<td>&gt; .90</td>
<td>.968</td>
</tr>
<tr>
<td>CFI</td>
<td>&gt; .90</td>
<td>.982</td>
</tr>
<tr>
<td>RMSEA</td>
<td>&lt; .05</td>
<td>.053</td>
</tr>
</tbody>
</table>

Note: “a” represents the value of RMSEA which is acceptable.

Table 5 shows the structural model with the standardized coefficients for the research sample. The results in Table 5 provide sufficient support for H₁. Support for innovation is significantly and positively related to organizational innovation, γ₁ = .790, p < .001. Table 5 also supports H₂ and H₃. Support for innovation is significantly and positively related to support for innovation, γ₂ = .788, p < .001. Support for innovation is significantly and positively related to organizational innovation, β₁ = .424, p < .001.

However, this study was measured using path analysis to show direct and indirect effects of each construct. The results are reported in table 6. After analysis, the direct
effect of organizational learning and support for innovation, $\gamma_1 = .335$, $p < .001$, is significant. The indirect effect is $.456$, $p < .001$ as shown in Figure 2. The indirect effect is greater than the direct effect. Therefore, organizational learning mediated the relationship between support for innovation and organizational innovation. $H_4$ is supported.

Table 5: Structural parameter estimates and goodness-of-fit indices

<table>
<thead>
<tr>
<th>Hypotheses</th>
<th>Paths</th>
<th>Standardized coefficients</th>
<th>$t$-Value</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>$H_1$</td>
<td>Support for innovation $\rightarrow$ Organizational innovation ($\gamma_1$)</td>
<td>.790</td>
<td>6.114***</td>
<td>Supported</td>
</tr>
<tr>
<td>$H_2$</td>
<td>Support for innovation $\rightarrow$ Organizational learning ($\gamma_1$)</td>
<td>.788</td>
<td>16.074***</td>
<td>Supported</td>
</tr>
<tr>
<td>$H_3$</td>
<td>Organizational learning $\rightarrow$ Organizational innovation ($\gamma_2$)</td>
<td>.424</td>
<td>5.815***</td>
<td>Supported</td>
</tr>
</tbody>
</table>

$^2(51 \text{ d.f.}) = 110.39$ GFI = .958 CFI = .982

Standardized RMSEA = .029

Table 6: Direct and indirect relationship

<table>
<thead>
<tr>
<th>Variables</th>
<th>Organizational learning</th>
<th>Organizational innovation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exogenous Support for innovation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Direct</td>
<td>.788***</td>
<td>.335***</td>
</tr>
<tr>
<td>Indirect</td>
<td></td>
<td>.456***</td>
</tr>
<tr>
<td>Total</td>
<td>.788***</td>
<td>.790***</td>
</tr>
<tr>
<td>Exogenous Organizational learning</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Direct</td>
<td>.424***</td>
<td></td>
</tr>
<tr>
<td>Indirect</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>.424***</td>
<td></td>
</tr>
</tbody>
</table>

$^p < .001$

Figure 2: Path coefficients of the research model

DISCUSSION

This study was aimed at examining the impact of support for innovation on organizational innovation and the role played by organizational learning as mediating variables. First, results indicated that support for innovation had direct positive influence on organizational innovation. This result concurred with Gumusluoglu and Ilsev (2009), Scott and Bruce (1994) whose study showed the greater support for innovation, the greater organizational innovation. It was important to show empirically that the effect of administration on organizational innovation increased with significant support for innovation.

Secondly, the results of the structural equation model indicated that support for innovation had a positive influence on organizational learning. That is, with greater support for innovation, there is more organizational learning. Organizations can learn through collective experience, perspective, and capabilities of individuals (Rait, 1995).

Thirdly, the results provided sufficient evidence to support a relationship between organizational learning and organizational innovation. This empirical evidence implies that organizational learning affects organizational innovation. In other words, higher organizational learning leads to improved organizational innovation. Accordingly, this finding is consistent with the research by Liao, Fei, and Liu (2008).

Fourthly, the hypothesized mediator role of organizational learning was confirmed. Empirical evidence indicates that the relationship between support for innovation and organizational innovation is significant where the direct effect is less than the indirect effect. Organizational learning triggers the relationship between support for innovation and organizational innovation.

LIMITATION

There are several limitations to the present study. The role of organizational learning as a mediator between support for innovation and organizational innovation was investigated. The results indicated that organizational learning served as a partial mediator. Other contextual variables were not included in the study.

The second limitation is related to the survey data. The survey data may have been subject to social desirability bias. This bias might occur in survey research when participants answer the questions to conform to the social norms or expectations. In particular, these samples were collected from teachers in charge of administration in vocational high schools. Their efforts are a possible determinant of innovation performance in schools. However, their perceptions of self-assessment may have a tendency to overestimate organizational innovation.

The third limitation of this study is related to the participants. Participants consisted of 421 teachers only from vocational high schools in Taiwan. Because it is a sampling from selection of people in a specific kind of school, findings cannot be generalized to larger populations. For this reason, future research can be conducted with a collection of more samples from different groups of teachers and areas of study to broaden the scope. This may include teacher trainers, students and parents.

DIRECTIONS FOR FUTURE RESEARCH

There are several suggestions for future research. First, this study examines only the role of support for innovation, organizational learning and organizational innovation. This study indicates that support for innovation is a key factor in organizational innovation. It
is possible that there are other variables not included in this study. Future research should further explore the perceptions of organizational climate, organizational behavior, and the administrative-teacher exchange relationship. This study investigated the relationship between the support for innovation and organizational innovation, and organizational learning as the mediator. There may be other factors which affect organizational innovation. Future research should not only explore relevant variables, but attempt to investigate interactions between group-level variables and individual-level variables. In addition, future research can be conducted with a larger sample across different levels or groups to provide more varied results.

CONCLUSIONS

This study explored the relationship between support for innovation, organizational learning and organizational innovation. The results indicated that the support for innovation and organizational learning are both important determinants of organizational innovation in vocational high schools. The school principals played a key role in school improvement. The results also suggest that successful organizational innovation requires strong support for innovation in the school improvement process. Principals should often support and encourage their staff in an innovative setting with strategies for organizational innovation. In addition, the study also suggests that in order to improve organizational innovation in vocational high schools, future studies could investigate the effects of other contextual variables such as organizational climate, team cohesion and leader-member exchange.

ACKNOWLEDGEMENT

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REFERENCES


Support for innovation, organizational learning, and organizational innovation in vocational high schools: a Taiwanese perspective

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Application of Challenge Based Learning Approaches in Robotics Education

Min Jou, Chen-Kang Hung, & Shih-Hung Lai
National Taiwan Normal University, Taipei, Taiwan, R.O.C

Abstract

Engineers involved in the product realization process must master technology as it develops and quickly integrate it into products well ahead of the competition. Many educators have developed a variety of pedagogical tools and curriculum to increase the competence of students in engineering. Robotics, being an interdisciplinary engineering subject, plays a key role in achieving this goal. Thus, the purpose of this research is to apply challenge based learning (CBL) approaches to enhance students’ motivation and learning effectiveness.

Keywords: Challenge Based Learning, Robotics, Student Motivation.

INTRODUCTION

Many robotics researchers have developed a variety of tools to support educators in teaching students about robotic-related technologies. Initial attempts were to simplify robotic instruction by employing programming tools to control robot arms for students to learn robotic thinking (Vira & Tunstel, 1992; Mrad & Deeb, 1997). In order to overcome the limitation of hardware constraints, graphic simulators of robotic dynamics have been developed to allow more students to participate in courses (Raz, 1989; Inigo & Morton, 1991). Vibet (1993) assembled elements to teach robot control. Pota (1992) employed an interdisciplinary project to construct a flexible manipulator to teach the integration of robotic mechanisms with electronics. Richard (1991) developed an interactive system that allows the student to gain practical experience with image processing and machine vision operators. The evolution of Internet technologies has made it easy to allow students to access robots for meaningful learning experiences everywhere. Real robots can be remotely controlled through the internet (Newman et al., 2002; Carley et al., 2000) A web-based simulation of the actual operating robot was implemented in 2004 (Kuc et al.). The simulation was written in JavaScript employing a freeware game library, which controls robot elements and environmental objects in a flexible manner. A package called Robot-Draw applied internet-based programming tools to generate three-dimensional virtual models of robot manipulators from a DH parameter table. Internet users can generate three-dimensional robot manipulator models on their computer screens, navigate around the robot model, and examine it from any angle. The package was designed as a visualization aid in robotics education and allows educators and students to easily visualize robotic structures and directly evaluate the effect of a parameter variation on the overall robot (Robinette & Manseur, 2001).

Robotics has been integrated into undergraduate courses to enhance teaching and learning activities (Maxwell & Meeden, 2000; Mehrl et al., 1997) (Rawat & Massiha, 2004) (Nagai, 2001). Robotic Autonomy is a seven-week, hands-on introduction to robotics designed for high school students (RASC, 2003). The course presents a broad survey of robotics, beginning with mechanisms and electronics and ending with robot behavior, navigation, and remote teleoperation. Some robotic educators employed Lego (LEGO Mindstorm) and Parallax (Parallax) to design curriculum around both robot morphology and construction as well as robot programming and interaction (Stein, 2002) (Wolz, 2000). Many robotic contests offer various design projects to encourage students to apply knowledge gained throughout the engineering curriculum. The contests span different education levels, from the high school competition FIRST (Foundation for the Inspiration and Recognition of Science and Technology) to advanced research programs, such as robotic soccer (RoboCup), the walking machine decathlon contest (Walking Machine Decathlon, 2003), and urban search and rescue (USAR) initiatives (Verner & Waks, 2000) (Osuka, 2002). Pack et al. (2004) presented the benefits of an autonomous fire-fighting robot design competition as an effective tool for undergraduate education. The uniqueness is that it offers a design challenge that can be addressed by students and professionals of all ages and skill levels.

The robotic educational endeavors are extremely large and diverse. These efforts represent significant advances in robotics education. However, there appears to be great demand for further study on how to enhance teaching and learning effectiveness. Therefore, this study adopts a challenge based learning approach to provide motivation and collaborative learning for students.

CHALLENGE BASED LEARNING (CBL)

Educational strategies are clearly changing due to the evolution of technology and new media formats. One such evolutionary educational strategy is the challenge based learning strategy or CBL. CBL is an educational
model that is incorporated into traditional fields of study such as science and engineering, providing the real-world perspective that learning should involve doing work in a topic rather than reading about a topic of study. CBL is based on a framework that is essentially aligned with the scientific process itself in which a real-world problem is identified, a set of activities is developed to understand the problem, and then an actionable solution is proposed followed by assessment and even publication (Johnson, Smith, Smythe & Varon, 2009).

This process can result not only in highly educated engineers but also in practical results with application to science and industry. Additionally, the CBL approach has a high degree of relevance in the contemporary education environment. Technology platforms have also worked to expand and revolutionize the learning environment and CBL can be easily integrated into online learning and computer based instruction (CBI) where students tend to work in groups or clusters. Students are focused on problems and they are assessed on easily identifiable outcomes (Sun, Cheng, Lin, & Wang, 2008). CBL is a model that industry embraces because it prepares students for the types of issues they will actually face in the workspace. Additionally, it also socializes them to work in groups and teaches them how to collaborate on issues in a meaningful fashion. However, CBL is not without its criticisms. Some researchers found that CBL oriented science courses run the risk of de-emphasizing the scientific principles and theories of why certain processes occur and only focusing on what the outcomes are (Abrahams & Miller, 2008). While this emphasis on practical outcomes is the intent of CBL educational programs, students that fail to understand the theory of processes behind these also lack the ability to identify important scientific relationships between observed phenomena.

CBL is a concept that has been utilized in engineering programs previously, albeit in a fashion that few would immediately recognize. This solution is readily apparent in the field of robotic engineering, and the United States (US) often utilizes competitions in robotic science as a means to improve its higher education engineering (US) often utilizes competitions in robotic science as a means to improve its higher education engineering programs previously, albeit in a fashion that few would immediately recognize. This solution is readily apparent in the field of robotic engineering, and the United States (US) often utilizes competitions in robotic science as a means to improve its higher education engineering programs and their students can greatly reduce the cost of hosting such programs and also improve the results that CBL programs can achieve.

**SETTING & METHODS**

There are five skill levels of practical work which are designed based upon the functions required of robots in this study (Table 1). The first three levels are made to see whether students are able to apply contact or non-contact sensors to fabricate robots to overcome environmental situations and to avoid obstacles. The fourth level is to measure whether students are able to function robots as line-following, and to realize whether or not they can design more complicated driving systems as well. This means that students need to design a driving system by using less motor. Students have to upgrade the control methods from sequential control to PID-control mode in the fifth level. Students may start from the easiest level (level 1), and get into the harder level after they pass the previous one.

The population of the study was students who took an automatic control course; the sample size was fifty-seven students. Within the 57 students, 31 were in the experimental group, and 26 were in the control group.

In this study, we used an independent T-test to test whether there was any obvious difference in learning performance between students from different groups. Table 2 shows that there was no difference (p>.05) in Concept of Mechatronics and Principle of Robotics. Students from the experimental group and the control group all reached significant difference in the three domains: Structure and Mechanism Design (p=.033<.05), Control System Design and Application (p=.002<.05), and Route Design and Programming (p=.045<.05). The results illustrate that applying CBL to process robotics-teaching can effectively enhance students’ cognition for the three domains.

We conducted satisfaction questionnaires for students to see if there was any difference between students from different groups. There were fifty-seven students who took the questionnaires and answered the questions completely. As shown in Table 3, students from different groups had no discrepancy in satisfaction according to the T-test’s results (p>.05). It illustrates that there was no difference in satisfaction for those students.
Table 1: Five Levels of Practical work.

<table>
<thead>
<tr>
<th>Levels</th>
<th>Robot functions</th>
<th>Driving system</th>
<th>Sensor apply</th>
<th>Control method</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Moving route: straight line</td>
<td>drive 4 wheels by 4 motors</td>
<td>No need to install</td>
<td>Sequential control</td>
</tr>
<tr>
<td></td>
<td>Road surface: flat</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Obstacle: none</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Moving border: not limited</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Moving route: straight line</td>
<td>drive 4 wheels by 4 motors</td>
<td>Contact sensors (bumper • proximity sensor)</td>
<td>Sequential control</td>
</tr>
<tr>
<td></td>
<td>Road surface: flat</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Obstacle: none</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Moving border: limited</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Moving route: straight line, wall following</td>
<td>drive 4 wheels by 4 motors</td>
<td>Contact and non-contact sensors (bumper • proximity sensor • Ultrasonic sensor)</td>
<td>Sequential control +Feedback control</td>
</tr>
<tr>
<td></td>
<td>Road surface: not flat</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Obstacle: yes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Moving border: limited</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Moving route: line-following</td>
<td>drive 4 wheels by 3 motors</td>
<td>Contact and non-contact sensors (bumper • proximity sensor • Ultrasonic sensor • Line-following sensor)</td>
<td>Sequential control +Feedback control</td>
</tr>
<tr>
<td></td>
<td>Road surface: not flat</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Obstacle: yes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Moving border: limited</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Moving route: line-following</td>
<td>drive 4 wheels by 2 motors</td>
<td>Contact and non-contact sensor (bumper • proximity sensor • Ultrasonic sensor • Line-following sensor)</td>
<td>PID control mode</td>
</tr>
<tr>
<td></td>
<td>Road surface: not flat</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Obstacle: yes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Moving border: limited</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2: Comparison of cognition between students from different groups.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Experimental Group (n=31)</th>
<th>Control Group (n=26)</th>
<th>p</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Concept of Mechatronics</td>
<td>6.52</td>
<td>2.30</td>
<td>6.15</td>
<td>1.95</td>
</tr>
<tr>
<td>Structure and Mechanism Design</td>
<td>7.87</td>
<td>3.13</td>
<td>6.15</td>
<td>2.71</td>
</tr>
<tr>
<td>Principle of Robotics</td>
<td>8.00</td>
<td>2.25</td>
<td>7.69</td>
<td>2.17</td>
</tr>
<tr>
<td>Control System Design and Application</td>
<td>35.35</td>
<td>4.36</td>
<td>28.31</td>
<td>9.89</td>
</tr>
<tr>
<td>Route Design and Programming</td>
<td>10.58</td>
<td>2.48</td>
<td>9.23</td>
<td>2.47</td>
</tr>
</tbody>
</table>

*p<.05; **p<.01

Table 3: Satisfaction of T-test of students from different groups.

<table>
<thead>
<tr>
<th>Group</th>
<th>Experimental Group (n=31)</th>
<th>Control Group (n=26)</th>
<th>p</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Satisfaction</td>
<td>4.11</td>
<td>0.52</td>
<td>4.23</td>
<td>0.56</td>
</tr>
</tbody>
</table>

*p<.05

CONCLUSIONS

The results of this study found that challenge based learning approaches are able to enhance students’ course achievements and students’ motivation. By means of such approaches, students can explore the essence of design, manufacturing, mechanisms, control, and the integration of robotics. However, in the aspect of satisfaction, there is no difference between students from two groups. The major reason might be that challenge based learning approaches require students to learn under a strict standard. Although learning effectiveness in the experiment was increased, students may not be appreciative of these on-going changes.

ACKNOWLEDGMENT

The authors gratefully acknowledge the support of this study by the National Science Council of Taiwan, under the Grant No. NSC96-2516-S-003-003-MY3.

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http://www.edu.tw/files/site_content/b0013/97_student.xls


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Developments of Students’ Spatial Abilities in a Computer Graphics Course Using 3D-CG Software

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Abstract

A full-year elective course of Computer Graphics is offered using High-end 3D-CG software. Lectures and exercises on projection drawing methods and sketch drawing are given at the beginning of the course. MCT was performed at the beginning and the end of the course. This paper examines the results, especially with respect to the relationship between scores on MCTs and scores on assignments of the 2008 class. MCT increased at the end of the course especially in case of students who got higher total subject scores. It became clear that the higher the score on assignments, the more improvement there was in the student’s spatial abilities. In case of assignments significantly correlating with MCT scores, students had to model objects by creating a picture in their mind, because examples were given only by orthogonal projection views or they had to compose by using some abstract conditions like “to include Boolean operation,” etc. Thus, the students those who could create clear images of the target objects both geometrically and dimensionally and the students who intuitively understood when they had created the wrong form of the model received good results on assignments and could gain greater understanding of spatial recognition. In conclusion, if we define abilities measured by MCT in terms of cognitive abilities relating to three dimensional objects drawn in a two dimensional plane, completing assignments by making images of objects improves the space sense of students.

Keywords: Spatial Recognition, Space Sense, Computer Graphics Course, Graphics Education, MCT, 3D-CG Software.

INTRODUCTION

A full-year elective course of Computer Graphics is offered to 3rd and 4th grade students of the School of Social Information Studies, Otsuma Women’s University. High-end 3D-CG software (‘3ds Max 9’, Autodesk Inc.) was adopted by the course in 2007. The curriculum puts emphasis on 3D shape representation. In this course, the most difficult aspect for students has been to embody their own ideas into computer graphics in 3-D space and to recognize three dimensional objects in two dimensional views, i.e., projection drawings.

So we decided to offer lectures and exercises on projection drawing methods and sketch drawing before students learn to use the 3D-CG software.

In courses on graphics at the undergraduate level of study, 3-D spatial abilities have received much attention lately. In fact, for the past decade, several tests have been created to evaluate the spatial abilities of students.

The Mental Cutting Test (hereafter, MCT: a sub-set of CEEB Special Aptitude Test in Spatial Relations, 1939) was used by Suzuki, et al. (Suzuki, Wakita, & Nagano, 1990) for measuring spatial abilities in relation to graphics curricula. Since then, improvement of students’ spatial ability has been discussed among graphics educators, and various experimental studies have started to evaluate the spatial abilities of students from the viewpoint of how they are related to graphics education. Suzuki (Suzuki, 1999, 2000, 2002) has compared the course differences between the MCT results of 53 groups, sorted by gender, at 16 universities in 5 countries in which 4 courses were included, i.e., Descriptive Geometry, Engineering Graphics, Computer Graphics and 3-D CAD. Suzuki reported that (1) female students tended to receive lower MCT scores compared to male students and (2) fostering of spatial abilities through 3-D CAD course was difficult. There have been, however, few studies on the development of spatial abilities in relation to graphics education using 3D-CG software.

This paper analyzed the course results, especially with respect to the relationship between scores on MCTs and scores on assignments, of the 2008 class at Otsuma Women’s University.

CURRICULUM & ASSIGNMENTS

Table 1 shows the contents of the curriculum and assignments. Fourteen assignments were given during the course. Assignments are shown using italics and the Roman numerals indicate the assignment number. The end-of-term exam for each semester was performed as a paper-pencil test. Although the number of registered students in this course was 54, only 33 students submitted all the assignments. Thus, analysis of this course included these 33 students.

MENTAL CUTTING TEST (MCT)

The MCT consists of 25 problems for which a perfect score is 25 and test time is 20 minutes. In each problem, subjects are given a perspective drawing of a test solid which is to be cut with an assumed cutting plane.
Developments of Students’ Spatial Abilities in a Computer Graphics Course Using 3D-CG Software

Subjects are asked to choose one correct cross section among 5 alternatives (Figure 1).

Table 1: Curriculum and assignments

<table>
<thead>
<tr>
<th>Week</th>
<th>First semester</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Guidance, pre-MCT</td>
</tr>
<tr>
<td>2-3</td>
<td>Projection drawing method</td>
</tr>
<tr>
<td></td>
<td>I, II: Principal views*</td>
</tr>
<tr>
<td></td>
<td>III, IV: Isometric views</td>
</tr>
<tr>
<td>4</td>
<td>Sketch drawing</td>
</tr>
<tr>
<td></td>
<td>V: Sketch drawing of mobile phone</td>
</tr>
<tr>
<td>5-8</td>
<td>Polygon-base modeling</td>
</tr>
<tr>
<td></td>
<td>VI: Polygon modeling of mobile phone</td>
</tr>
<tr>
<td>9-11</td>
<td>Entry-level use of 3D-CG software</td>
</tr>
<tr>
<td></td>
<td>VII: Modeling using Loft surface</td>
</tr>
<tr>
<td>12-13</td>
<td>Various 3D shape modeling</td>
</tr>
<tr>
<td></td>
<td>VIII: Modeling of familiar housewares</td>
</tr>
<tr>
<td>14</td>
<td>End-of-term exam</td>
</tr>
<tr>
<td>15</td>
<td>Interim summary, Explanation for the answer of end-of-term exam</td>
</tr>
</tbody>
</table>

Second semester

| 1-3 | Geometrical transformation  |
|     | IX, X: Selection of camera views |
| 4   | Material |
| 5   | Lighting |
| 6   | Shade and shadow |
| 7   | Rendering  |
|     | XI: Scene rendering |
| 8-11| Animation  |
|     | XII: Motion of objects |
|     | XIII: Walkthrough |
| 13-(15)| Comprehensive assignment  |
|      | XIV: Animation under several conditions |
| 14  | End-of-term exam |
| 15  | Summary, Explanation for the answer of end-of-term exam, post-MCT |

Table 2: MCT results

<table>
<thead>
<tr>
<th>Year 2008</th>
<th>From Semi-annual 2008</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of students</td>
<td>33</td>
</tr>
<tr>
<td>Pre-MCT score</td>
<td>10.76</td>
</tr>
<tr>
<td>Post-MCT score</td>
<td>12.79</td>
</tr>
<tr>
<td>Difference</td>
<td>2.03</td>
</tr>
<tr>
<td>p</td>
<td>0.05%**</td>
</tr>
<tr>
<td>r</td>
<td>0.759</td>
</tr>
</tbody>
</table>

CORRELATION BETWEEN TOTAL SUBJECT SCORES & MCT SCORES

Although pre-MCT scores have no significant correlation with the total subject scores (r=0.26, p=0.14>0.05), post-MCT scores have significant correlation with the total subject scores (r=0.59, p=0.0003<0.01). Figure 2 indicates that the scores of MCT increased at the end of the course especially for students who got higher total subject scores.

Correlation coefficient was 0.76 and there was a significant difference (p<0.0005) between the average scores (Table 2).

CORRELATION BETWEEN ASSIGNMENT SCORES & MCT SCORES

Figure 3 shows the correlation coefficients between the scores of seven typical assignments and pre- and post-MCT scores. In most assignments correlation coefficients with post-MCT scores were larger by 0.15 points compared to pre-MCT scores. The results show that improvement in spatial ability was assured through this course and the improvement was concerned with various processes of assignments.

Assignments Correlating Weakly with MCT Scores

When the sample size is 33 there is a statistically significant correlation when r is more than 0.35. Figure 3 shows that in assignments like “Polygon modeling of mobile phone (VI),” “Modeling using Loft surface (VII),” and “Scene rendering (XI),” the correlation coefficient between the assignment score and MCT score was relatively lower and had no statistical significance (r<0.35).

So we will call these assignments as ‘Assignments correlating weakly with MCT scores’.

MCT was performed both at the beginning (pre-MCT) and end (post-MCT) of the course. The average score of pre- and post-MCT were 10.76 and 12.79, respectively.

Assignment correlating weakly with MCT score. Table 2: MCT results Year 2008
Figure 2: Relation between pre- and post-MCT scores and total subject scores

Figure A-1: Scores of assignments significantly correlating with MCT scores
Developments of Students’ Spatial Abilities in a Computer Graphics Course Using 3D-CG Software

Assignments Significantly Correlating with MCT Scores

In several assignments like “Principal views and isometric views (I-IV),” “Sketch drawing of mobile phone (V),” “Modeling of familiar housewares (VIII),” and “Animation under several conditions (XIV),” the correlation coefficient between the assignment scores and MCT scores was relatively high and had statistical significance (r>0.35).

Figure 3: Correlation coefficients between the scores of seven typical assignments and pre- and post-MCT scores

Figure A-1 shows the scores of such assignments with MCT scores. In figure A-1(a), students were arranged in the order of pre-MCT score. In figure A-1(b), they were arranged in the order of post-MCT score.

There was a rather strong correlation between post-MCT scores and the assignment scores (r=0.52, 0.49, 0.50 and 0.49, respectively).

Figure A-1 (b) shows that students whose post-MCT score was higher than 14 tended to get high scores on these assignments and they increased the MCT score. The average MCT scores increase among them was 3.8.

Figure 4: Polygon model for 4 students (Assignment VI)

Figure 5: Modeling using Loft surface (Assignment VII)

DISCUSSION

Average Scores of MCT

Average score of MCT increased by 2.03 at the end of the course. This increase was a little bit larger than the so called learning effect by receiving pre-MCT. Thus we can say that spatial ability as it is measured by MCT was improved through this course.

Degree of Scores on Assignments & MCT Scores

There was a significant correlation (r=0.59) between post-MCT and total subject score. It seemed that spatial abilities measured by MCT must be improved to some extent through assignments, considering that there was no significant correlation (r=0.26) between pre-MCT and total subject score, and that 50% of the total subject score reflects the sum total of 14 assignment scores. Many students who got high total subject scores increased their MCT scores at the end of the course.

It may also be verified by the fact that the r of the post-MCT scores and assignment scores were larger than the r of pre-MCT scores and assignment scores in 7 assignments, as seen in figure 3. It becomes clear that the higher the score on assignments, the more improvement there was in the student’s spatial abilities.

These results show that improvement in spatial ability was assured through the exercise in this course, and the improvement was concerned with various processes of each assignment.
Characteristics of Each Assignment & Spatial Recognition

Correlations between assignments and MCT varied according to the characteristics of each assignment. In case of the assignments correlating weakly with MCT scores, students could model objects taking and observing actual equipment in their hands (assignment VI) or students were given measurements of the example objects (assignment VII).

Figure 4 shows pictures and 3-D models of mobile phones, generated in assignment VI. Before this assignment, students sketched and drew principal views while observing their own mobile phone (Assignment V). As most of the recent mobile phones have rectangular bodies with rounded corners, it is not so difficult to capture the shape if they keep a correct aspect ratio. So a number of students must have made a model precisely capturing the equipment’s characteristics.

Figure 5 shows a Loft surface model and the pre-MCT models at the bottom of the figure were generated using a helical path and two contour shapes. The angle of helical rotation and the shapes (a circle and a stellated polygon) were given. Although there are a few inaccurate models, most of the models were well done.

Eight models at the bottom of the figure were generated by the students who withdrew from the class. They did well also except one.

Thus, it could be considered that the assignments in which most of students could reach a desirable level of proficiency have a weak correlation with MCT score. Models generated by the students who withdrew from the course differ little from those by the students who got through the course.

In the meantime, in assignments significantly correlating with MCT scores, students had to model objects by creating a picture in their mind, because examples were given only by orthogonal projection views-like pictures (assignment VIII: targets of modeling were bottles of famous shampoo and mouthwash brands, a milk frother, a whisk, and a pear as shown in Figure 6) or they had to compose by using some abstract conditions like “to include Boolean operation,” “to use basic 3 point lighting,” “to move camera,” etc. (assignment XIV).

CONCLUSION

The students those who increased skills of creating clear images of the target objects both geometrically and dimensionally with less hint about the assignments, and the students who learned to understand intuitively when they had created the wrong form of the model might received good results on assignments and could gain greater understanding of spatial recognition. At the same time such students might be able to get some strategic competence against the problems such as that of MCT.

In conclusion, if we define abilities measured by MCT in terms of cognitive abilities relating to three dimensional objects drawn in a two dimensional plane, to complete assignments not only by using CG software automatically but by fully making images of objects improves the space sense of students.

Figure 6: Examples in assignment VII which were given only by orthogonal projection views-like pictures

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The Mediating Effect of Technology toward Knowledge Management Services for e-learning Satisfaction

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**National Institute for Research in Computer Science and Control, Paris, France
***Department of Information Engineering, National Changhua University of Education, Changhua, Taiwan

Abstract

Rising fast with the Internet network, e-learning has already becoming the new learning style in economic era. It also breaks the convention constrains on knowledge sharing and offers learners the learning style in more pluralism, and hence even more, meet the individual's demand of learning. The research that was studied in the technology mediating learning model in the past, scholars studied from the psychology with the real learning process view mostly, it influences the e-learning to study the effect to probe into. However, knowledge management service still lack of the positive research on technology mediating effects while studying. Thus, this research proposes that the technology mediating learning model to extend according to Wan, Zeying et al. (2007), regard the knowledge management service as the learning process, examining the effects of e-learning. The observations of selected courses were sampling from university in Taiwan. Totally 125 students participate in and through the questionnaire investigation method of the network platform. Finally, we obtain 110 effective questionnaires. The result of study shows that the information technology, teaching strategies, Teacher’s specialty are positively significant effects on knowledge management service. It’s also shown that the knowledge management service is positively significant effects on the e-learning satisfaction, and reveals that the knowledge management service really plays an important role to the learning satisfaction in the e-learning strategies.

Keywords: e-learning, knowledge management service, learning satisfaction, technology mediating learning model, teacher's specialty.

INTRODUCTION

Background

With the rapid development and popularization of information, it is driving the overall technology industry worldwide. Also, it is subtly changing the messages and ways of thinking of human transmission in education, but also with the rise of e-learning, online collaboration and learning technology is a growing trend direction. Information technology involves into educational activities, teaching evolution textbook from the first to diversify the use of computer software and hardware, so that the pace of progress towards diversification of modern education.

Wan et al (2007) said that in the last decade, due to gradual increase in demand for higher education, development of science and technology mediated learning booming trend. Most of the empirical study of e-learning, the personal point of view of integration and learning outcomes does, however, the intermediate course is rarely discussed. The technology is still a lack of mediated learning process. Alavi and Leidner (2001) proposed framework for science and technology mediated learning, emphasis on technology, teaching cases, psychological and environmental factors that affect learning effectiveness. Benbunan-Fich and Hiltz's (2003) with the point of view of an intermediary in designing the course from the application of technology in curriculum design and analysis of the actual impact of the learning process, technology and learning relationships. Wan et al (2007) compiled literature on technology mediated learning in the information technology, major players, instructional design has been discussed, which is pointing out that little is known about the learning process of psychological and neglect, it is necessary to discuss the mediated effects.

Wiig (1994) proposed that the knowledge management services are kinds of activities to assist the organizations to obtain a series of themselves and others' intellectual knowledge. As determined through a careful process to achieve organizational mission. According to Chen (2001) pointed out that knowledge management can help organizations and individuals, through information technology, through the creation of knowledge, classification, storage, share, update, and create real value processes and strategies for the business or individual. Young (2004) discovered that using the e-learning technology could improve the staff access, dissemination and sharing of knowledge functions. The technologies that applied by the organizational learning, including the multimedia computers, audio-video equipment, digital learning and hence becoming technology-based learning.
Motivation

We extend the framework proposed by Wan et al (2007) for technology mediated learning. The point of view to be extended is focused on actual learning activities of learners from the learning perspective to observe the knowledge management activities so as to reveal some extent on the effectiveness of learning impact. In this study, knowledge management was viewed as services for learning process, because of the learner's knowledge management activities will affect the learning situation. The knowledge management services for learners from the case as the middle course of events, on learning satisfaction to play an important key factor.

In this study, knowledge management point of view as a learning process and it is rare in the e-learning literature. Hence, we aimed to strengthen the inadequacies of previous studies of this area so that the learner's knowledge management services are necessary to focus.

Research Objectives

Empirical way from the e-learning technology models, teaching strategies, teacher’s characteristics dimensions to measure the satisfaction of learning in this paper. The knowledge management is served as a learning process to find the role and importance on learning satisfaction. Specific objectives of this paper are: (1). to discuss how the information technology affected the knowledge management services for the learners? (2). to explore how the teaching strategies affected knowledge management services for the learners? (3). to find how the teacher’s characteristics affected knowledge management services for the learners? (4). how knowledge management services affected the e-learning satisfaction for the learners?

LITERATURE REVIEW

Technology Mediated Learning

Alavi and Lederer (2001) proposed the technology mediated learning (TML) perspective in which learners construct the learning environment through the information technology, and further, their teachers and students communicate on, and interactive learning in the learning environment. TML defined by advanced information technology as a medium to reach learners and learning materials, peers and educators interact. Wan et al (2007) compiled in the past science and technology mediated learning literature, summarized the three dimensions (the original participants, instructional design and information technology) affect children's psychological learning process, lead to different learning outcomes.

Kettanurak et al (2001) study will approach as mediator, that the positive effect on interactive learning attitude, attitude changes includes some dimensions to increase the user's performance. Benbunan-Fich et al (2003) discussed the cooperation and information transfer case scenario as the middle of the process of learning, discovery and cooperation through the network to discuss the case study, the integrity of the group final report has great benefit. Chen (2002) of the learning process of interaction as a mediator, outline teaching methods were more than outline posted articles supporting the traditional teaching methods, no significant difference between learning an interactive process. Zhuang (2005) will learn strategies as a mediator, the use of learning strategies when the learner the better, the satisfaction of the e-learning the better.

Information Technology

Cassation (2003) that the e-learning is the use of the Internet for different locations, different time, mentoring, self-paced instruction on the other, but also its development for job training. Thornton et al (2004) pointed out that the e-learning is to enhance learning and teaching tool, not to replace teaching. It is an effective tool for all whether or not proper use, rather than to the amount. Lin (1998), Yueh & Zhong (2005) is an online learning environment web browsing and communication, teaching situation, such a teaching situation can make all the network of teaching and learning activities, with location, time of the independence, students can progress according to their own learning, anytime learning curriculum.

Young (2004) the use of e-learning technology can improve staff access, dissemination and sharing of knowledge functions. The technologies that applied by the organizational learning, including the multimedia computers, audio-video equipment, and technology-based learning. Taiwan Cisco Systems (2000) for e-learning makes learning to bring more diverse information and provide quick-learning function, reduce the learning costs, improve learning quality and increase participation rates, responsible for training their own learning, through the e-learning online teaching, learning opportunities extended to every person, in order to continuously update the capacity and knowledge to accelerate the diversification of life-long learning.

Chiu (1998) that the learning community of learning is not a new concept in computer distribution network, provide precisely the concept of learning communities can realize the environment and tools that learning communities could be developed with the computer network space. Chang (1998) indicates that online learning community is a network virtual environment, it is the use of educational technology and the concept of Internet communication technology evolved, the participants shared through the network involved in learning activities and communication through discussion interaction, and can break through the constraints of time and geographical barriers, so that time and space in different regions and community members
to share their knowledge and experience to achieve resource sharing, common information, knowledge exchange and experience sharing.

**Teaching Strategies**

Refers to the use of teaching strategies to provide teacher’s teaching methods, procedures and techniques, the strategies used in teaching are usually a variety of procedures or technologies, and use (Wang, 1994; Shen, 2001; Oliva, 1992). Design teaching strategies and teaching activities should take disciplinary nature of the level of the students, teaching objectives, and teaching materials and other factors (Shen, 1998; Chang, 1994). Cavanaugh et al (2000) pointed out that the teaching strategies, interactive, educational content and effective control and management will affect their learning, through empirical study found that a positive attitude towards science and technology educators to attach importance to interactive teaching and application of technology maturity and control has a positive impact on the teaching effectiveness.

Hong (1997) of the argument for education, science and summarize our influence "to promote active learning capacity of students to develop scientific inquiry ability, reasoning ability to enhance the development of thinking, to enhance the ability to judge the" four directions as follows: (a) Marson (2001) pointed out that demonstration teaching, students face the real problem situation, students must take the initiative to obtain information and put forward their own ideas, and others do not only reach a group consensus on the final rebuttal, it was the individual's internal perception of the harmonic, and then build up the knowledge; (b). Gagne (1963) think that the so-called scientific inquiry using scientific methods to solve only the problems faced, when students participate in science themes demonstration activities, students of the problem situation, design an appropriate solution, to collect the required information and evaluation evidence, a reasonable proposition, and held a number of discussions and consultations with peers, access to the collective consensus; (c). Kuhn (1992) pointed out that the students in the course of argument, mind to answer questions way to nurture the idea. The idea needed further assess the feasibility of a search for available information and evidence, advocate and support the formation of reasons; (d). Voss and Means (1991) noted that activities in the argument that the students should not be continuous to advocate or agree with others to meet their own thoughts, needs and reasons for the claims of others to judge, observed differences in the various messages, the courage to reasonable criticism and rebuttal. Therefore, teaching through demonstration activities, students can gradually enhance the critical capabilities.

Slavin (1995) defines the definition of cooperative learning for students with learning, sharing ideas on the group as responsible as individuals learning to emphasize group goals and group achievement. Therefore, cooperative learning should include a completed project and tasks, team members need to help each to complete, each member will have to really learn and have the group return the results. The studies of Hiltz et al (2002) have shown that cooperative learning not only to participate in asynchronous online courses can increase the motivation, which can stimulate students to actively participate in enhancing the quality of their learning.

**Teacher Characteristics**

Webster and Hackley (1997) said that the teaching of any teaching and learning environment in the feet play a very important color. Although e-learning environment, teaching instructor who has been the main facilitator of role transition, its position in the online learning environment is still important, but playing the role of the traditional learning environment is different. Webster and Hackley (1997) found that teachers' teaching style to encourage student interaction will affect learning. Hiltz (1997) thought that will affect the style of teaching-learning participation and involvement, if the digital learning environment will encourage students to co-produce successful learning experience. Garrison and Shale (1987) emphasized the interaction between teacher and education center, through the interaction with the students, teachers can determine the needs of students and teachers. Students also need feedback on the course learning achievement and a timely correction.

Piccoli et al (2001) proposed that the virtual learning environment of computer-based, will penetrate all aspects of the student learning experience, teaching attitudes and actions by those who show the behavior of the students in the learning environment have a major impact. Moore and Kearsley (1996) believe that must be timely intervention of teaching students to interact and encourage students to learn. Hiltz (1997) discovered that will affect the style of teaching-learning participation and involvement, if the e-learning environment will encourage students to co-produce successful learning experience.

Shi (1984) found that the professional competence of teachers of teachers engaged in teaching work, which should have the ability. The ability of the substance involved in teaching activities included in the available knowledge and methods used to achieve the objectives of teaching skills and performance can enhance the growth behavior of students. Professional competence of teachers is divided into three dimensions by Chai (1993), including professional knowledge and professional capability, professionalism and professional attitude, professional organizations and professional norms.
KNOWLEDGE MANAGEMENT SERVICES

Daveport and Pusnak (2000) defined knowledge management services for the organization to enhance the viability and competitive advantage of the existing organization to internal and external individuals, groups of valuable knowledge, a systematic definition of, or access, store, share transfer, use of assessment termed. Lin (2003) defined knowledge management services for the organization to enhance the viability and competitive advantage of the existing organization to internal and external individuals, groups of valuable knowledge, a systematic definition of, or access, store, share transfer, use of assessment termed. Snowden (2000) think that the knowledge management services is recognized intellectual assets, optimization and active management of intellectual assets, including artificial product that has the explicit knowledge, or individual, the community has a tacit knowledge.

Bostrom (1989) pointed out that efficient knowledge sharing can be considered as a group generate synergy, this synergy is defined as the mutual respect and understanding between people, escape from the scope of knowledge management, knowledge sharing is still a daily non-stop in the organization run by members daily cooperation, are part of knowledge sharing. Wiig (1994) said that the knowledge management services assist organizations to obtain a series of themselves and other intellectual activity, as determined through a careful process to achieve organizational mission.

Demarest (1997) pointed out that the knowledge management process should include storage, transfer, share, spread, creating the five steps. Avelino (2003) provide knowledge management services to process activities, including discovery, retrieval, sharing, applications of knowledge to the objectives to achieve improved efficiency.

Learning Satisfaction

Chen (2003) said that the satisfaction is a key to stimulate learning motivation, but also needs fulfilled, referring to the learners in the learning process, pleasure, adequate levels, or learning to meet the needs and expectations of the degree. Wang (2003) from a marketing point of view, students can be considered as a final customer, will be among educators and learners through the education product or service outcome satisfaction.

Binner et al (1994) defined the satisfaction of the study in addition to assess student learning results as the basis, but also to the development of a course evaluation used, produced by learners on the courses, the curriculum revised. Piccoli et al (2001) think that the learning environment in an emerging measure of learner satisfaction is very important to learner satisfaction can be used to predict a similar opportunity to participate in learning.

RESEARCH METHODS

Research Structure

This study in accordance with the dimension from information technology intermediary strategic framework developed by Wan, Fang, Yulin, & Derrick (2007), as shown in Figure 1.

Definition of Variables Measured

In this study, a total of three dimensions from the variables: the first dimension is the information technology, and the second dimension is the teaching strategies, and the third dimension is the teacher characteristics.

Independent Variables

(1) Information Technology

The learning environment in this study is based on the definition of network learning environment proposed by Lin (1998), Yueh & Chong (2005). And, the questionnaire on the basis of that the students may not limited by learning time, space and developed areas. Cassarino (2003) shows that the e-learning is using the Internet to different locations, different time, mentoring, self-paced instruction on such views; also made reference to Chiu (1998) that the learning community of learning is not a new concept in computer distribution network, provide precisely the concept of learning communities can realize the environment and tools, that is, learning community with the development of computer networks have developed a questionnaire space. With totally ten items, while using the Likert five-point scale method to measure.

(2) Teaching Strategies

This study refers to the research of Huang (2007) that demonstrates the argument for education, science and summarizes the influence: "promote active learning, the development of scientific inquiry ability, reasoning ability to enhance the development of thinking, enhance critical capabilities". Hiltz et al (2002) studies have shown that cooperative learning will not only increase
the participation of non-synchronous Internet courses of learning motivation, which can stimulate students to actively participate in enhancing the learning quality of the questionnaire developed by a total of sixteen questions, using Likert five-point scale to measure.

(3) Teacher Characteristics

This research is based on the results from Moore and Kearsley (1996), which pointed out that the teaching will be required to intervene interactive learning, will motivate students to learn; and stressed the interaction between teachers and students contribute to learning impact. Piccoli et al (2001) proposed that virtualization of computer-based learning environment, an element of all aspects of the student learning experience, so teaching attitudes and actions by those who show the behavior of the students in the learning environment have a major impact, developed by nine question survey, using Likert five-point scale to measure.

Mediating Variables

In this study, based on knowledge management services, Avelino (2003) defined knowledge management process of service delivery activities, including discovery, retrieval, sharing, and application of knowledge to the objectives of the four steps to achieve greater efficiency. Reference to Wiig (1994) that proposed the development of knowledge management services to view the questionnaire out of a total of nine questions, using Likert five-point scale to measure.

Dependent Variable

This study Binner et al (1994) and Piccoli et al (2001) point out the development of the questionnaire used to assess student-learning course for satisfaction, a total of eight questions, using Likert five-point scale to measure.

Research Hypothesis

The main purpose of this study of knowledge management e-learning service satisfaction influence the learning of information technology, teaching strategies and Teacher’s characteristics of the students in the learning process, the impact of knowledge management services, thereby affecting student learning satisfaction.

Information Technology for the Impact of Knowledge Management Services

According to Qiu (2004), which pointed out that the learners use of rich audio-visual media, not only cannot get rid of the text presented difficulties, through an interactive learning platform will enable more effective knowledge acquisition. Young political science (1993) wrote that, for e-learning with no time limits, break area, easy to spread and accelerate the reaction rate, so organized, and so information can quickly accumulate and spread of a learning organization focused on knowledge sharing and creation, through the knowledge of each other sharing, so that the entire organization to continually upgrade staff to create value, so that performance improved significantly, according to this view a hypothesis 1 as follows:

H1: Information Technology for students to have positive effects on knowledge management services.

Teaching Strategies for the Impact of Knowledge Management Services

According to Chen (2005), application for technical and vocational college students for foreign language teaching strategies and student services, knowledge management has done research, teaching strategies that teachers are the better, which are more able to help students making knowledge management services. Yu (2002) think that teachers, who have the better of teaching strategies, students more likely to have better knowledge management level, the view put forward the hypothesis of vertical integration 2 as follows:

H2: teaching strategies for students to have positive effects on knowledge management services

Characteristics of Teachers of Knowledge Management Services

Cavanaugh et al (2000) pointed out that the teaching strategies, interactive, educational content and effective control and management will affect their learning, through empirical study found that a positive attitude towards science and technology educators to attach importance to interactive teaching and application of technology maturity and control has a positive impact on the teaching effectiveness. Gregory (2003) pointed out that teaching in a distance learning study were positively correlated with satisfaction, as educators teaching strategies used will affect the learning process, so if the learner can produce a positive experience, there will be a higher learning satisfaction, according to this view a hypothesis 3 as follows:

H3: characteristics of the student teachers have positive influence on knowledge management services

Knowledge Management Services for the Satisfaction of Learning

Watson (1998) pointed out that knowledge management services for the organization of knowledge, mainly extracted from different sources of information to be stored, memory, the use of its member organizations can be used to improve organizational competitive advantage. Huang (2002) think of that the knowledge management services with emphasis on integration of corporate tangible and intangible assets with information technology use and organizational internal circulation of
knowledge through the storage, accumulation, sharing, diffusion, creative process, and promote individual and organizational progress enhance the core competence and competitive advantage, achieve business continuity objectives, vertical integration hypothesis put forward this view 4 as follows:

H4: knowledge management services for student learning satisfaction has a positive impact

Observations

This study selected samples of the questionnaire from the University in Taiwan. Setting up 96 related courses with distance learning and e-learning courses through the classes of students attend to this study.

EMPIRICAL RESULTS & ANALYSIS

Data Analysis

In this study, samples of questionnaires selected from the class students who join the e-learning course in the University of Taiwan. The observations were obtained from the e-learning students after finished their course taken by secret ballot on the Internet to complete the questionnaire. A total of 125 students participate in the questionnaire respondents. After removing invalid questionnaires (such as the same answer all the questions, and so on), with there are 110 effective questionnaires. The response rate is around 88% and describes the samples descriptive statistics as follows:

Gender

The proportion of male students’ questionnaires is about 34%, the proportion of female students’ questionnaires is about 66%, the female students accounted for with the majority.

Grade Distribution

Third year students in the majority proportion of the number of nearly 41%, followed by the ratio of the number of first year students was 29%, others are second and fourth year students.

Number of Weekly Logging in Learning Platform

The frequency of weekly logs of students on the learning platform is about 1-3 times. The largest ratio is about 69%, followed by 4-6 times with the proportion of about 17%. Most of frequency of the logs per week on learning platforms for the students is 1-3 times.

Reliability & Validity

Toward the reliability analysis, we employed the satisfaction questionnaire for measurement of knowledge management services for e-learning, and through the reliability test, which is testing whether the scale items in question are consistent or not. The larger value of Cronbach's α value indicates that the larger scale correlation for question items each other, and represents higher internal consistency. Based on the Guieford's (1965) point of view, if Cronbach's α value is greater than 0.7, indicating very high reliability. The Cronbach's α value ranged from 0.35 to 0.7 that can still, once less than 0.35 indicated that reliability is low.

Validity, the study exam the satisfaction questionnaire for measurement of knowledge management services for e-learning via validity analysis. The validity includes the content validity, construct validity and expert validity.

| Table 1: Dimensions, measuring variables with the corresponding literature. |
|-----------------------------|---------------------------------|---------------------------------|
| Dimensions                  | Measured variables              | Corresponding literature        |
|                            | Learning Community              | Chiu (1998); Chang (1998)      |
| Teaching Strategies         | argumentation science           | Marson (2001); Gagne (1963); Kuhn (1992); Voss & Means (1991) |
| Teachers' Characteristics   | Teaching Style                  | Moore & Kearsley (1996); Webster & Hackley (1997) |
|                            | Professional Ability            | Shi (1984); Chai (1993)        |
| Knowledge Management Services | Knowledge Capture               | Wiig (1994); Avelino (2003)    |
|                            | Knowledge Share                 | Wiig (1994); Avelino (2003)    |
|                            | Knowledge Application           | Wiig (1994); Avelino (2003)    |
Table 2: Effective questionnaire.

<table>
<thead>
<tr>
<th>Background Variables</th>
<th>Category</th>
<th>Observations</th>
<th>Category (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td>Male</td>
<td>37</td>
<td>33.6</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>73</td>
<td>66.4</td>
</tr>
<tr>
<td>Grade</td>
<td>First</td>
<td>32</td>
<td>29.1</td>
</tr>
<tr>
<td></td>
<td>Second</td>
<td>19</td>
<td>17.3</td>
</tr>
<tr>
<td></td>
<td>Third</td>
<td>45</td>
<td>40.9</td>
</tr>
<tr>
<td></td>
<td>Fourth</td>
<td>14</td>
<td>12.7</td>
</tr>
<tr>
<td></td>
<td>1-3 times</td>
<td>76</td>
<td>69.1</td>
</tr>
<tr>
<td></td>
<td>4-6 times</td>
<td>19</td>
<td>17.3</td>
</tr>
<tr>
<td></td>
<td>7-9 times</td>
<td>3</td>
<td>2.7</td>
</tr>
<tr>
<td></td>
<td>More than 10</td>
<td>12</td>
<td>10.9</td>
</tr>
</tbody>
</table>

Content validity refers to whether the contents of measurement tools to reflect the theme of suit. Construct validity refers to the measurement tools to see if theory predicts well. Expert validity means that the questionnaire fitness degree between five phases and the content items. After examination by professors and experts, the cumbersome narrative and ill-defined items would be amended after the adoption. This research apply the principal component analysis to delete the factors contain lower factor loading (under 0.5). The reliability and efficiency of the results were shown in Table 3.

Through the reliability and validity analysis, all of the Cronbach’s values were higher than 0.8, representing the consistency is acceptable. For reliability, the factor loading from the table can be seen are larger than 0.5, representing the consistency is acceptable also.

e-learning, Knowledge Management & Learning Satisfaction Path Analysis

To test the suitability of the causal model, this study apply the path analysis to verify the causal relation through setting up the information technology, teaching strategies and teacher’s characteristics as independent variables. The knowledge management services were set as the intermediate variable, and the learning satisfaction set as the dependent variables. Hence, the degree of causation of e-learning, knowledge management services and learning satisfaction were testing.

From the path analysis diagram shown in the Figure 2, there are nine significant paths that can influence the learning satisfaction of students. First, be the information technology→knowledge management services→learning satisfaction; Second, be the information technology→teaching strategies→knowledge management services→learning satisfaction; Third, be the information technology→teaching strategies→teachers’ characteristics→knowledge management services→learning satisfaction; Fourth, be the information technology→learning satisfaction; Fifth, be the teaching strategies→knowledge management services→learning satisfaction; Sixth, be the teaching strategies→teachers’ characteristics→knowledge management services→learning satisfaction; Seventh, be the teachers’ characteristics→knowledge management services→learning satisfaction; Eighth, be the teachers’ characteristics→knowledge management services→learning satisfaction; Ninth, be the teachers’ characteristics→learning satisfaction. So that attitude of technology indirectly affects learning through the phases of teaching strategies, teacher’s characteristics and knowledge management services. The teaching strategies indirectly affect the learning satisfaction through the phases of teacher’s characteristics and the knowledge management services. The teacher’s characteristics indirectly affect the learning satisfaction through knowledge management and learning satisfaction. The knowledge management services directly affect the learning satisfaction.

Table 3: the reliability and validity for questionnaires.

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Cronbach’s</th>
<th>Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information Technology</td>
<td>0.843</td>
<td>70.32%</td>
</tr>
<tr>
<td>Knowledge Management Services</td>
<td>0.936</td>
<td>66.77%</td>
</tr>
<tr>
<td>Teacher’s characteristics</td>
<td>0.934</td>
<td>65.55%</td>
</tr>
<tr>
<td>Learning satisfaction</td>
<td>0.946</td>
<td>72.92%</td>
</tr>
</tbody>
</table>

Note 1: the estimated value is the standardized regression coefficients
Note 2: dotted line path not significant

Figure 2: path analysis.
THE RESULTS OF TESTING

Summarizing above, we can conclude that the findings were: the information technology, teaching strategies, knowledge management services are significant positive influences the learning satisfaction. Indicating that, the e-learning satisfaction could be affected by the knowledge management services, teacher’s characteristics, teaching strategies and the strength of relations among them for the e-learning satisfaction. On the other hand, from the path analysis diagram we found that the teaching strategies are not directly significant influences the learning satisfaction, which may have potential impact on relations. Thus, the results of hypothesis tests were shown as Table 4.

Table 4: the results of hypothesis tests.

<table>
<thead>
<tr>
<th>Hypotheses</th>
<th>Test Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>H1: information technology for students has positive effects on knowledge management services</td>
<td>Support</td>
</tr>
<tr>
<td>H2: teaching strategies for students has positive effects on knowledge management services</td>
<td>Support</td>
</tr>
<tr>
<td>H3: teachers’ characteristics for students have positive influence on knowledge management services</td>
<td>Support</td>
</tr>
<tr>
<td>H4: knowledge management services has positive influence on learning satisfaction</td>
<td>Support</td>
</tr>
</tbody>
</table>

CONCLUSION

The Impacts of Various Phases toward Knowledge Management Services

Firstly, the study reveals that information technology has positive effects on the knowledge management services for the students, while students use the e-learning regardless of time constraints, individual knowledge acquisition, sharing and application. And hence also enhance the professional knowledge diligent. We have the same conclusions with Yang (2004), which advocates that students can learn anytime and anywhere, according to individual needs so as to enhance the capacity of individual knowledge acquisition and accumulation. It would bring more efficient behavior to improve the learning effectiveness.

And secondly, we also found that teaching strategies for students has positive effects on knowledge acquisition, sharing or application. The teachers involved in the e-learning environment would be more easy to guide and encourage students to think and solve problems with classmates. And further, the students would increase knowledge and enhance capacity. That show the same empirical results conclude by Chen (2005).

Finally, this paper shows that when students the better knowledge management service capabilities, the learning satisfaction would be the better, instead when the student's knowledge management capacity of the more weak, the effectiveness of e-learning would be unsatisfactory. The study concludes with the Huang (2002) the same empirical results. It shows that the students in the class of e-learning environment would be helpful for knowledge acquisition, sharing and application, and then fairly certain satisfaction in learning.

The Mediating Role of Knowledge Management Services

From our research, people would know that the positioning of knowledge management services in e-learning environment for students. The different teaching strategies for students in the learning process associated with the activity level of personal knowledge management services. Thereby these changes affecting the learning satisfaction of students. It also illustrates that the knowledge management services play an intermediary role for students in the teaching strategies and learning satisfaction. The teaching strategies for learning not too direct and significant relationship with the learning satisfaction but must be by way of knowledge management services, have significant positive impact. The knowledge management services to be the intermediaries meet our expectations of technology intermediary model.

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The Mediating Effect of Technology toward Knowledge Management Services for e-learning Satisfaction

Network Learning Conference, Lancaster University, UK.

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The ATEEM aims to produce a volume of the International Journal of Technology and Engineering Education with as uniform an appearance as possible and it is therefore requested that you conform to these instructions when preparing your article. These instructions are following APA style.

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   2. send your files on a CD compatible diskette to the following address:
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      Department of Engineering Science, National Cheng Kung University
      No. 1, Ta-Hsueh Road, Tainan 701, Taiwan

2. LENGTH OF ARTICLE
   The length of article is about eight to ten (8-10) pages, arranged on white paper, A4 size (210 x 297 mm).

3. TYPEFACE AND LINESPACING
   Those with laser printers should select a Times New Roman font of 10-pt size on 12-pt line spacing (6 lines per inch). Papers must be justified, with the text in single-line spacing, and one-line spacing between paragraphs. Do not indent paragraphs. In preparing your paper you may use the Word style file on the attached disk, designed for an IBM or compatible computer. When keying in your paper use the page-layout view option to get a better view of the page layout. When transferring the file of your paper to the supplied style file on the disk, the computer may change the page layout settings. The correct page layout settings are as follows:

<table>
<thead>
<tr>
<th>Margins</th>
<th>From Edge</th>
<th>Format</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top: 3 cm</td>
<td>Header: 1.5 cm</td>
<td>2 Columns</td>
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<tr>
<td>Bottom: 2 cm</td>
<td>Footer: 1.5 cm</td>
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<td>Left: 2 cm</td>
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<tr>
<td>Right: 2 cm</td>
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</tr>
</tbody>
</table>

4. TITLE, AUTHOR AND ABSTRACT
   The title should be in the style as indicated in the sample (only capitalize the first letters of proper names). Author(s), affiliation(s), city and country should use first capital letter and lower case. Do not abbreviate the affiliation.

5. ABSTRACT
   Please write a 75-100 word abstract (with keywords) of your paper, which should include your main idea and your major points. You also may want to mention any implications of your research. Place the abstract on its own page immediately after the title page. Center the word “Abstract” and then follow with the paragraph.

6. THE TEXT (please follow APA style)
   Arrange the text of the paper in two columns. The text (or first heading) of the paper must start two lines beneath the abstract. The second and consecutive pages must start from the top of the new page. Do not leave space at the top of the new page. Make sure that left-hand and right-hand columns of text are balanced, top and bottom. Please ensure that the columns on the last page of the paper are evenly balanced.

7. IN-TEXT CITATION (please follow APA style)
   When using APA format, follow the author-date method of in-text citation, and a complete reference should appear in the reference list at the end of the paper. APA style requires authors to use the past tense or present perfect tense when using signal phrases to describe earlier research. E.g., Jones (1998) found or Jones (1998) has found...

8. REFERENCE (please follow APA style)
   Authors are named last name followed by initials; publication year goes between parentheses, followed by a period. The title of the article is in sentence-case, meaning only the first word and proper nouns in the title are capitalized. The periodical title is run in title case, and is followed by the volume number which, with the title, is also italicized or underlined.

9. BIOGRAPHICAL SKETCHES
   Each author of an accepted article is asked to submit a biographical sketch of about 150 words and the author’s photograph. Your sketch should identify where you earned your highest degree, your present affiliation and position, and your current research interests. The first author should include an e-mail address which is optional for the other authors.
International Journal of Technology and Engineering Education
Process of Paper Evaluation

I. Papers will be evaluated by reviewers come from *International Journal of Technology Engineering Education* publication committee and related experts/scholars.

II. While receiving submitted paper, editor consults with publication committee about papers’ fields.

III. Each academic paper will be evaluated by two reviewers (double-blind), reviewers will write down their opinions in the comment paper.

IV. *International Journal of Technology Engineering Education* will send the reviewers’ comment to the papers’ authors and express accept, modify or refuse paper.

V. The process of paper evaluation as following:

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<th>Process of Evaluation</th>
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* If two reviewers opinions are too much difference (up to 15 points), the paper will be evaluated by third reviewer.

* Publication committee have right to determine accept, modify or refuse by reviewers comments.
# International Journal of Technology and Engineering Education

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