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Articles
After 15 successful years, the UNESCO International Centre for Engineering Education (UICEE) based at the Faculty of Engineering, Monash University, Melbourne, Australia, closed on 31 December 2008. As a result, members of our group known then as the Global Family of Engineering Education felt a prevailing need to fill the gap by establishing this World Institute for Engineering and Technology Education (WIETE) so that our global effort could continue. An overview of the mission, concept, objectives, strategies, and organisational structure, is presented and discussed in this paper. The author has endeavoured to present WIETE’s role and activities, along with its established links with other institutions, and considers some of the activities carried out already, as well as plans for future developments so that WIETE can fulfil its assumed role as a global hub and as an independent leader and international focal point in engineering and technology education. Emphasis is placed on the demonstration that WIETE is a unique development and sees itself as having an important role to play in world education.

INTRODUCTION

With the closure of the UNESCO International Centre for Engineering Education (UICEE), based in the Faculty of Engineering at Monash University, Melbourne, Australia, members of the group called Global Family of Engineering Education felt a prevailing need to fill the gap by establishing this World Institute for Engineering and Technology Education (WIETE), so that the global effort of many international academics would continue (Z.J. Pudlowski, 2008; World Institute for Engineering and Technology Education, 2010). Hence, the WIETE was established as a Company Pty Ltd incorporated in Victoria, Australia, and was registered with Consumer Affairs Victoria on 16 March 2009. This particular type of entity was chosen for the simplicity and clarity of its legal and financial operations, which are governed by the Corporation Act 2001. Although an Australian private company, the WIETE does not intend to generate company profits. Further, professional indemnity insurance was also chosen to ensure no party involved is exposed to any professional risk, which is nevertheless extremely low, in conducting planned activities.

Based on extensive experience gained earlier in conducting research, development and promotional activities in an international arena, the principal strategy envisaged for the WIETE is to create an independent, interactive and friendly international environment in which academics, industry leaders and members of the global community can freely express their views and develop ideas without prejudice or discrimination. It is hoped that, in acting as a global hub, the WIETE will be conducive to facilitating innovation and best practice in engineering and technology education.

During the author’s long involvement in engineering and technology education through such initiatives and ventures as the Electrical Engineering Education Research Group (EEERG) based at the University of Sydney, Sydney, Australia (1991 Annual Report, 2010); the Australasian Association for Engineering Education (AAEE) (AAEE Newsletter, 2010); the International Liaison Group for Engineering Education (ILG-EE); then the UNESCO International Centre for Engineering Education (UICEE) (Z.J. Pudlowski & P.P. Darvall, 1994; Z.J. Pudlowski & P.P. Darvall, 2000; Z.J. Pudlowski & P. LeP. Darvall, 2004), and other local and international organisations, it has been his personal goal and ambition to establish and promote collaboration in the field of engineering and technology education between institutions and organisations in developed and developing countries, as well as countries in political, social and economic transition. This strategy aims to stimulate, promote and facilitate progress and harmonious development in all countries of the world.

Mission

The mission of the World Institute for Engineering and Technology Education is to develop and maintain an independent global network of individuals and institutions concerned with the quality of engineering and technology education. The WIETE seeks to promote international collaboration and dissemination of information on research and development in this area of academic endeavour. Particular emphasis is given to providing assistance to engineering education institutions in developing countries and countries in economic, social and political transition. The WIETE is proud to operate under the following motto: Serving the International Engineering and Technology Community.
Concept
A group of highly experienced scientists and academics decided to join forces to establish this Institute, with the main goal of working collectively and independently of any institutional or governmental regime and influence in order to carry out a wide range of activities. This decision was based on extensive experience gained previously in conducting research and undertaking development and promotional activities in the international arena.

Objectives
To fulfil its mission, the WIETE endeavours to carry out a wide range of activities. Its objectives are to:

- create and maintain an international platform for the exchange of information on engineering and technology education;
- promote and facilitate international collaboration in engineering and technology education;
- stimulate, encourage and pursue research and development activities in engineering and technology education, and multidisciplinary research, in order to link the science of engineering and technology with other disciplines;
- provide consultancy services in engineering and technology education for educational institutions, governments, professional societies and industrial organisations;
- organise and conduct short courses, international seminars and conferences on engineering and technology education to promote innovation, best practice, human resource development and capacity building;
- initiate, stimulate and coordinate international postgraduate activities in engineering and technology education;
- establish and maintain interest groups, regional networks and centres of excellence in engineering and technology education;
- disseminate information, expertise and research results through various media such as printing and electronic publishing;
- seek financial support for research and development activities to be carried out by member institutions (WIETE Objectives, 2010).

Strategies
The principal strategy of the WIETE is to create an independent and friendly international environment in which academics, industry leaders and members of the global engineering and technology community can freely express their views and ideas without prejudice or discrimination. Such an environment should be conducive to facilitating innovation and best practice in engineering and technology education.

The WIETE places particular emphasis on the participation of young academic staff in its activities and programmes in order to enhance their knowledge of basic principles of education and recent advances in engineering and technology education. It is envisaged that the WIETE will facilitate the participation of young academics in postgraduate activities and programmes offered by the WIETE’s partner institutions by promoting their programmes and recruiting potential participants. A database of potential placements, available scholarships and candidates, will be established and maintained at the WIETE.

In addition, strong emphasis will be placed on the involvement of women in engineering and technology education and, in particular, their important role in engineering and technology faculties, as well as their participation in research and development activities.

Another important strategy for the WIETE is to establish and promote collaboration in the field of engineering and technology education between institutions and organisations in developed and developing countries, as well as countries in political, social and economic transition. This strategy aims to stimulate, promote and facilitate progress and harmonious development in all countries of the world.

Organisational Structure
The WIETE operates under the Directorship of Professor Zenon J. Pudlowski. Several coordinators responsible for the management of individual activities assist the WIETE Director in day-to-day operations.

International Academic Advisory Committee
A WIETE International Academic Advisory Committee (WIETE-IAAC), consisting of senior members from academia, industrial organisations, societies and other institutions, advises the WIETE Director on academic and organisational matters. Professor Derek O. Northwood, University of Windsor Research Leadership Chair at the University of Windsor, Windsor, Canada, is President of the WIETE-IAAC. At present, he is assisted by two Vice-Presidents: Professor Adinarayana Kalanidhi of the Commonwealth Science and Technology Academy for Research, Chennai, India, and Professor Harold P. Sjursen of the Polytechnic Institute of New York University, New York, USA.

Ms Dianne Q. Nguyen, Project Coordinator and Manager, School of Information Technology at Monash University, Melbourne, Australia, is the Academic Secretary of WIETE-IAAC.

Support
The WIETE will seek to attract the support and partnership of internationally acclaimed academic
institutions, leaders in the field of engineering and technology education, international non-governmental organisations and associations, in order to support and promote its operation and activities.

Also, the WIETE will endeavour to attract individual persons, and international leaders in the field of engineering and technology education, by offering the following memberships:

- Honorary Member
- Individual Member

**Membership Structure**

WIETE membership categories include:

- Honorary Member
- Partner Institution
- Individual Member

**Partnership Benefits**

WIETE’s operation and the conduct of its activities are based mostly on interaction and cooperation with WIETE Partner Institutions. Benefits of partnership include:

- inclusion and presentation of partner institutions’ name and logo in all WIETE media, promotional materials and publications;
- representation on the International Academic Advisory Committee (WIETE-IAAC);
- access to, and participation in, the activities of the WIETE and its global network;
- access to all WIETE-published materials in all media;
- the right to establish a WIETE centre of excellence;
- cooperation in seeking funds from local and international funding bodies and agencies to support joint activities and projects.

**DEVELOPING WIETE AND ITS GLOBAL NETWORK**

On Wednesday, 20 May 2009, the former UICEE Director, Prof. Z.J. Pudlowski, Director of WIETE, received a Deed of Assignment document in which Monash University transferred to him UICEE intellectual property and copyright. Also, in its generous move Monash University passed the rights to use the symbol of the UICEE logo, as well as the possibility of using the name of UNESCO International Centre for Engineering Education (UICEE), with the latter subject to approval by UNESCO. This decision opened up the possibility for the WIETE to continue most of the activities so successfully carried out by UICEE over the previous 15 years.

In expressing its strong support for establishment of the World Institute for Engineering and Technology Education, successor to UICEE, the Technological Education Institute of Piraeus (TEI-Piraeus), Piraeus-Athens, Greece, decided to join WIETE as its first Member/Partner Institution. It should be pointed out that the Partnership was facilitated by Prof. George Metaxas, Dean of the School of Engineering at TEI-Piraeus, an active member of the UICEE, and is now an Honorary Member of the WIETE.

The TEI-Piraeus is a relatively young academic institution in Greece, but under the leadership of its President, Prof. Lazaros Vrizidis, has strengthened and expanded its international programme, with particular emphasis on joint postgraduate courses carried out in close collaboration with several EU universities, including Kingston University, London, UK.

On attending an international conference held in Australia, Professor Derek O. Northwood paid a visit to the WIETE in Melbourne on Monday, 6 July 2009. Prof. Northwood is University of Windsor Research Leadership Chair and Professor of Engineering Materials at the Department of Mechanical, Automotive and Materials Engineering, University of Windsor, Windsor, Ontario, Canada, and President of the WIETE International Academic Advisory Committee (WIETE-IAAC).

Prof. Northwood made himself familiar with WIETE facilities and spent considerable time discussing many burning issues on the operation and activities of the WIETE. High on the agenda was the revival of some UICEE activities carried out in light of the recent transfer to the WIETE Director of its Monash University intellectual property and copyright.

On Friday, 24 July 2009, a Memorandum of Understanding between the WIETE and NYU-Poly was signed by Polytechnic Institute Provost Professor E. Dianne Rekow. Prof. Rekow said participation by NYU-Poly in WIETE’s important work is consistent with our position as a leading global technology and engineering school. Professor Harold P. Sjursen, Vice-President of WIETE’s International Academic Advisory Committee (WIETE-IAAC), suggested that the particular role of NYU-Poly would most likely be in the area of emerging technologies, innovation strategies, as well as the integration of the humanities, social sciences and management education into engineering curricula.

The Polytechnic Institute of NYU, second-oldest private engineering college in the United States (founded 1854) and formerly a UICEE partner, merged with New York University to become the Polytechnic Institute of NYU. This merger expands greatly the capability of the Institute to conduct research in all areas of engineering and technology, including bio-medical engineering. The newly reorganised NYU-Poly has joined the WIETE as a
partner institution. The Polytechnic was the host of UICEE’s successful 5th Global Congress on Engineering Education in July, 2006.

While in Krakow, Poland, in September 2009, the WIETE Director met with his long-time friend and collaborator Professor Stanislaw A. Mitkowski, Head of the Department of Electrical and Power Engineering (DEPE) at AGH University of Science & Technology (AGH UST). Prof. Pudlowski briefed Prof. Mitkowski on WIETE’s recent developments, and subsequent discussions concentrated on research collaboration and future joint activities, including the possibility of developing a partnership with the WIETE. The possibility of organising jointly an international conference to be held in Krakow in September this year (2010) was also discussed, with Prof. Mitkowski offering his support. It should be mentioned that in September 1998, under the auspices of the UICEE, the extremely successful 1st Global Congress on Engineering Education was organised by the two parties. This resulted in the Department becoming a member/partner institution of the WIETE and the subsequent joint organisation of the 1st World Conference on Technology and Engineering Education, held in Krakow, between 14 and 17 September 2010.

The WIETE network of partner/members has steadily developed, with 9 institutions becoming WIETE partners by the end of 2009. Then, January 2010 turned out to be a very eventful month for WIETE, culminating with the Association of Taiwan Engineering Education and Management (ATEEM), Taichung, Taiwan, under the Presidency of Professor David W.S. Tai, Dean of the College of Management at Hungkuang University, Taichung, Taiwan, becoming the WIETE’s tenth partner.

This relationship is a further extension of the highly successful collaboration between Prof. Tai and the WIETE Director, initiated in early 2000. It is the work of Prof. Tai, the then Head of the Department of Industrial Education at the National Changhua University of Education (NCUE), Changhua, Taiwan, that resulted in the NCUE becoming a Supporter Member of the UICEE in 2000. This membership was upgraded to full partnership in November 2002, during Prof. Tai’s Deanship of the College of Technology at the NCUE.

A significant breakthrough came with the signing of five Memoranda of Understanding (MoU) between WIETE and five academic institutions at the 1st WIETE Annual Conference on Engineering and Technology Education in Pattaya, Thailand, on Wednesday, 24 February 2010. Representatives of the signing institutions were: Prof. Kaliappan Manivannan who signed on behalf of two academic institutions in Tamil Nadu, India, that is VMKV Engineering College at Vinayaka Mission’s University in Salem and RMK Engineering College in Chennai; Prof. Slawomir Wiak, Dean of the Faculty of Electrical, Electronic, Computer and Control Engineering at the Technical University of Łódź, Łódź, Poland; Mr R. Srinivasan, Executive Director of KSR Group of Institutions, signed on behalf of K.S. Rangasamy College of Technology, Tiruchengode, India; and Prof. Promod Vohra, Dean, at the College of Engineering & Engineering Technology, Northern Illinois University, DeKalb, Illinois, USA.

With the signing of these MoU, the number of member/partner institutions has risen to 15 academic establishments, hence significantly strengthening the WIETE global network of engineering and technology education. The WIETE staff, members and associates cordially welcome the new institutions, and look forward to close collaboration for the benefit of the members of the WIETE network and its member/partner institutions.

**ACTIVITIES**

With the expansion of its infrastructure, the WIETE intends to pursue a wide range of activities, subject to the availability of funds, including the following:

- research and development projects in engineering and technology education;
- specific courses, seminars and conferences, including the following international gatherings:
  - WIETE Annual Conference on Engineering & Technology Education (WIETE-ACETE);
  - World Conference on Technology and Engineering Education (WCTEE);
  - regional conferences and meetings;
  - retreats for international leaders in engineering and technology education;
  - ad hoc functions, training courses, seminars, retreats, symposia, etc;
- WIETE publications, such as books, conference proceedings, periodicals, journals, etc, including permanent features, such as:
  - WIETE News;
  - World Transactions on Engineering & Technology Education (WTE&TE)
- postgraduate activities and programmes;
- professional consultancies;
- regional and topical groupings, networks and centres of excellence;
- Women in Engineering and Technology Education Global Forum (WETEGF).

Although the WIETE is still in its initial stages of development, it has already vigorously pursued research, development and promotional activities for the benefit of its members and the international engineering and technology education community as a whole. WIETE’s staff and associates long ago recognised the importance
of research in this area of academic endeavour, and have continued its publishing effort with the objective of promoting and sharing research achievements. Along this line, in its role as an international facilitator and a global hub of engineering and technology education, the WIETE has undertaken several activities in line of its plan, and they are elaborated on in the next section (E.A. Danilova & Z.J. Pudlowski, 2010; D.Q. Nguyen & Z.J. Pudlowski, 2010).

WIE TE Annual Conference

In recognising that international collaborative structures and networks are effectively developed through direct contact between individuals, the WIETE has undertaken to institute, promote, support and organise various international conferences and meetings. The paramount objective of this activity is to raise the profile of engineering and technology education and its promoter, the WIETE, an organisation fully committed to the progress of engineering and technology education. In so doing, the WIETE intends to create opportunities for the exchange of information and research achievements in engineering and technology education so vital for harmonious development of world education.

Hence, the 1st WIETE Annual Conference on Engineering and Technology Education in Pattaya, Thailand, was held between 22 and 25 February 2010 at Seri Place Hotel Pattaya, Pattya, Thailand. The Conference was organised against all the odds arising from the global economic downturn and the present unfavourable situation at universities concerning international travel. This Conference was a special occasion for members and associates of the WIETE; celebration of the Institute’s first year of eventful and successful operation. Although a small meeting by the number of papers, it has attracted the most loyal and dedicated of colleagues and friends who, despite the global economic hardship, are showing utmost support of the WIETE and its global cause by submitting their valuable research papers and attending this Conference. The aims and objectives of this Conference were to bring together members and associates of the WIETE, as well as other international academics, to identify and discuss challenges and opportunities for the WIETE and its global operation. Sharing new ideas, discussing the needs for innovation and airing the issues of importance for engineering and technology education, were also important Conference objectives.

Despite these difficulties, more than 20 international academics attended the Conference and presented their papers. The Conference resulted in several important outcomes, which will help to set the stage for effective operation of the WIETE through its future activities and ventures. The Conference Proceedings, including 23 informative papers, were published on CD and are now available on the WIETE website (Z.J. Pudlowski, 2010).

World Transactions on Engineering and Technology Education (WTE&TE)

In 2002, the international journal, World Transactions on Engineering and Technology Education (WTE&TE), was established at the then UICEE, with the objective of providing the international academic community with an opportunity to publish original articles on engineering and technology education (World Transactions on Engineering and Technology Education (WTE&TE), 2010).

In its mission, the WIETE seeks to advance continued growth and evolution in knowledge and understanding in engineering and technology education by publishing strictly refereed international articles in the field, thereby benefiting humankind by providing the next generation of engineers and technologists with a greater knowledge of educational methods.

The six volumes of WTE&TE were published at the UICEE and in them were presented a range of papers from the engineering and technology education spectrum worldwide, with interesting and insightful representations from countries across each of the major continents.

In its commission to serve the global engineering and technology community, and acting as the successor of the UICEE, the WIETE launched the World Transactions on Engineering and Technology Education (WTE&TE) on 14 July 2009, by releasing a Call for Articles to be included in Volume 7, Number 1. In its reincarnation, it was anticipated that articles submitted to the journal would cover a wide and diverse range of topics and issues concerning contemporary problems and challenges in engineering and technology education that should be identified, addressed and discussed. Such topics include pedagogical and methodological issues, case studies, results of unique educational research, as well as cross-cultural, regional and country developments. Also, articles dealing with cross-disciplinary matters to promote and encourage interdisciplinary research, development and collaboration are particularly welcome.

The release of WTE&TE, Vol.7, No.1, in November 2009, represented the beginning of a new era for the journal, being published under its new host and with a renewed Editorial Advisory Board. This issue included 17 fully peer-reviewed original articles, from authors based in nine countries, worldwide. Volume 7, Number 2 of the WTE&TE concluded the WIETE’s publication effort in 2009 with 15 fully peer-refereed original articles. The entire Volume 7, therefore, consists of 32 highly informative and insightful articles from almost all corners of the world. The articles come from a variety of backgrounds covering a wide range of issues, topics, ideas, problems and challenges faced by academics...
involved in engineering and technology education. Several articles deal with cross-disciplinary matters to promote and encourage interdisciplinary research, development and collaboration.

This following issue of WTE&TE, marked Vol. 8, No.1, released in early April this year (2010), includes 20 fully peer-reviewed original articles from authors representing eight countries worldwide. It should be pointed out that academics from Taiwan have contributed 10 of them, which constitutes half of the entire issue.

An interesting trend has been observed over the past year of this publication, with many articles reporting on the application of modern information technology and the Internet to the teaching-learning processes in engineering and technology education. In particular, several researchers have presented their research and development achievements in creating remotely accessible and operated facilities, such as virtual engineering laboratories. Therefore, a decision was made to produce a Special Issue of the WTE&TE, that is Vol.8, No.2, titled E-learning Facilities and Systems in Engineering and Technology Education. The issue is dedicated to this important area, with two Guest Editors, members of the Editorial Advisory Board: Prof. Andrew Nafalski of the University of South Australia, Adelaide, Australia, and Prof. Slawomir Wiak of the Technical University of Lodz, Lodz, Poland.

From this, it can be seen that the then UICEE and, now the WIETE has endeavoured to contribute strongly to the global publishing of articles in engineering and technology education. The WTE&TE is open to everyone around the world who is interested in progressing engineering and technology education. Further, the journal offers a safe and cost-effective alternative to conference participation. The WTE&TE has been included in the list of journals generated by the Australian Research Council (ARC) under the Excellence in Research for Australia (ERA) initiative. The paramount objective of this initiative is to launch a journal ranking list on a discipline-specific basis to evaluate research excellence and research impact.

Involvement in Postgraduate Programmes

With the closure of the UICEE, the WIETE Director continued to supervise several postgraduate candidates who completed enrolment and were finalising their theses.

At a gala Graduation Ceremony on Thursday, 15 April 2010, in the Robert Blackwood Hall at Monash University’s Clayton Campus, Melbourne, Australia, Dr Elena A. Danilova was officially conferred a Doctor of Philosophy (PhD) by the Deputy Chancellor of Monash University, Ms Louise Adler AM.

The award was based on the doctoral dissertation titled: Important issues in the development of a curriculum for English and communication studies in engineering and technology courses to improve communication skills of students in developing countries [13]. As stated by the author, this thesis examines the inability of the existing engineering and technology curricula to meet the requirements of contemporary engineering and technology practice in relation to developing communication skills. Although the latter are recognised as critical skills for successful professional involvement, communication studies are rather neglected in the existing curricula. The outcome of this research is a proposition of an innovative model of a curriculum to develop students’ communication skills in engineering and technology courses (E.A. Danilova, 2010). As one of the examiners pointed out … this thesis constitutes a significant contribution to knowledge and understanding of the enhancement of communication skills for engineering and technology students through an ESP program.

Dr Danilova, who is from Tomsk, Western Siberia in Russia, began her PhD studies on 6 June 2006. She joined the then UICEE as one of several postgraduate scholars. Based at the UICEE until its closure, she was enrolled through the Monash Asia Institute (MAI) at Monash University. Her achievement was the first PhD award to come from this postgraduate group of UICEE scholars.

In early May this year, another former UICEE postgraduate external student, Mr Detlev E. Jansen, who enrolled through the Department of Mechanical Engineering at Monash University, submitted his PhD dissertation titled: Intercultural business communication: an investigation of the cultural influences on business negotiations in the field of engineering. As stated by the author, the thesis examines intercultural negotiation in the realm of engineering. It identifies variables that influence the intercultural negotiation process in the regions of Far East Asia, South East Asia, Middle East, Eastern Europe, and Latin America and seeks to contribute to a better understanding in an increasingly globalised world.

CONCLUSIONS

The development of the WIETE has proved a worthwhile initiative in order to create and maintain an independent international platform for the exchange of information on engineering and technology education, with the objective of stimulating, encouraging and pursuing research and development activities in engineering and technology education.

Within a year or so, the WIETE has developed a considerable international network of partner institutions and individuals particularly concerned about engineering
and technology education, with the objective of promoting and facilitating international collaboration in research, development and promotion in this area of academic endeavour. It is believed that this has initiated the process of establishing and maintaining interest groups, regional networks and centres of excellence in engineering and technology education.

The WIETE has staged and organised its own international conferences on engineering and technology, as well as encouraged and supported international and regional conferences conducted by its partner organisations in order to promote innovation, best practice, human resource development and capacity building. It has also undertaken several activities in order to disseminate information, expertise and research results through various media, including electronic publishing.

The WIETE Director has continued to supervise international postgraduate activities in engineering and technology education, with the completion of some research projects undertaken in multidisciplinary research in order to link the science of engineering and technology with other disciplines.

As the WIETE is a unique development in the world and sees itself as having an important role to play in engineering and technology education, it has undertaken a vigorous campaign to seek financial support for research and development activities to be carried out with its member institutions.

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AUTHOR

Zenon Jan Pudlowski graduated Master of Electrical Engineering from the Academy of Mining and Metallurgy (Cracow, Poland), and Doctor of Philosophy from Jagiellonian University (Cracow), in 1968 and 1979 respectively. Professor Pudlowski is currently Director of the World Institute for Engineering and Technology Education (WIETE), based in Melbourne, Australia, and is an Adjunct Senior Research Fellow at Monash Asia Institute (MAI), based at Monash University, Clayton, Melbourne, Australia. Most recently, he was Associate Professor, Professor, and the Director of the UNESCO International Centre for Engineering Education (UICEE) in the Faculty of Engineering at Monash University, between 1994 and 2009. 2002, he was awarded the title of an Honorary Professor of the Tomsk Polytechnic University, Tomsk, Russia, and was an External Professor at Aalborg University, Aalborg, Denmark (2002-2007). He is listed in 14 Who's Who encyclopedias, including the Marquis Who's Who in the World. In 2009, he was appointed Vice-Chairman of the Board of Governors of the Commonwealth Science and Technology Academy for Research (C-STAR), based in Chennai, India.
WIETE – a Global Hub of Engineering and Technology Education
The Future of Engineering Education: What does the Re-entry of China and India as World Technology Leaders Mean for Engineering Education?

Harold P. Sjursen

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INTRODUCTION

These remarks will focus on how engineering education needs to respond to the current ascendency of China and India economically and technologically. The premise is that while world events, external to engineering or engineering education per se, have always established the agenda for engineering and consequently for engineering education, in the present day this phenomenon is particularly intense, likely to create a crisis if not addressed coherently. The rise of China and India give a concrete and specific urgency, but other transformative changes compound this urgency and challenge engineering practice and education. The question of how to respond to this complex of changing conditions requires that the elements be set in a coherent relation to each other so that the reaction is comprehensive rather than occasional knee jerk responses at various pressure points. This is an attempt to lay out the issues in an orderly and coherent fashion. It will become at once obvious that a sufficient response to these external demands cannot be limited to curricular reform alone.

There are three large issues to be considered in order.

1. Should engineering schools become more scientific and theoretical, more practical and vocational, or more managerial?
2. Is engineering political, professional, capitalist, militarist -- or is this the wrong question?
3. Is it East versus West or China versus India?

Issue One: Engineering and Science

Engineering as a practice is driven by social purposes. This fact puts engineering in the company of other similarly driven professions such as law and medicine and as a collaborating partner with such activities as urban planning, economic development and military defense. On the other hand this fact sets engineering apart from the discipline that many assume to be its closest in content, viz., natural science. In the current circumstance this creates an unusual dilemma for engineering education. As a discipline that both responds to socially expressed needs and desires and at the same time, through the innovation of new devices, stimulates, creates and satisfies social needs and desires -- whether sober (safe bridges) or intoxicated (the Wii), engineering tends to focus on commodities. Science on the contrary investigates the nature of reality, its baseline and changing conditions. Science has discovery and truth as goals while engineering has production. To a large degree engineering depends upon science and in its quest for new devices especially upon scientific discovery. Thus if science discovers that green house gasses damage the environment engineering seeks a means to repress them. So while the drivers and goals of engineering and science have dissimilar ends engineering nonetheless looks to science as a source. The obvious implication for education is that engineers must learn to understand science in a way sufficient to permit working with scientific results. Developments in science consequently change aspects of engineering practice.

Contemporary science since the discoveries of relativity and quantum theory has challenged the practice of engineering which was firmly and successfully rooted in Newtonian physics. Scientific revolutions by their very nature undermine accepted belief and practice and redefine common sense. This was dramatically true of the Copernican revolution which displaced the earth from the center of the world to an undistinguished address in an infinite universe (Koyré, Alexandre, 2008). One could no longer believe that ordinary observation corresponded to the true structure of reality. But Newtonian physics at least asserts the uniformity of nature and measurement within the paradigm of Euclidian geometry, theoretical postulates that bridge the concepts of science with the practical arts. To a great extent engineering became the scientifically precise extension of traditional crafts. However contemporary physics in forms such as string theory, quantum mechanics, nano-science, fractal geometry and chaos theory posits a wide gulf between theoretical science and intuitive, practical engineering. Such science demands additions to the engineer's toolbox and requires an expanded or at least different mathematics skill set. Recent advances in the biological sciences ally it more closely than ever with the physical sciences and create new agenda for engineers. Much of this scientific theory has led to powerful new and emerging technologies that beggar the traditional precautionary methods of engineering. Contemporary science, therefore, has altered radically the tasks assigned to engineers. The differences to engineers are not limited to the requirement to comprehend an ambiguous, complex and non-intuitive scientific construction of reality but also to grasp the implications of technologically enhanced actions with a multitude of unanticipated and possibly destructive, long-term and irreversible consequences. The burden thus imposed upon the engineer's course of study is hard to overstate. In a sense engineering has become the fulcrum to transfer science to society. One
might suppose that this would pertain only to certain branches of engineering but in fact the discoveries of contemporary science now influence every aspect of life. Engineers perform have become our age’s renaissance men when the requisite breadth of knowledge clearly unattainable.

The obvious difficulty is that engineering education simply cannot be expected to master the full range and breadth of modern science, to attempt to do so would surely lead to mediocrity; moreover it would alter the spirit of engineering from the pragmatic and utilitarian to something more contemplative and theoretical. The proper way to handle the STEM disciplines is a problem that extends beyond the curriculum of engineering to secondary and even elementary education and continuing professional lifelong learning. However acute their scientific and mathematical skills become, engineers will never be scientists. The true issue for engineering is how to build effective discursive communities in common with scientists such that the pragmatic impulse of engineering complements and extends the best science. To an extent this is a matter of communicative strategies but it is also clearly a matter of management. Both matters bear profoundly on the possibility of cooperation and collaboration with China and India and will be addressed below in that context.

Project management is an essential component of engineering. Effective project management, however, cannot be done from within the horizons of engineering alone. The engineer always has clients whose expectations differ from or may be impatient with the protocols of best engineering practice. The project manager has to satisfy the client while sustaining the integrity of the engineering process. When an engineering project is in collaboration with, e.g., a science research lab, where the standards for success are derived differently, new difficulties arise. Engineers are trained to consider the costs of production as a matter of efficiency so that the best engineering solutions tend to be cost effective. However “cost effectiveness” is not intrinsically a scientific criterion as it is for engineering, the concern of the science research lab being little more than staying within the approved budget. Such examples make it clear that the working relationship between science and engineering is not one way and not limited to issues of science theories.

Issue Two: Is Engineering in Service to Capitalism, the Military, or the Good Life?

Engineering is not an end in itself; one does not study engineering just for the sake of learning. Engineering is justified only when the impact it has, the result of its activity, is deemed beneficial. But to whom or to what is it beneficial? Often there is disagreement about the benefit. It is currently frequently argued that the devastation wrought in New Orleans by hurricane Katrina should not be seen as the result of a natural disaster but rather the consequence of poor engineering. By this it is meant that the U.S. Army Corps of Engineers who built and maintained the flood control and levee system used standards that did not put the well being of the residents first. Instead the Corps, according to this view, answered to political and economic criteria rather than scientific and safety standards. In another case financial engineering as an approach is blamed for the current economic crisis. Here it is argued that the greed of capitalism was served by the powerful techniques of engineering which took no account of the broad economic and social consequences. Likewise numerous examples could be cited where engineering is implicated in the design and production of evermore powerful weaponry that expands the horrors of warfare and terrorism. How are the benefits of engineering to be judged?

This certainly is not a new question but both science and globalization have magnified its significance. Modern science has increased by orders of magnitude the power of modern technological devices to change (to improve or destroy) our environment, the life world. Similarly the rapid globalization of commerce and the attendant interdependency of regions around the world on each other means that technologically induced change, even when small scale and local, spreads rapidly without regard for national borders or regional differences. Technology has a viral character meaning that no engineered solution or innovation can be expected to remain in place or in its original form for very long. Thus the impact and the possibility of benefit, in other words the very justification of engineering itself, is ultimately judged everywhere and by everyone. What does this mean for the practice of engineering?

Just as engineering cannot regard itself as science it can neither see itself as the agent of special interest. Engineering must serve the common good with precautionary wisdom and responsibility. This ideal raises two specific problems:

1. Engineering is not philosophy and not ethics yet it must be guided by practical wisdom. The results of engineering must not create injustice yet the introduction of any new technology changes the balance of power making inequities inevitable. Engineering may have a vision of the good life but that vision is not shared by all in our multi-cultural world. These questions and the conflicts they generate will only increase as our world continues to shrink.

2. Engineers always have clients. One cannot conceive of engineering otherwise. Even altruistic and idealistic engineering organizations such as Engineers without Borders works within a framework defined by clientele. Thus the organizational and philosophical issues join together.
Two interlocking challenges to engineering education have now been identified. The first has to do with the complex, abstract and theoretical character of modern science. This is complemented by the differing cultural purposes and vales of science and engineering. Engineers need not only to understand science to a high and proficient degree but must possess management and discursive strategies that can bridge the gap in collaborative situations. The second is the question of engineering responsibility which in today’s world is much more than accountability. Although both of these challenges are amplified by the realities of globalization they are still distinct from it. Now globalization should be considered in itself.

Issue Three: Globalization and the Shift of the Technology / Economic Epicenter to China and India

It is perhaps most natural to think of this dimension of the problem in terms of competition. Competition suggests only relative differences and a level playing field. This, however, may not be the case. The spectacular rise of both China and India in the span of just a few short years has characterized the realities of globalization in ways perhaps not anticipated by even its most ardent advocates. China and India each represents an ancient civilization now rapidly reemerging from third world status. Many analysts in the developing world imagine that each country will follow a trajectory although probably accelerated similar to the pattern seen in west that began with the industrial revolution. Indeed this was the path followed by Japan, Taiwan and South Korea. Yet there are reasons to think that history may not repeat itself in the current situation.

By now it is acknowledged nearly universally that the economic and geo-political world center of gravity is shifting (how quickly is a matter of debate) from the west to Asia, with India and China presumed soon to regain the influence and power they had in previous eras. The question anxiously put in Europe and the United States—and by their close allies in Asia, Japan, Taiwan and South Korea-- is how we should respond both to preserve our own hard won quality of life while at the same time establishing meaningful and mutually beneficial cooperation with these two re-emerging great powers. Yet the size, complexity and diversity of both China and India, both with long and polysemic histories, and varying characteristics of the systems that fostered their return to prominence on the world stage in the 20th century, makes these considerations complex. The lessons of colonial history only exacerbate the difficulty. Nor can China-India be considered as a singular entity.

"While both India and China have a long history, their histories are very different. China has been by and large a stable, centrally run state throughout its history with limited periods of instability and a lack of a single authority. India's history has been exactly the reverse. The periods when a single king or political authority ruled over even the major part of India’s territory can be counted on the fingers of one hand. In China's case there was a deep desire for unification of the country as a driving force of nationalism in the twentieth century. ... In India's case, there never was any authority that has ruled over all of India; indeed, not even the British or even the present Indian government. India has been idea in world culture for millennia, but its borders had been fixed only in the late nineteenth century... (Desai, Meghnad, 2005)"

This suggests that a useful approach to building cooperative enterprise and encouraging mutual understanding may be to focus on development within natural regions and the cooperation possible on that level rather than exclusively on that of the nation-state.

Many have accepted the thesis of Samuel Huntington. In a seminal paper he argued that certain cultural traditions inhibit and strive to destroy others and that this condition must be overcome in order to realize the salutary benefits of Western modernity, a capitalist economy and a rational, scientific worldview (Huntington, Samuel, 1996). There are two opposing questions of specific concern here. On the one hand “Have India and China by now inherited sufficiently the operative values of Western modernity, capitalism and scientific rationalism to become full and respected participants on the world stage presently dominated by Western technology?” or conversely “Do residual cultural norms and values stifle global collaboration and mutually beneficial economic development?” The thesis of Huntington presumes such an either/or. But for engineering education and scientific research collaboration to succeed along the lines suggested here his view should not be valorized as it asserts an attitude toward Asia and other parts of the world that is contradicted by historical fact.

The ideals of the European enlightenment and liberal democracy, and thus of modernity itself, are often said to be intrinsically western and contrary to the traditional and prevailing values of China and India. Without trying to resolve this debate the contrary assertion offered here is that within both Chinese and Indian traditions there are strong philosophical structures entirely compatible with, although conceptually different than, the principles of Western modernity. There is a multiplicity of indigenous philosophical traditions available to support technical, economic and political development in both China and India. Likewise both China and India have strong, but distinctive (from each other and the West) traditions in natural science and technology. The reclaiming of these traditions is an important intellectual project in both places.

Regardless of the particular perspective it is essential that a pluralistic outlook be accepted. While traditional
The majority of discussions of the future of India and China tend to abstract from their historical-cultural legacies and consider only the extent to which western models are successfully emulated. As Yasheng Huang and Tarun Khann point out, there were two different paths to technological development following western precedents. "...China's export-led manufacturing boom is largely a creation of foreign direct investment, which effectively serves as a substitute for domestic entrepreneurship." And "...India has managed to spawn a number of companies that now compete internationally ... many of these firms are in the most cutting-edge, knowledge-based industries(Huang, Y. & Khanna, T., 2003)."

However, such observations, while pointing to issues important to economic development anywhere, tend to be narrowly construed, taking too little account of the cultural environment that constitutes the arena for economic development and technological innovation. Careful consideration of such crucial topics as knowledge and human resources, educational policies, systems and institutions, including engineering education and technology development in China and India is also imperative (Ray, J.K. and Prabir De, P., 2005). In other words, the phenomena that Huang and Khann describe may be better approached if re-contextualized under the broad historical/philosophical categories briefly suggested above.

One can understand these aspects through issues of regional economic development. For example the opportunity exists for Yunnan province in SW China to develop markets and access to seaports through India, Bangladesh and Myanmar; conversely, there is opportunity for these regions to plug into growth in China; the complementary nature of high tech in India and China leads to an opportunity for synergistic development centered in this region (Parayil, Govindan & D’Costa, Anthony P., 2009).

A recent paper by Wu Xiaobu et al frames the issue of regional, technological development as follows:

"Today's economic map of the world is dominated by what are called clusters ... clusters not only become the basic framework of regional economy, but also act as the main form of spatial distribution of global economy. With the enhancement of both investment and trade activities among countries, the pace of global industry transfer speeds up, which results in interregional technology gaps and industry clusters as byproducts. ... The questions are how the industrial clusters in developing countries collectively identify, pursue and acquire external technology resources from industrially advanced countries by constructing external innovation networks to strengthen their technological capabilities in virtue of industrial clusters’ advantage, and how they can effectively internalize external technology resources acquired, and successfully transit from imitation to innovation (Wu, X., Gu, Z. & Zhang, W., 2008)."

In his widely read work, Capitalism with Chinese Characteristics (Huang, Yasheng, 2008), Yasheng Huang argues that one of the great potential strengths in China is the existence of a highly motivated rural entrepreneurial class.

In his intriguing historical analysis, Adam Smith in Beijing (Arrighi, Giovanni, 2007), Giovanni Arrighi maintains similarly that historically the economies of Asia were based more on locally specific industry than was that in Europe--a tendency that continues today and which supports the possibility of strong, regional development. The current climate of opinion in China particularly appears poised to benefit from regional technologies and the situation in India is perhaps even better. Bill Emmott predicts a power struggle between China and India that he says will shape the global economy for at least the next decade (Emmott, Bill, 2008). The alternative to this wasteful scenario might well be regional cooperation.

Many of these issues were anticipated by Joseph Stiglitz (Stiglitz, Joseph E., 2003) who argued that the policies and approach of the IMF has not recognized the differences inherent in local and regional economies and therefore somewhat paradoxically contributed to movement resisting globalization. And from a different political standpoint Jagdish Bhagwati points out that technology and technical change foster far reaching local and regional cultural changes that require acknowledgement and adjustment in a global economy. The penetration, for example, of American popular media culture, perhaps a double affront to traditional culture because of its wide acceptance and popularity, ought not, Bhagwati argues, lead to protectionist policies.
but rather encourage measures to support indigenous cultural activity (Bhagwati, Jagdish, 2004).

Thus Huntington’s clash of civilizations appears not to be inevitable. On the contrary technology, if deployed regionally in a manner that fosters localization and addresses specific needs, can be a powerful force of mediation and reconciliation. Moreover, collaborative models that multiple sources of input are more likely to produce innovative results.

**Conclusion: How Should Engineering Education Respond?**

This discussion has considered three external forces that are shaping the profession of engineering and subsequently engineering education. Each is in itself complex and each alone exerts a powerful influence. Yet they cannot be addressed individually as each compounds itself with the other two. The three forces discussed were:

1. The ongoing revolution in contemporary science renders it continuingly more complex, more mathematical and more open-ended. These factors together with different goals and a different working culture profoundly challenge the possibility of strong collaboration between science and engineering. Yet such collaboration is vital to engineering’s future.

2. The need for engineering to care for and repair the world arises at the intersection of scientific complexity and ambiguity and expectations of a multiplicity of special interest and public clients. It is clear that the power vested in the hands of engineers (along with others who manage and deploy technology) is great, potentially redemptive or apocalyptic. From an ethical perspective the engineer’s duty is to the world. But how is that to be accomplished? Both philosophical and organizational issues block the easy exercise of such duty.

3. Globalization is not a phenomenon of equal distribution of goods, services, power, influence, wealth, or intellect. The West has been accustomed to occupying a leadership position which it believed was both inevitable and justified. This is currently being severely challenged, especially by the growth of China and India. Western institutions, including universities, can no longer hope to reign as the natural leaders and standard bearers, but must begin to build peer networks that acknowledge that fact.

Engineering education is at the fulcrum of these dynamic events. The best prospect will be found in discursive networks of engineering educators. The most likely format may be the CDIO process which rationalizes a process that honors multiple perspectives and purposes and can be conducted on a global virtual platform. While it is a useful strategy to manage engineering curriculum reform, CDIO methods permit opening the discussion to include the broader external demands discussed here. Primarily engineering education needs to be involved in the larger cultural, political and economic discourse, and not only as the technical agency that executes the objectives of others, but as a full partner willing and prepared to assert its fundamental responsibility and duty to care for the earth and advance the good life for all its inhabitants. For engineering education to prepare engineers who can make this kind of commitment more than piecemeal curriculum reform is urgently needed.

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The Future of Engineering Education: What does the Re-entry of China and India as World Technology Leaders Mean for Engineering Education?

AUTHOR

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Issues & Concerns in Engineering Education

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Abstract

Engineering Education has always been at the cross roads. Policy makers are at the cross roads not knowing how to accommodate the fast changing developments. Students are at the cross roads not knowing how to face obsolescence in technology of understanding. Successive developments in semiconductors, Integrated Circuits and very large scale integration resulted in faster developments in computer and miniaturisation of large computers. Developments in Bio-technology, a new promising and frontier area resulted in advanced areas such as Genomics and Proteomics. Bio-informatics has helped in the invention of Bio-computers and Nano-biotechnology. Research in Material science has resulted in a quantum jump that lead to the development of Nano-materials. Convergence of Information Technology, Bio-technology and Nano-technology along with cognizant technology resulted in new phenomena and new working methodologies in every field of engineering and science in every walk of life.

It is understood that the knowledge profile of an engineer becomes completely obsolete within three years, if he is not in touch with the developments in the respective field. If he is a computer science graduate, his knowledge profile gets grounded to zero, if he is not in touch with the developments in computers and information technology field. It is also understood that the technology innovations we see today is one third of what we would see in the next five years. Our capability and capacity is not adequate to face the new inventions and innovations.

The developments in the IT and computers have made the existing system obsolete and redundant. In manufacturing industry computers with the help of rapid proto type devices, could produce components with better accuracy and precision at a much cheaper price. Such phenomenon is widely prevailing in the manufacturing industry, housing and service sectors too. Faster development in computers and related services sent a shock wave in the sectors where computers involved. These sectors could not accommodate the speed in development and hence resulted in the recession.

Education sector as a whole is one sector where the computers and related services are widely used and hence the shock wave has penetrated here very seriously. Consequential developments in computers and allied services have transformed the shock wave into Tsunami.

The effect of the Tsunami in the education sector is that all our teachers have become obsolete; the teachers who are not in touch with the developments have become redundant irrespective of their age and experience. The educational system and the universities that govern the educational system are headed by people who provide very weak leadership in accepting the challenges in the technology of education. Administrators of education and policy makers continue to play with the age old technologies and are not willing to accept the changes in technology of education due to the inventions and innovations. Seniors in academics are not in tune with the current technologies; some are not ready to accept the new technologies. Unfortunately our educational system is such that the degrees and diplomas are awarded to the aspirants through the system called university. And such universities are headed by the so called educational stalwarts. Such stalwarts normally are not willing to adopt themselves for the changes. They have limited capacity to accept the new inventions and innovations in the educational methodologies. Faster progress in education and educational methodologies depend upon the Vice-Chancellors/Rectors and Vice-Rectors. However innovative, these younger teachers are, the whole progress in education limits at a point where the academic leaders stay.

On the whole it is understood that the average Engineer needs 100 percent in the relevant field to call himself an Engineer. Our academic institutions provide only 20 percent of it in the academic institutions. He is expected to learn the remaining 80 percent from the field, society and from the market. The faster he picks up, the sooner he can declare himself to be a qualified Engineer.

There are two aspects to be considered here. To equip him/her with the 20 percent of knowledge in the institutions and the next is to allow him to equip the remaining 80 percent at the earliest. If we consider the first 20 percent we will realise the large gap that exists in the educational methodologies. Framing the syllabus has been a Herculean phenomenon in many of the universities. Updating of syllabus has been in the dark for many years. Choice based system of question paper setting and evaluation allow the university to evaluate the student’s knowledge only from the 30 percent of the syllabus. Out of this if he is successful in 18 percent of the syllabus, he is declared to have passed in first class. The stake holders get an engineering graduate passing out of the university with the most out-dated syllabus. Irrespective of the university updated the
syllabus every year or not, the obsolescence and advancements in engineering and technology makes the individual an out-dated engineer. This peculiar phenomenon is not specific to one particular university. This is a phenomenon that is prevalent in all universities around the world. The student should realise that the 20 percent of knowledge for which he enrols in the university itself has become outdated. If he takes considerable period for acquiring the 80 percent of knowledge after passing out of the institution, he will be lagging behind far away from the ideal standards. The student should realise and identify mechanisms to acquire in the possible form and possible mechanism apart from the university education.

If one critically looks at the educational maladies the following issues and concern would emerge:

**Concern**

1. Educational system is not dynamic to accommodate the invasion of new technologies.
2. Engineering Education lacks strong knowledgeable leadership to face the obsolescence in educational system.
3. Engineering Education lacks courageous leadership to venture for new technologies in educational system.
4. Engineering Education lacks in understanding the changing social relevance and the social responsibility.
5. Engineering Education lacks in understanding the obsolescence that engulf the teacher, educational administrator and policy makers of education.
6. Engineering Education lacks in understanding the new changes that invade in the learning process, delivery methodology.
7. Engineering Education lacks in understanding the complexities of teaching – learning process.

**Issues Today**

- **Definition of teacher has changed:** In the past, the teacher was expected to teach the prescribed syllabus defined by the university. But things have changed with time that he is expected to inform the student of the latest technology change which means he has to update himself and equip himself with various form of presentation including on-line to impart the new technology.

- **Definition of student has changed:** the time duration of Retention of the students’ attention to the subject matter in a class room has become a challenge. At home and in other recreation places he has exposure to the television channels and the speed with which he changes the channel has increased. This has made the student to choose which one to accept and which one to reject instantaneously. This kind of training made the student to reject the lectures if they are not interesting. To make it interesting, the teacher has to resort to various innovative measures including the use of modern gadgets and internet.

- **Definition of Classroom has changed:** the age old chalk and talk method is disappearing. Since the expectations of the student in a class room is fast changing, the teacher has to resort to the introduction of new gadgets, multi-media delivery techniques and internet based on-line exposition including the pre-recorded lectures from experts in the field.

- **Definition of conventional degrees and diplomas has changed:** in the past a degree holder was expected to know a reasonable amount of knowledge. Today, it is an agreed fact that the institution offering the course provides 20% of what the individual is ought to learn for his professional status. Hence to make him suitable for a job or to make him an Entrepreneur one needs to provide additional knowledge in the allied subjects. Apart from this he needs to learn peripheral knowledge in Human relations, man management, Social responsibilities etc.

- **Definition of research methodology has changed:** in the olden days, literature survey alone would take anywhere from one two years. Even then he does not have the satisfaction that he has searched through the entire literature from allied topics also. With the availability of internet, the literature survey does not take more than one month. In fact he could search allied areas too. Internet also provides instant comparison of work done by someone elsewhere in the world. Instant verification of results is made easy with internet. The quantum of work and the quality of work done by an individual researcher is increased many fold. Comparison of on-line journals and publication of the original work has been made simpler and less time consuming. In fact the research worker from one corner of the world could compare his data with that of his counterpart in another corner of the world through on-line mechanism and get research support online.

- **Definition of Education itself has changed:** Education was considered to be transfer of knowledge from the teacher to the taught. With the advent of internet, the teacher has become a facilitator and the student has become the self learner with guidance from the teacher. Also the education does not confine to the class room or to the institution. With the introduction of internet, it has become a continuous process of learning with no boundary and no limit. As the obsolescence is galloping, it is to be noted that education does not
end at any point of time. Continuous learning has become the part of regular education.

✓ **Internet has brought revolution**: Internet has transformed the understanding of the class-room, student, teacher, research and research methodology and education as a whole.

✓ **Internet has introduced complexities in understanding the education**: Since computers can handle lot of data and the internet can support the import of data, with the evolution of sophisticated software, more complexities have been introduced in understanding the education.

✓ **Internet has also brought simplicity for complex educational issues**: also issues considered hitherto have become solvable and simpler with the advent of internet.

✓ **Teaching delivery methodology has become complex**: unlike the conventional chalk and talk method of teaching, modern teaching and delivery has become complex. In fact we need an engineer to monitor the working of various gadgets in the class-room, similar to an advanced operation theatre in a hospital.

At the same time difficult concepts have been made easy to understand with the help of Internet; with on-line system and multi-media gadgets in place it has become easier to explain difficult concepts in an easier way in a short time.

There is no place for values of life in the fast changing educational scenario. Social and cultural values are disappearing with the modern education system. The value based education is disappearing. However educated a person is, he needs to have his own culture and socio economic system to advance his life-style. Internet has made the globe an IT village. Cultural boundaries are disappearing. Because of disappearing boundaries, human vale in life is slowly deteriorating and hence fast changing technology could afford a society with culture and values in life. This is bad tendency.

**Remedial tasks ahead of the planners**

1. Use of latest gadgets in the classroom
2. make class room lecture interesting by using various delivery methodologies
3. Update the syllabus every semester
4. Update the curriculum in tune with international development keeping in mind the local demands
5. Introduce innovations in teaching methodologies
6. Bring out native intelligence
7. Establish research programmes for introducing innovations in teaching learning process.
8. Incorporate values of life and social responsibility into the fast changing educational methodology.
9. Timely education for the leaders and policy makers to make them understand and increase their capacity to absorb the new inventions and innovations.
10. Teachers should realise that conventional teaching has no place in the educational process.
11. The chalk and talk method is fast disappearing in the teaching learning process.
12. The teacher should realise that in the teaching-learning process, his major task will be facilitation.

**AUTHOR**

Adinarayana Kalanidhi, Vice Chairman, Commonwealth Science and Technology Academy for Research is an outstanding Academician & Administrator and rendered yeomen service in the field of Technical Education, and Renewable Resources of Energy, in particular IT and IT enabled services. His Excellency Dr.A.P.J Abdul Kalam, The President of India, Felicitated and presented him an award for his Path Breaking Initiatives in IT-Driven Engineering Education at Anna University on 28th May 2003. Recently the Commonwealth Science and Technology Academy for Research (C-STAR) was inaugurated by His Excellency Dr.APJ Abdul Kalam, Former President of India in the presence of several stalwarts from the academic field. Dr. Kalam, congratulated Prof. Kalanidhi, for creating this new venture on the mission of research and said the C-STAR Academy shall provide a virtual platform for collaboration among institutions of higher education. Excellence should be infused into engineering colleges in the country and senior researchers should serve as role models for the younger generation. Prof. A. Kalanidhi, has been appointed as Vice President of the International Academy Advisory Committee, (World Institute for Engineering and Technology Education, Australia). He was responsible for creating a mechanism to monitor the progress of research. Thus ‘World Accreditation Council for Research’ was formed at Thailand by signing an accord with ten countries. It is a significant Accord signed on February 23rd 2010 at Thailand. Dr. A. Kalanidhi has been appointed as the convenor for the “World accreditation Council for Research”. It is a victory for all the academicians from India that the idea generated from India has culminated into “World Accreditation Council for Research”. It is an important milestone for the C-STAR, for the academics and for the research and research institutions.
Using Graduate Attributes and Profiles in Design of Engineering Programmes

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Abstract

The paper describes the importance of graduate attributes and graduate profile in curriculum design process. It describes different domains of the attributes and some specific accreditation requirements. The process for embedding graduate attributes into courses and across programme as well as its relation to quality assurance has been presented. Mapping of the curriculum as a tool to can enhance the teaching of key concepts, technical skills and graduate attributes has been discussed. The paper indicates that the mapping process can be made more formal and effective by creating a graduate profile database. The case of mechanical engineering programme at the University of Botswana is used an example of programme in need of mapping.

Keywords: Graduate profile, mechanical engineering, industry, accreditation, curriculum

INTRODUCTION

Higher education providers and graduate employers often have a misunderstanding about the role of each other (Martin, R. et al, 2005). Employers are sometimes concerned about the quality of graduates exiting from universities while higher education providers feel that employers are not fully appreciative of what qualities and skills these graduates possess (Nguyen, D. Q., 1998 and Robinson, M. A. et al 2005). This dichotomy creates clear gaps between employer expectations and higher education outcomes.

In case of engineering graduates industry requires infusion of both technical and non-technical skills and attributes into the programmes. However, most of the research studies have consistently identified communication, interpersonal and teamwork attributes as important competency gaps (Lang, J. D. et al, 1999, Meier, R. L., et al 2000 and Scott, G., et al 2002). Some other studies reveal that engineering graduates have adequate expertise in technical skills but are however weak in other important skills such as working in multidisciplinary teams, leadership, practical competency and management skill (Martin, R. et al , 2005). Therefore it is crucial that engagement be encouraged between employers and higher education providers to narrow the attribute gaps. Careful planning of the graduate attributes and proper design of curricula may narrow the gaps substantially.

Graduate attributes form a set of individually measurable outcomes that should indicate the potential competence and skills of a graduate. Attributes are clear, succinct statements of the expected capability. They are endorsed by a range of indicators appropriate to the type of programme. The set of attributes provides an outcome of the educational processes within and outside of the educational institution. In the case of engineering the outcome is normally benchmarked against specifications set by accreditation bodies. The specific standards may be slightly different depending on the accreditation body but the graduate attributes provide a point of reference to describe the outcomes of substantially equivalent qualifications.

Graduate attributes are defined as:

‘...the qualities, skills and understandings a university community expects its students to develop during their time at the institution and, consequently, shape the contribution they are able to make to their profession and as a citizen’. (Bowden, J et al, 2000)

The graduate profile characterizes the attributes and competencies of a graduate of an academic programme. It includes descriptions of the key attributes which a graduate is expected to acquire during studies. The anticipated attributes are expressed in the form of educational aims which guide curriculum development and mode of instruction delivery and describe intended graduate learning outcomes.

Establishing the set of desired graduate attributes is fundamental in the process of designing a curriculum. Although curriculum design is a multifaceted challenge each academic programme has to answer ultimate questions about ‘what competencies students should have upon graduation’ and ‘what should be the relative emphasis among those competencies’. In particular academic programmes that prepare students for a profession (medicine, law, or engineering) the curriculum will ideally develop some of the competencies that are imperative for professional practice and success.
DOMAINS OF GRADUATE ATTRIBUTES

A graduate profile needs to address attributes within three broad domains: personal, professional and intellectual, acknowledging that these attributes are interrelated in the overall development of a graduate. Figure 1 provides examples of more specific attributes within these domains. Some of the attributes are implied in the mission of the university or department and others are identified as necessary and must be accomplished through programme delivery (Patil, A. et al, 2007).

The specific attributes for any particular programme, and the way in which the courses are contextualised, described and offered will vary according to the professions or disciplines.

ATTRIBUTES OF ENGINEERING GRADUATES

The discussion regarding the desired attributes of engineering graduate has been on-going for some years. However a measure of uniformity and acceptance has been achieved through the accreditation process since the engineering accreditation bodies (e.g. Engineering Council of South Africa, ECSA; American Board of Engineering and Technology, ABET; Engineering Council of United Kingdom, ECUK) are governed by the same principles. The paradigm shift made around year 2000 completely replaced focus on inputs (topics taught) to focus on outputs (competencies achieved by students).

The main attributes of the engineering graduate are as follows:

- in-depth technical competence with application of science and engineering knowledge,
- problem identification, formulation and solution,
- effective communication,
- function effectively as an individual and in teams,
- awareness of the social, cultural, global and environmental responsibilities,
- commitment to professional and ethical issues,
- capacity to undertake lifelong learning.

There are also other desired attributes desired of the graduates, which reflect requirements specific for the location and ethos of the training institution. However assessing whether those attributes are successfully achieved in a programme is usually a common problem in curriculum design. Additional problem is the relative emphasis among those competencies, such as; how important is the ‘effective communication’ in relation to ‘capacity to undertake lifelong learning’?

The process of curriculum mapping is a tool which can be used to identify, characterize and chart the teaching of key concepts, technical skills and graduate attributes. It identifies where the graduate attributes occur in the curriculum, recognizing gaps, overlaps and omissions; it also helps to develop curricula to fill these gaps. The curriculum mapping that has been practised in designing the curriculum could also be used as a benchmarking to map the learning outcomes and making sure that there is no gap throughout the graduates learning process. This will help the graduates to understand what is expected from them and they are able to excel when they enter the industry.

MODELLING OF THE GRADUATE PROFILE

Each programme will, over time, develop a profession-specific graduate profile. The profile should be described in terms of educational aims or objectives as part of the accreditation process. It will inform the design of the overall curriculum, including the relationships of courses to the programme, teaching and learning processes and
assessment patterns. It will also inform programme evaluation processes undertaken for regular course monitoring and accreditation.

Fig. 2: Pedagogical model (Humphries, J. et al, 2004)

The design of a new or re-design of an existing programme or course for any purpose requires some fundamental understanding of the cyclic process to be followed. Figure 2 shows a pedagogical model which can be used in creating a programme. It shows a sequential relationship between graduate attributes and other elements. The model can also be used for embedding graduate attributes into courses and programmes (Humphries, J., & Jolly, L., 2004). The process starts with a list of desired graduate attributes, which are expanded to a set of programme specific learning objectives. These objectives can be achieved by designing a series of student focused learning activities, which prepare the student for the assessment tasks. Assessment consists of two elements; assessment criteria which are measured against a set of assessment criteria. The loop of the model is closed as these assessment criteria can be used as a feedback to show that a student has developed particular aspects of the desired graduate attributes in a programme. Assessment criteria should show that all graduate attributes to be achieved in the programme have been indeed acquired and assessed. The assessment criteria also confirm that the programme/course learning objectives have been achieved or delivered.

However, a closer look at the list of graduate attributes shows rather imprecise and idealised description of the well-defined graduate. This is due to the general nature of the attributes and also that the actual realization of how to achieve a particular attribute would differ depending on the engineering specialization and educational institution. For these reasons, the attributes need to be specified more precisely for each programme and they should be expressed in the form of indicators – behavioural characteristics that can be observed and assessed. Hence, the process for embedding graduate attributes into courses and across programme has five stages:

• expanding the graduate attributes to form specific learning objectives,
• achieving these learning objectives though a series of student focused learning activities,
• preparing the student for the assessment tasks,
• measuring assessment tasks against a set of assessment criteria,
• demonstrating the realization of graduate attributes and learning objectives.

A major challenge in curriculum design is to determine essential graduate attributes and integrate them in the educational process cycle. Figure 4 shows a generic educational process cycle that may be used to design any programme that requires accreditation. It consists of four 4 sub-systems, namely engagement process, setting goal phase, curriculum development and assessment process. The results at the output part of the cycle can be periodically monitored for comparison with the desired attributes. Each sub-system of the cycle can also be monitored individually to ensure that the required outcomes will be delivered.

Fig. 3: Phases of developing graduate profile in a course/programme.
Using Graduate Attributes and Profiles in Design of Engineering Programmes

MECHANICAL ENGINEERING PROGRAMME AT THE UNIVERSITY OF BOTSWANA

The current programme in mechanical engineering at the University of Botswana (UB) was reviewed significantly in 2002. It has been designed to give students a choice from a wide range of courses, and to permit them to broaden their studies by taking courses offered by other faculties. The B.Eng. programme extends over ten semesters after entry with the General Certificate of Secondary Education (GCSE) qualification, or eight semesters for those with Advanced level or Ordinary Diploma qualifications. Each across disciplines University programme consists of core, elective, optional and general education courses. The total course credits over ten semesters are 150 credits, at approximately 15 per semester, of which one-third of the total credits should be gained from general education or elective courses. The mechanical engineering degree programme consists of 42 courses (core and optional) including two periods of industrial attachment. The general structure for the B.Eng. programme is shown in Fig 5 (Foster, J. D., and Uziak, J., 2002).

The aim of the programme is to produce graduates with an appreciation of the practical, social and ethical dimensions in the area of mechanical engineering and with the skills and knowledge to operate effectively in culturally diverse workplaces within changing international contexts. Flexible approach, which is expressed through the effective use of technology and an information technology rich environment, has been employed to develop graduate skills and attributes (Scott, G., and Yates, K. W., 2002). In addition to the more traditional curriculum practices, many mechanical engineering students experience a range of opportunities to engage in learning inside and outside of the University. These include industrial training and visits to manufacturing or process industries.

The mechanical engineering department at the University of Botswana (UB) is currently reviewing its programme. The purpose is two-fold; namely, to improve the curriculum of the programme in order to make it more desirable for employers and other stakeholders and secondly to align the curriculum with the accreditation requirements of the Engineering Council of South Africa (ECSA). The starting point in the programme review process is to re-define the overall set of graduate attributes. It is envisaged that the graduate profile database, as described in the next point, would help in the process of re-assessing the graduate attributes.
GRADUATE PROFILE DATABASE

The process of assessing whether the graduates have achieved the required attributes and thereby possess appropriate employability skills and competencies is important for the success of the teaching programme. The actual assessment can only be done once the students have graduated from the university and are engaged in the workplace. The assessment can be carried out by using surveys based on questionnaires. However, a mapping process can be employed to monitor success of programme or identify problems and address them speedily (Oliver, B., Jones, S., Ferns, S., & Tucker, B., 2007). The curriculum mapping can be introduced when designing the curriculum and could be used to benchmark the learning outcomes and making sure that there is no gap throughout the learning process. This will also help the students to understand what is expected of them and prepare them for employment.

Effective mapping of the teaching programme should commence from the stage of design of the curriculum and end most often after its implementation but before students leave the university. Normally the mapping process involves learning outcomes to be coded and mapped to show the spread of course learning outcomes and how they will be delivered and assessed to ensure student achievement of the programme learning outcomes. Such mapping can even be quantified if course learning outcomes within a programme are assigned rating based on Bloom’s taxonomy of educational objectives (Anderson, L. W. et al, 2001). The rating can be used to observe the spread of higher order thinking skills, and where they are developed within a programme.

The mapping process can be made more formal and effective by creating a graduate profile database which combines course profiles. Course profiles should include, among other descriptors, the information on how specific graduate attributes are achieved. That will improve the process of mapping of graduate attributes by:

- centralizing the data,
- allowing for easy access and retrieval,
- efficiently maintaining the records i.e. archival system,
- allowing for easy administration and quality control i.e. programme management,
- showing assessment schedules and contact schedules for courses,
- indicating graduate attributes addressed in courses which allow for immediate mapping of attributes across the programme and even for individual students.

The graduate profile database can be created at the stage of designing the curriculum. However, the database should be populated and continuously updated when the programme is offered. The information in the database can be verified by conducting graduate profile survey.

The verification phase requires questionnaires to collect information from students-graduates and from industry. Different questionnaires can be used for the final year students who are about to graduate and the industry to obtain comments on the attributes of the recent graduates of the programme. Verification phase provides a feedback mechanism on the graduate attributes achieved and offers the possibility of applying corrective measures.

The process of reviewing the mechanical engineering programme has been on-going and the exercise is currently at the stage of mapping and creating the database. Once successfully implemented in the mechanical engineering programme the graduate attribute database would be recommended for other engineering programmes in the Faculty.

CONCLUSION

Academic programmes that prepare students for a profession, such as engineering, should develop some of the competencies that are imperative for professional practice. The competencies that engineers are expected to possess are influenced by local context in addition to some universal attributes which should characterize all engineering graduates. However, there is a competency gap between skills required by employers and those developed through curriculum of engineering education. Therefore a body of knowledge about the required profile for the graduate engineer is a valuable resource for educators, employers and students aspiring to become high performing professionals. Such information should also help to answer typical questions faced by engineering educators - which attributes are important for professional practice and what should be the relative emphasis between them.

The graduate attributes are one of the most important factors in the process of designing or re-designing the engineering curriculum. Attributes form a set of outcomes formulated as statements of the expected capability. Curriculum mapping has been recognized as a tool which can identify where the graduate attributes occur in the curriculum, recognize gaps, overlaps and omissions. The process of mapping can be effectively improved with the help of a graduate profile database. Such a database should assist in assessing whether the necessary skills demanded by various stakeholders have been achieved. The design of actual database is still incomplete at this stage of the study. The plan is to develop and populate it during the next phase of the research.

The mechanical engineering degree programme at the University of Botswana consists of 42 courses (core and optional) which have to be included in the database. It is expected that the advantages of the system to both staff and students should make the University consider adopting the graduate profile database as a model for university wide application. However, it has to be borne
in mind that mapping defined as the identification of courses, or their elements, in which certain attributes are developed, should not be designed based only on the course content. Graduate attributes should be treated more as a function of what students do in class (teaching and learning activities) as well as what they are being taught in class (content).

REFERENCES


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Identifying the Threshold Concept of Learning Nano-Science and Nano-Technology in Material Engineering by Curriculum Map

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Abstract

The purpose of this study is to introduce new approach to university nano-science/technology curriculum planning based primarily on the threshold concept. Curriculum mapping is employed to explore curricula in the field of nano-related material engineering. Data are derived from 137 course syllabi of twelve Taiwan nano-science/technology undergraduate and graduate programs. In addition, semi-structured interviews with the instructors and program coordinators are conducted. Findings suggested that the “nano-scale” or “small-scale” is pivotal to a better understanding and successful learning of nano-science/technology. In conclusion, the implications of instructional design features as well as exploited threshold concepts for the preparation of nano-science/technology education are discussed.

Keywords : curriculum map, threshold concepts, nano science, nano technology, material engineering

INTRODUCTION

As a result, universities around the world have devoted themselves to the establishment of undergraduate and graduate nanotechnology programs since 2000. Meanwhile, in addition to examination of what essential skills needed for new graduates before entering nanotechnology industries, many studies also focus on addressing the instructional design concerns related to the development of an effective nanotechnology course (Luckenbill, Hintze, Ramakrishna, & Pizziconi, 1999). What seems lack of in current studies is a thorough analysis of curricula developed for nanotechnology learning. Research on university nano-science/technology curriculum of the present study aims to introduce new approach to curriculum planning based primarily on the threshold concept.

Threshold concepts are defined as concepts that bind a subject together, being fundamental to ways of thinking and practicing in that discipline (Mayer & Land, 2003). Threshold concepts offer potential help to instructors in higher education to tackle two widely reported problems, including students can not apply the knowledge outside the classroom and unable to use the knowledge in conjunction. Once students internalized threshold concepts, they are more able to integrate different aspects of a subject in their analysis of problems, and to see the relevance between related disciplines (Land, Cousin, Mayer, & Davies, 2005; Worsley, Bulmer, & O’Brien, 2008). Besides, threshold concepts also can help instructors manage the ever-growing curriculum. If instructors can identify a relatively small number of threshold concepts within the curriculum, they can make refined decisions about what is fundamental to a grasp of the subject they are teaching. Contrarily, if instructors do not pay attention to introducing these concepts to our

Nanotechnology development is determined by a variety of factors, such as creativity of researchers, professional training of students, international context, and the connectivity among institutions, patent regulations, physical infrastructure, and legal regulations (Roco, 2003b). Nevertheless, one of the key factors determining the success of nanotechnology development lies in training and development of human resources at all levels, which encompass school students from K-12 to higher education, technicians, and postdoctoral fellows, etc. In addition, attributes such as creativity of individual researchers and skilled workers with interdisciplinary perspectives are considered necessary for coping with the rapid changes of nanotechnology (Lee, Wu, & Yang, 2002; Roco, 2002, 2003a). A sufficient and well-prepared workforce for research, development and production is required to achieve the potential impact of nanotechnology on our society.
students and monitoring their understanding, students may fail to move on, or move on only with surface knowledge of the concept. Therefore, it is a “less is more” approach to curriculum design (Boustedt et al., 2007; Cousin, 2006; Trend, 2009). In the present study, the aim is to explore and identify the threshold concepts of learning nano-science/technology. To achieve this study purpose, curriculum mapping is employed as a tool to explore nano-science/technology curricula in the field of material engineering.

LITERATURE REVIEW

Threshold Concept

The threshold concept was first proposed by Mayer and Land (2003) as a way of characterizing particular concepts that might be used to organize the educational process. A threshold concept can be “considered as akin to a portal, opening up a new and previously inaccessible way of thinking about something. It represents a transformed way of understanding, or interpreting, or viewing something without which the learner cannot progress.” The transformation may be sudden or it may progress over a period of time. Such a transformed view represents how people think in a particular discipline or how they perceive, apprehend, or experience particular phenomena within that discipline. Hence, threshold concepts reveal the relationship between big shifts in thinking in the subject and transformative changes that learners have to experience in their thinking (Davies & Mangan, 2007).

Although the threshold concept is new to instructors, a number of disciplines, including computer science, information science, economics, networked learning, marketing, mathematics, statistics, and geosciences, have begun the process of identifying threshold concepts and investigating how to take advantage of them to improve student learning (Boustedt et al, 2007; Cope & Staehr, 2008; Davies & Mangan, 2007; Dunne, Low, & Ardington, 2003; Khalife, 2006; Kligyte, 2009; Lye, 2006; Rountree & Rountree, 2009; Trend, 2009; Worsley, Bulmer, & O’Brien, 2008).

The conceptual framework is different between threshold concepts and learning outcomes (Rountree & Rountree, 2009). Learning outcomes treat education as a set of activities designed to achieve pre-specified outcomes, with success defined in terms of meeting those outcomes. On the other hand, threshold concepts emphasize that students go through a transformation, and after that they begin to “think like a specialist.” Similarly, there is common confusion about the difference between core concepts and threshold concepts. All threshold concepts are core concepts, but not all core concepts are threshold concepts (Rountree & Rountree, 2009). A core concept is a conceptual building block that it has to be understood but does not necessarily lead to a qualitatively different view of the subject matter. However, across a range of subject contexts, the general characteristics of threshold concepts are transformative, irreversible, integrative, bounded, and potentially troublesome (Mayer & Land, 2003).

The shift in perspective may lead to a transformation of personal identity, a reconstruction of subjectivity, even shift in values, feelings or attitudes. New understandings are assimilated into our biography, becoming part of what we are, how we see and how we feel. Irreversible means that the change of perspective caused by acquisition of threshold concepts is unlikely to be forgotten, or will be unlearned only by considerable efforts. Learning involves the occupation of a liminal space during the process of mastery of a threshold concept. This space is similar to the one occupied by adolescents who are not yet adults, not quite children. It is an unstable space in which the learner may oscillate between old and emergent understandings, just as adolescents often move between adult – like and child – like responses to their transitional status. Once a learner enters this liminal space, he/she is engaged with the project of mastery. Besides, threshold concepts also expose the previously hidden interrelatedness of something, and helps delimit the boundaries of a subject because it integrates a particular set of concepts, beliefs and theories. The stronger the integration, the sharper the boundaries of a subject; the looser the integration, the more the boundaries of a subject become open to debate (Mayer & Land, 2003). Finally, threshold concepts generally appear to be alien, incoherent, or counter-intuitive for learners. That is, threshold concepts are often fundamental concepts for which learners may express a tacit understanding, yet learners have difficulty applying them to real life, have little evidence for, or have little understanding of the origin of the ideas (Perkins, 1999).

Threshold concept research offers a way of transactional curriculum inquiry in which all the key players, such as subject specialists, academics, students, and educationalists, can work iteratively together to explore the complexity of the subject, generate dialogues among them, as well as allow them to focus on the subject rather than on general education theory (Cousin, 2007, 2010). According to Boustedt et al. (2007) and Kligyte (2009), the threshold concept enables curriculum developers to focus on long-term change, recognize students who are in the liminal space, and create opportunities for them to approach the threshold concepts in iterations. Mayer and Land (2003) also points out that a discipline may have a number of threshold concepts. Similarly, based on Kinchin (2010), the consideration of threshold concepts at different levels of resolution (macro and micro) suggests that students need to cross many threshold concepts of the macro level before making the transition to higher level learning of a particular subject. These macro threshold concepts should form the core of the subject’s basic curriculum. Acknowledgement of such a web of threshold concepts may help to establish greater
disciplinary continuity for students making the transition from basic to more advanced learning. In this sense, the primary goal of the present study is to solicit the macro level of threshold concepts related to nano-science/technology taking advantage of material engineering as a case.

Curriculum Mapping

The concept of curriculum mapping is pioneered by Hausman (Hausman, 1974), and the role of computers in the process is introduced by Eisenberg (Eisenberg, 1984). Curriculum mapping is a procedure which promotes the creation of a visual representation of curriculum based on real time information (Jacobs, 1997). A curriculum map can be seen as a roadmap of a curriculum, guiding its users through the various elements of the curriculum and their interconnections. Curriculum elements may include people (learners, teachers), activities (learning and assessment events), courses, outcomes and objectives, learning resources, topics and locations. Therefore, curriculum mapping is a consideration of when, how, and what is taught, as well as the assessment measures utilized to explain achievements of expected student learning outcomes (Harden, 2001).

All participants involving in curriculum development together identify the strengths, gaps, and overlaps through the process of reviewing curriculum map. Once the review is complete, the faculty identifies the focus of a given grade level, the patterns across grade levels, the potential for interdisciplinary collaboration, and determines what and where to add or eliminate contents or strategies, which results in a more streamlined curriculum and integrated program (Eisenberg, 1984; Plaza, Draugalis, Slack, Skrepnek, & Sauer, 2007; Uchiyama & Radin, 2009). As a result, the curriculum map is viewed as a useful tool to facilitate the process of curriculum review and evaluation, and the curriculum transparency and accessibility giving stakeholders, including teachers, students, curriculum developers, managers, public and researchers, a broad overview of the curriculum (Harden, 2001; Plaza et al., 2007; Willett, 2008).

Curriculum mapping is an essential tool for the development and implementation of a curriculum in higher education. Mapping not only assists the planning and implementation of a curriculum, but also helps to facilitate the discussion and reflection about the curriculum and resource allocation (Harden, 2001). Through the collaborative process of curriculum mapping, instructors came to an agreement as to what content should be kept in the course sequence, what should be dropped, what new content should be added, as well as an increase in collaboration and collegiality among participants (Uchiyama & Radin, 2009).

By acknowledgment of the advantages of curriculum maps in higher education, many universities have started to apply it in curriculum planning. In Canadian and UK schools, Willett (2008) found 74% of undergraduate medical schools are building or have built curriculum maps. Plaza et al. (2007) employed a descriptive cross-sectional study design based on learning outcome documents, course syllabi, and students’ reflective reports to examine the differences between the perceptions of what competences had been taught by faculty members and what had been learned by pharmacy college students. The results showed that there was concordance between student and faculty members’ ranking of domain coverage in their respective curricular maps. The medical curriculum in surgery and internal medicine at the University of Munich applied an online tool for developing a curriculum map based on specific learning objectives and standard catalogues (e.g. the Swiss Catalogue of Learning Objectives) (Hege, Siebeck, & Fischer, 2007). Cottrell, Linger, and Shumway (2004) adopted competence-based framework to map the undergraduate medical school curriculum at West Virginia University.

In addition to identifying the specific competences expected to be developed by the students taught, some researchers focused on identification of generic skills through curriculum mapping. The process of curriculum mapping enables researchers to identify general patterns within the undergraduate education program in relation to the promotion of generic skills, as well as provides faculty members valuable opportunities to reflect on their course and assists them to identify directions for further pursuit (Sumison & Goodfellow, 2004). Also in this research, curriculum mapping built upon the mapping technique is recognized as a useful tool for elicitation of the threshold concept from an integrated curriculum related to nano-science/technology.

METHODOLOGY

Since there is still no consistent agreement on appropriate methodology to identify threshold concepts among researchers, different strategies are developed. Davies (2006) suggested two methods for recognizing the threshold concept within a discipline. The first approach argues that the threshold concept can be recognized by examining different ways in which two disciplines analyze the same situation. And the second approach focuses on the distinction between people inside and outside the community of practice, specifically, in the differing ways in which students and experts in the discipline analyze the same problem. Even though examining the different ways of which practitioners in related disciplines use to solve similar problems may produce excellent candidates for threshold concepts in each discipline, it opens up a research question concerning whether threshold concepts are shared between disciplines, and whether threshold concepts mutate as they cross between disciplines (Rountree & Rountree, 2009). Additionally, Davies and Mangan (2007) advised that to explore a distinction
among basic, discipline, and procedural concepts may be useful in determining a framework for the identification of threshold concepts. Boustedt et al. (2007) and Worsley et al. (2008) utilized interviews, surveys, and course documents to gather data from instructors and/or students for investigation. Cope and Staehr (2008) first identified possible candidates of threshold concepts, then verified them based on an analysis of the general characteristics of threshold concepts proposed in the literature. Cousin (2010) further delineated that the point of threshold concept research is to share an inquiry into the difficulty of their subject with the academics and students. It is student-focused but not student-centered in ways that remove the academics from the stage. In other words, it is unlike phenomenographic research centered on the students so that once data obtained from students may heighten the risk of the students’ experience being interpreted through the researchers’ “eyes” or viewpoints.

Taking into consideration the above mentioned and research attempts of this study, content analysis and interview method pertaining to qualitative research is employed for data collection. Data are derived from 137 course syllabi of twelve nano-science/technology undergraduate and graduate programs in the field of material engineering from nine leading universities in Taiwan. Items analyzed include course title, description, objective, and outline. Curriculum maps are then constructed based on the results of analyses.

The curriculum was first mapped by course attributes. There are four categories identified based on the course attributes, consisting of the basic course, core course, nano-related professional course, and non nano-related professional course. Basic courses are the fundamental courses related to surface physics and material science, which does not belong to nano-science/technology field. Core courses provide basic knowledge in nano-science/technology, like introduction to nano-science and technology. Nano-related professional courses are those that offer advanced knowledge in nano-science/technology. And courses built upon basic sciences and integrated with advanced knowledge in other fields of science and engineering are classified into the category of non nano-related professional courses.

Curriculum maps are also constructed by the expected competences to be learned in the courses. By definition, expected competences are capabilities that instructors expect students to possess after they finish the course. Four competence categories are concluded in this study. Conceptual knowledge is introductory and theoretical knowledge, in respond to what or why some phenomenon happened. Procedural knowledge includes the knowledge about theories and methods to operate instruments and systems. Operational skills are the actual capabilities to manipulate an experimental equipment or anytical software. And other ability attributes are something related to personal internal characteristics, such as the abilities of independent thinking, creativity, or problem-solving and so on.

Each course analyzed might be classified into more than one competence category since all the course cross varied domains and provide different competences. However, one course can only belong to one specific course attribute category. After completion of coding, several discussions about coding and classification are held to achieve the “inter-rater agreement.” The quality of the coding was assessed by determining Cronbach alpha. A value of 0.8 was put forward as an acceptable criterion for inter-rater reliability. The inter-rater agreements among three raters with instructional design backgrounds varied from 0.80 to 0.88, and the inter-rater reliability, the value of Cronbach alpha was 0.942 which attained a rather high reliable level.

In addition, several semi-structured interviews with the instructors and one program coordinator of nano-science/technology are conducted. Interviews carried out in the current study are mixed with the semi-structured and informal aiming at clarification and elaboration of the results of content analysis and curriculum maps. Strategies of triangulation using multiple viewpoints, member checks as well as peer debriefing of three co-researchers are applied to the establishment of trustworthiness of this research.

RESULTS

Among 137 course syllabi analyzed, 67 of them belong to the undergraduate level and 70 syllabi are the graduate level. Table 1 shows the summary of course attribute identified in the analyzed courses by undergraduate and graduate levels. As revealed, more than half the courses (56.20%) in the curriculum of nano-science/technology in field of material engineering are none nano-related professional courses, following by nanotechnology-related professional courses (35.77%) and core courses (5.84%).

Results of further analyses of two curriculum maps by course attribute and expected competence are displayed in Table 2 and Table 3. For the courses offered in undergraduate level, conceptual knowledge (47.14%) is more emphasized than procedural knowledge (35.77%), operational skills (8.94%), and other attributes (8.13%). However, the conceptual knowledge (47.96%) and procedural knowledge (43.90%) are both concerned in graduate courses, and operational skills (4.07%) and other attributes (4.07%) are less mentioned.

Further exploration of the conception of nano-science/technology using both semi-structured and informal interviews and comparative analyses is proceeded. Initial findings based on the analyses of curriculum maps and interviews are concluded in Table 4. Four typologies of conception are viewed critical to transformative learning of nano-science/technology
according to the results of comparative analyses. Interpretations of the conception of fundamental, science, technology, and application are also illuminated by the description of its essence and by representation of aspect of variation based on iterative comparisons among different layers of coded themes. Additionally, the curriculum maps are included for analysis. Over half of the courses of nano-material engineering regardless of the basics or operation are considered pertaining to the fundamental and application unrelated to property change, 31.16% and 22.79%, respectively. And 46.05% of courses linked to property change.

Table 1: Summary of course attribute by undergraduate and graduate levels.

<table>
<thead>
<tr>
<th>Level</th>
<th>Course</th>
<th>Undergraduate level</th>
<th>Graduate level</th>
<th>Total (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic</td>
<td>0</td>
<td>3</td>
<td>3</td>
<td>3 (2.19)</td>
</tr>
<tr>
<td>Core</td>
<td>4</td>
<td>4</td>
<td>8</td>
<td>5.84%</td>
</tr>
<tr>
<td>Nano-related</td>
<td>14</td>
<td>35</td>
<td>49</td>
<td>35.77%</td>
</tr>
<tr>
<td>Non nano-related</td>
<td>49</td>
<td>28</td>
<td>77</td>
<td>36.20%</td>
</tr>
<tr>
<td>Total (%)</td>
<td>67</td>
<td>70</td>
<td>137</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 2: Undergraduate curriculum map by course attribute and expected competence.

<table>
<thead>
<tr>
<th>Competence Course</th>
<th>Conceptual knowledge</th>
<th>Procedural knowledge</th>
<th>Operational Skill</th>
<th>Other attributes</th>
<th>Total (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0 (0.00)</td>
</tr>
<tr>
<td>Core</td>
<td>4</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>7 (5.69)</td>
</tr>
<tr>
<td>Nano-related</td>
<td>12</td>
<td>12</td>
<td>1</td>
<td>1</td>
<td>26 (21.14)</td>
</tr>
<tr>
<td>Non nano-related</td>
<td>42</td>
<td>30</td>
<td>10</td>
<td>8</td>
<td>90 (73.17)</td>
</tr>
<tr>
<td>Total (%)</td>
<td>58 (47.14)</td>
<td>44 (35.77)</td>
<td>11 (8.94)</td>
<td>10 (8.13)</td>
<td>123 (100)</td>
</tr>
</tbody>
</table>

Table 3: Graduate curriculum map by course attribute and expected competence.

<table>
<thead>
<tr>
<th>Competence Course</th>
<th>Conceptual Knowledge</th>
<th>Procedural knowledge</th>
<th>Operational Skill</th>
<th>Other attributes</th>
<th>Total (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>4 (3.25)</td>
</tr>
<tr>
<td>Core</td>
<td>3</td>
<td>4</td>
<td>2</td>
<td>0</td>
<td>9 (7.32)</td>
</tr>
<tr>
<td>Nano-related</td>
<td>31</td>
<td>31</td>
<td>3</td>
<td>3</td>
<td>68 (55.28)</td>
</tr>
<tr>
<td>Non nano-related</td>
<td>22</td>
<td>18</td>
<td>0</td>
<td>2</td>
<td>42 (34.15)</td>
</tr>
<tr>
<td>Total (%)</td>
<td>59 (47.96)</td>
<td>54 (43.90)</td>
<td>5 (4.07)</td>
<td>5 (4.07)</td>
<td>123 (100)</td>
</tr>
</tbody>
</table>

Table 4: Typology of conception of nano-science/tech.

<table>
<thead>
<tr>
<th>Type of conception</th>
<th>Fundamental</th>
<th>Science</th>
<th>Technology</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Course frequency</td>
<td>67 (31.16%)</td>
<td>50 (23.26%)</td>
<td>49 (22.79%)</td>
<td>49 (22.79%)</td>
</tr>
<tr>
<td>Description</td>
<td>Interpreted as the basics unrelated to property change</td>
<td>Interpreted as the basics related to property change</td>
<td>Interpreted as the operation related to property change</td>
<td>Interpreted as the operation unrelated to property change</td>
</tr>
<tr>
<td>Aspect of variation</td>
<td>Basics Related to property change</td>
<td>Operation</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**DISCUSSION**

The results showed that the numbers of nanotechnology professional courses are nearly triple than nanotechnology-related professional courses in undergraduate level. However, the amount of nanotechnology-related professional courses is more in graduate level. This may be reasonable since nanotechnology is an interdisciplinary profession in which the concept of nano can be utilized across varied engineering fields. It is better for students to have the prerequisite backgrounds and become specialized in their undergraduate majors to further integrate what have been learned with nano-related knowledge for extended applications in graduate level of studies. Besides, the results also indicate relatively few core courses are offered in the curriculum of nano-material engineering, and in fact, not every university investigated offers the core course. This evokes the doubt of what exactly nano-science/technology consists in the sense of epistemology.

Most competences expected to be learned in such curriculum are linked to conceptual knowledge and procedural knowledge. The result is consistent with the common phenomenon seen that university instructors put much more emphases on teaching advanced theories but ignore the importance of practical applications in engineering education. Similar to what former president of National Chi Nan University, professor Li once said, “now students in engineering fields even have no feeling with practice” (Chiu, 2008). Roco (2003a) predicted that job market and related careers in nanotechnology will
reach approximately 5 million by 2015 globally, which means the demand of practical and skilled workforce are getting urgent. Although the gap between what have been taught at schools and what is in need in industry can be understood by the shortage of resources and expensive experimental equipments allocated for each university, it is suggested that governments should put more concerns, efforts and budgets in preparing future nanotechnology workforce.

To solve the limitation of budgets or resources required, one of the e-learning technologies - virtual reality (VR) - is another appealing alternative for application to engineering education. VR is an artificial communication environment which is able to convey meaning, transfer knowledge, and generate experience (Pares & Pares, 2006). VR can immerse people in an environment that would normally be unavailable due to cost, safety, or perception restrictions. VR has been applied as an instructional support mechanism in varied fields, such as biology (Lu et al., 2006) and surgery (Klapan et al, 2007), and VR-based job training, which is proved beneficial to training beginner or intermediate level workers by enabling them to virtually experience the workflow beforehand (Watanuki, 2008). Based on the advantages confirmed, VR may be suitable for providing nanotechnology students with realistic-like experiences and helping them possess operation skills.

Although principle or professional knowledge and skills are important for students to learn, the person with proper personal attributes is considered more crucial in future workplace. The personal characteristics, such as innovation, activeness and aggressiveness, flexibility, and understanding of market trends are pivotal nanotechnology workforce competences (Liu, Chen, Yueh, & Sheen, 2010). Instructors are encouraged to apply varied instructional strategies to offering students the opportunities to exercise these unique capabilities. Project-based learning (PBL) is suggested as an appropriate instructional approach which allows students to acquire new knowledge and skills through designing, planning and producing a product on their own (Simkins, 1999). Students in PBL need to form a learning group to solve complex real-world problems and learn how to communicate and work collaboratively with team members. No doubt integrating a PBL strategy into interdisciplinary learning is helpful to increasing personal creativity, team performances, presentation skills, learning involvement, communication skills, and project practicality for nanotechnology students.

Based on the findings of this study, although concepts, such as surface area, surface force, surface energy, small scale, and nano scale, etc. elicited remain vague to some extents, what is clear is the phenomenological essence underlying the conception of nano-science/technology seems related to property change. Built upon such reasoning mechanism, the threshold concept of “nano-scale” or “small-scale” is particularly suggested as pivotal to a better understanding and critical to students’ successful learning of nano-science/technology as to the field of material engineering.

A nanometer is one-billionth of a meter. By definition, dimensions between approximately 1 and 100 nanometers are known as the “nano-scale”. Physical, chemical, and biological properties become unusual and appear on materials at the nano-scale. These properties may differ in important ways from the properties of bulk materials to single atoms or molecules (NNI, 2001). Even the concept of nano-scale was first brought up in 1959 by Feynman, its promotion and research investment by National Science Foundation in US actually started in 1997 (Roco, 2004). Also most of its research is application-oriented; thus, the conception of nano-scale may be troublesome for students to learn since it remains somehow alien.

Nanotechnology changes the world and the way we live, creating new scientific applications that are smaller, faster, safer and more reliable. For its unique small-scale feature, the conception of nano-scale is transformative and irreversible since it involves an ontological as well as a conceptual shift. When it is truly comprehended, the concept of nano-scale can be viewed as the integrative and bounded force for connecting interdisciplinary knowledge and skills which are unapparent previously in medicine, energy, material, communication, and mechanical components, etc.. The integration is not only limited in engineering-related professions, but also in biology, basic science, computer science, public health, life science, medicine, and so on. The comprehensive integration of varied fields makes the nanotechnology research boundaries sharper.

In practice, when integrating any threshold concept in curriculum development, it requires use of different application strategies since what is a threshold concept for one person, may not be for another (Rountree & Rountree, 2009). Due to the level of resolution or transformative characteristics of threshold concepts (Boudedd et al, 2007; Davies & Mangan, 2007), for a better fit in multiple courses, it is necessary to revisit the same threshold concepts incorporated in the instruction from time to time because the concept itself may subsequently be transformed through the acquisition of further threshold concepts.

**CONCLUSION**

The application of curriculum map in the present study is considered beneficial and successful. An interview probing based on what is presented in the curriculum map also turns out appropriate, but the most critical of all is that iterative nature of continuous dialogues and reflexivity allows us to further unveil the academic conceptions simultaneously eliciting the threshold concepts based on experienced experts’ points of view. However, it is necessary to also be alert, as advised by...
Dunne et al. (2003) that an essential element of threshold concepts is defined mainly by the subjective experience in acquiring it instead of an objective analytical process. In this sense, the findings of the present case study of material engineering field still need to be confirmed. Further research involving varied student groups for investigation is recommended.

ACKNOWLEDGEMENT

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A Study of Enhancing Students’ Employability in Vocational Higher Education

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Abstract

The precipitous collapse of investment giant Lehman Brothers heralded a chain reaction in the financial world that led to a broad and significant economic downturn. Educators in vocational higher education focused on educational objectives, such as equipping student employability, soft skills and facing the challenge employment environment. In this study, the researchers set out to develop indicators of employability competency based on experts from industry, government, and academic institutions by using documentary analysis, focus group meetings, and Fuzzy Delphi Method. The results of documentary analysis showed 3 domains with 29 indictors, when taken through focus group meetings and Fuzzy Delphi Method, left 3 domains with 17 indictors. Based on the research results, practical suggestions could be provided to government, related business industries, and technical colleges/ universities.

Keywords: Employability Competencies, Soft Skills, Vocational Higher Education,

INTRODUCTION

Due to the worldwide financial crisis, unemployment rates in many countries hit record-highs. Job opportunity stimulus is considered to be one of the major responsibilities of government in every nation or evolving economy. Nonetheless, strengthening job seekers’ employability might be the fundamental building block of a competitive career path, as well as the means to halting the increasing unemployment rate.

The demographic structure of the global labor market has been changing based upon technology development. For many countries in Asia for example, due to the rapid change of industry structure, capital intensive industry has become the leading economic sector. Due in part to the impact of actions taken by international nonprofit organizations such as the WTO, the workforce demand in industry has declined, which has resulted in a continual high unemployment rate in the labor market (Liu & Miao, 1997). Apart from the forecast of labor demand and the stimulus of job opportunities that government must strive for, the understanding of what core competencies the industry needs, especially as reflected in the teaching goals and directions in technical colleges and universities, has become more important than ever. To help students meet the criteria necessary in the employment market, schools should seriously consider providing students with related educational plans before they enter the labor market. Dyrenfurth contended (2000) that regardless of objectives for general education, the educators should be clear about which outcomes in the students’ programs of study prospective employers expect the new hires will bring into their companies. Consequently, educators should be purposeful in establishing a set of standards that certainly strengthen competitive potential.

Vocational education at the college level is most often considered to be industry led, and this has been reinforced through industry cooperation as an educational trend to balance the needs of most industries. The professionals-to-be from the vocational system are cultivated to meet industry requirements and unprecedented attention has recently been given to both academic and industry sectors regarding this issue. Many countries have been reinforcing the potential workforce’s employability both by government policy and through the educational system. The Australian government established the National Training System in 1990 as a long term strategy to improve the Australian workforce. Through the Industry Training Advisory Boards (ITABs), industry led programs have been carried out to meet the needs and knowledge demanded by employers and unions in most industry sectors. These include the vocational educational training (VET) development of training and competency assessment packages used to achieve industry qualifications (Malloch, Martino, Waterhouse, & Townsend, 2003).

With respect to that, many countries have worked on employability surveys for graduates as a reference before entering the employment market or planning a career path. In Australia, the government wrote a white paper entailing “Employability Skills for the Future” that emphasizes eight major competencies: communicating, teamwork, problem solving, originating and learning, planning and organizing, self-management, initiative and enterprise, and technology. In Taiwan, employability has become a major concern of older adolescents and young adults. The National Youth Commission, Executive Yuan, R. O. C., conducted a survey in 2006 among business workers, college graduates, and governmental and private employment consultants. The outcome of the survey became a reference for related educational policy.
The investigation concludes that the practical core competencies required by the typical workplace include eight major elements: work attitude, stability and pressure persistence, expressing and communicating, professional knowledge and technique, flexibility and willingness to learn, teamwork ability, basic computer skills, and problem analyzing and solving. Apart from the professional skills that refer to an individual’s ability to perform specific tasks in the workplace, both investigations emphasize personal competencies, by attribute and quality, which normally refer to an individual’s capability to perform in concert with others at work. They also seem to represent an increase in the emphasis on soft skills over the past 10 years.

The soft skills of an employee have been increasingly emphasized as an important quality needed to reach task goals in the workplace. Pulko (2003) observed that a poor absorption rate of soft skills by students leads to an inability to benefit from these skills both personally and professionally. The researcher emphasized that soft skills in the study program should be infused into professional learning. The result of the research led to experimental research utilizing an international consulting and training company with soft skills expertise to better integrate soft skills training into school curriculum.

Soft skill training is a key element in being employable. Soft skills and other competencies, and the extent to which they are needed, must be determined. By using documentary analysis in this study, what core workplace competencies should employers possess to satisfy employers and to perform their jobs successfully? What core competencies will give prospective employees a competitive advantage in securing employment?

The purposes of this study are as follows:

1. To explore characteristics of employability competencies
2. With the findings of this study, to incorporate core employability competencies training into courses at technical colleges and universities

With the above purposes, the key questions drawn to carry out the research results are:

1. What are the employability competencies that public parties, including industry, academics, and government, perceive to be most important?
2. What employability competencies should be incorporated into courses at technical colleges and universities?

Educators in technical colleges and universities can adapt the research outcomes of this study as guidelines for future curriculum design and implementation strategy. Furthermore, the competencies found to be important herein should become the criteria graduates or job applicants aspire to and utilize as they seek to enter the employment market.

LITERATURE REVIEW

Employability

Harvey, Locke and Morey (2002:16) stated that employability of a graduate relates to the propensity of the graduate to exhibit attributes that employers anticipate will be necessary for the continued effective functioning of their organization. Harvey (2003) also noted that employability is not just about getting a job. Indeed, a student is on a vocational course does not mean that somehow employability is automatic. The definition adopted by the UK’s Enhancing Student Employability Co-ordination Team (ESECT, 2005) and widely adopted in the UK is: a set of achievements, skills, understandings and personal attributes that make graduates more likely to gain employment and be successful in their chosen occupations, which benefits themselves, the workforce, the community and the economy. Hillage and Pollard (1998) defined employability as the ability to gain and retain fulfilling work. Most employability variants focus on the propensity of graduates to secure a job and progress in their careers. For example, University of Newcastle (Allison, Harvey, & Nixon, 2002) defined employability as the capacity to move self-sufficiently into and within the labor market, and to fulfil potential through sustainable employment. Employability, as defined by scholars, can be clearly categorized into two sets of competencies for individuals. One is the set of employability skills that individuals must have to achieve job tasks in the specific fields within certain industries. The other is the core employability competencies, which emphasizes an individual’s ability to fit into the job in general.

Viewpoints from different nations

Countries such as the United States of America, the United Kingdom, Canada, the European Union and Australia have noted the importance of employability competencies because it impacts not only personal career opportunities but also the progress of national economies. The key employability values and governmental policies of representative countries are described in the following paragraphs.

In Taiwan, the National Youth Commission (Executive Yuan, R. O. C., 2006) explored employability competencies by conducting a survey regarding preparation for entering the employment market and planning a career path. In China, the economy has experienced rapid growth and significant reforms have commenced in its educational systems. Curriculum at vocational schools has been altered to form a better linkage with industry needs. Velde (2009) contended that employers’ perceive positive attitudes and behaviours, such as working cooperatively with others, being
Employability in a practical business world

To perform specific tasks in different industries, employees should possess certain skills and competencies. The present researchers’ concern is that there are certain performance related knowledge bases and skill sets that crosscut industries, such as accounting, marketing, finance, human resources, public relations, international coordination, etc., that students are not necessarily prepared for. Though professions in different industries usually require unique skills to achieve their tasks, they still share similar employability competencies needed to function. Consequently, to a single-minded focus on unique industry-specific skills, employability competencies are too often avoided in the practical business world. In this study, the researchers were interested in what core competencies are perceived by employers, government and academy as the most important in workplaces.

To discover the domains and indicators of business practice employability, apart from the related literatures collected, a model from the website of CareerOneStop (pathways to career success), developed by the U. S. Department of Labor (2009), was referred to as an important guideline. In this study, the core competencies of business related industries, such as information technology, financial services, hospitality/hotel and lodging services, and retail industry, listed in the model were chosen and developed as 3 domains with 29 indicators (Table 1) for the fundamental basis of focus group meeting and Fuzzy Delphi Method analysis. The research result was expected to help establish training standards for industry employment demands and to enhance the overall value of education.

METHODOLOGY

Research Framework

By using documentary analysis of the literature regarding policies of vocational education worldwide, and followed by focus group meeting, the domains and indicators of employability competencies were collected and organized. A Fuzzy Delphi expert questionnaire was distributed to 15 field experts and used to sort out key indicators. The resulting domains and indicators could be referred as the development of curriculum and teaching on practical business employability competencies in the government, industry and educational sectors in the future. The research framework is shown in Figure 1.
A Study of Enhancing Students’ Employability in Vocational Higher Education

To sort out the domains and indicators of business employability competencies

The research result of business employability competencies

Focus Group Meeting

Documentary Analysis

1. To define business employability competencies
2. To collect and organize the indicators of national and international business employability competencies

To build up the domains and indicators of business employability competencies

Focus Group Meeting Research Instruments

Questionnaire Design

Through the literature review, the practical business employability competency indicators were collected and organized for the discussion of focus group meeting. Experts from industry, government and academics were invited to determine the domains and indicators that would be most expected and required by industries across Taiwan. Hence, a questionnaire survey appropriate to the Fuzzy Delphi Method was developed based on the important indicators as determined by the experts.

The research sampling of Fuzzy Delphi Method

Purposive sampling was used to select the 15 experts from industry, government and academics in accordance with the research objectives. The industry experts were mainly from the financial, service and IT sectors; government representatives were from major business related and employment related departments such as the National Youth Commission and the Council of Labor Affairs, which set up governmental direction and strategy; experts from academics were mainly professors in business and management.

Analytic Methods

Documentary analysis of the literature review with regard to policies of vocational education preceded the focus group meeting, wherein the domains and indicators of employability competency were developed. Then, a Fuzzy Delphi expert questionnaire was used to sort out the key indicators among the expert suggestions from the focus group meeting.

Focus Group Meeting

The focus group meeting was comprised of 8 experts from the government, industry and academic sectors. These included 3 experts from finance, service, and IT industry; 2 experts from the National Youth Commission, and Bureau of Employment and Vocational Training; and 2 experts with business and IT management expertise. Two major discussions in the focus meeting were addressed as follows:

1. What are the important core employability indicators in the workplace from the viewpoint of industry, government and academics?

2. The 3 domains and 29 indicators based on the documentary analysis were reviewed and revised by the focus group experts.

Seven questions and opinions from experts in the focus group meeting are described below: (Refer to Table 2. The 7 questions and opinions from experts in focus group meeting)

The development of employability competencies

Based on the related employability competencies literature, experts from the focus group established the final 3 domains and 17 indicators, with definitions of each domain and indicator as described below: (Refer to Table 3. The definitions of each domain and indicator are described)

The key indicators of employability

The Fuzzy Delphi Method is an extension and
combination of the traditional Delphi Technique and Fuzzy method, and is thus considered to be an expert decision method (Zadeh, 1965). It can be used by decision making groups for effective decision evaluation by using a geometrical average value to prevent statistical bias and the outlier effect for a best outcome (Chen, 1994). The analytical steps of Fuzzy Delphi Method as used in this study are described as follows:

a. The collection of focus group opinion: “Questionnaire of Goodness of Fit Test” was firstly developed from the consensus of the focus group meeting. Later, 15 selected experts rated the importance of “the indicators of practical business employability” and by that means each indicator acquired its value ranking.

b. The triangular fuzzy number (TFN) of each indicator was established. TFN can be calculated in different ways; a commonly used method is the 5-point Likert Scale, which was used, and the result translated into TFN; for instance 5, which means very important, was converted to TFN (0.75, 1, 1), 4, as important, was converted to (0.5, 0.75, 1), 3 to (0.25, 0.50, 0.75), 2 to (0, 0.25, 0.50) and 1 to (0, 0, 0.25).

RESEARCH RESULTS & DISCUSSION

The First Phase: The empirical results of the focus group meeting

By evaluating criteria of practical core employability in the literature review, 3 domains and 29 key indicators were derived. A focus group meeting was held consisting of 8 experts from industry, government and academia. The experts proposed important employability indicators from the point of their fields of expertise and reached a consensus on the 3 domains and 17 key indicators for core employability criteria. Three domains are Personal Effectiveness Competency, Learning Competency and Workplace Development Competency. Definitions of the 3 domains and 17 indicators are described in Table 3.

The resulting 3 domains and 17 indicators of this study are consistent with “the Employability Skills for the Future” published by the Australian National Training Authority, Commonwealth of Australia (2002). The results are also consistent with the investigation outcomes of the study by the National Youth Commission, Executive Yuan, R. O. C. in 2006. This present research is intended to utilize them as evaluation criteria, and establish them as the data for the second research phase—the Goodness of Fit Test questionnaire utilizing the Fuzzy Delphi Method.

The Second Phase: the empirical result of Fuzzy Delphi Method

Fifteen experts from industry, government and academia completed the questionnaire for the Goodness of Fit Test. Selected indicators passed the threshold value (α=0.7), which shows consensus reached by the experts. The calculation process of defuzzification uses the concept of geometric average. Experts valued each indicator using a 5-point Likert scale. Therefore, the results show the relative importance of each indicator. Based on the degree of importance, each domain and indicator can be placed in an order consistent with overall expert opinion. (Refer to Table 4: The result of Fuzzy Delphi Method).

The empirical result of this phase showed a relationship with the outcome of the focus group meeting; for example, work responsibility, problem solving skills, communication and conflict management are all points on which the experts placed great emphasis. The result also indicated consistency with the literature as stated earlier. Hence, the core employability competencies referring to current local employment status is consistent with a consensus base of previous literature and expert opinion.

1. The domain of personal effectiveness competency: From the results shown in Table 4, “Work Ethics” and “Responsibility” are valued most by the experts. The result is in accordance with the selection criteria drawn from the in-depth focus group interview. The new-hired criteria depend on personal integrity first, and responsibility for tasks second. The third-ranked indicator is “The Competency of Communication and Conflict Management”. It explains that communication and listening skills should be taken into account for conflict resolution in the workplace. This also proves to be consistent with the literature done by Wen (1999), and Liu, Chiu and Hu (2006) that shows communication and negotiation skills are key and important indicators in the workplace. The rest of the indicators, such as “Emotional Adaptability and Pressure Management” and “Proactive Attitudes”, are also indicators valued by industry, and that employees should possess them to achieve goals with high-pressure resistance.

2. The domain of learning competency: In this information generation, information overload complicates reality. People should have the ability to solve problems by exploring, distinguishing and analyzing information. Therefore “The Competency of Reading Comprehension” and “The Competency of Critical and Analytical Thinking” are placed first and second, respectively, in this domain. Furthermore, in the ever-changing work environment, employees are expected to take any opportunities for professional improvement. “Lifelong Learning” is therefore considered the third-most important indicator of learning competency. With all the new technologies and instruments in the typical workplace, the ability to adapt to new technology was strongly emphasized by the experts of the
CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Based on the research results and the discussion made in accordance with the research purposes, the conclusions of this study are stated as follows:

1. The focus group and Fuzzy Delphi Method were applied to discuss employability competency domains and indicators. These two research methods reduce time cost in coming to a consensus and help solidify the decision base being formed. The analysis of the results should be logical and more persuasive.

2. The findings of the empirical analysis show that experts from industry, government and academia agree on three domains of practical business employability competency: personal effectiveness competency, learning competency and workplace development competency domains.

3. In the domain of the personal effectiveness competency, “Vocational Ethics”, “Responsibility” and “Communication and Conflict Management” are placed in the top three positions as the most important indicators. This result shows companies emphasize employees should possess professional skills and soft skills which can be adapted in potential unexpected circumstances with stable emotions and professional behavior. It indicates that many employees have problems controlling their emotions and dealing with pressure at work. In an age of organizational design based on field specialization, organizational performance improves mainly through employees’ proactive attitudes, communication and conflict management.

4. In the domain of learning competency, “Reading Comprehension”, “Critical and Analytical Thinking” and “Lifelong Learning” are the most emphasized. This result shows that employability indicators have changed along with the transition to an information economy and diversified information operations. In the business world, the ability to handle complicated information with critical and analytical thinking can assist individuals in completing difficult job assignments; even “how to learn” becomes an indicator in job selection.

5. In the domain of workplace development, the competencies of “Problem Solving”, “Teamwork” and “Customer Oriented” are in the top three positions. This result indicates that the professional skills learned from school are no longer enough to satisfy companies, and that schools need to be more sensitive to business environment concerns such as creating opportunity and lowering risk. In the current complicated and competitive market environment, companies reply upon problem solving ability of employees to cope with business environment uncertainty. Team spirit and organizational cooperation become important indicators in strategic planning and best operation modeling at companies.

6. Overall, with respect to the research results in this study, “Problem Solving Skills”, “Work Ethics”, “Responsibility”, “Teamwork”, “Customer Focus”, “Communication and Conflict Management” and “Reading Comprehension” are the top 7 key indicators among the 17 key indicators of business employability approved by focus group experts.
Recommendations

Based on the findings and conclusions of this study, the following recommendations are drawn for further implementation and study:

Three domains and 17 indicators for practical business employability competencies are selected through documentary analysis, focus group method and Fuzzy Delphi Method. These indicators can be provided as suggestions for curriculum design of business and management courses in higher vocational education. Apart from the basic core courses, these indicators from experts can be incorporated into course content aimed at preparation for employment. The results of the study can further be used as preparation points for job applicants. According to the results, job applicants should try to obtain personal employability competencies that help them stand out from other applicants. The results can also be used as criteria for new-hire selection or a company training system for industry managers; for training and educational authorities, it can be an important reference and guide to reduce the unemployment rate of college graduates.

For further research, the results of implementing the 17 key business employability indicators into course materials can be analyzed and used to further refine teaching strategy design and development to improve the efficacy of including employability teaching into course content.

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Table 2: The 7 questions and opinions from experts in focus group meeting.

<table>
<thead>
<tr>
<th>Question</th>
<th>What is the unemployment rate amidst this period of financial crisis? How does the unemployment rate affect the employment market?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expert opinions summarized</td>
<td>The employment market has been hit tremendously. The labor demand ratio was usually greater than 1, and it is now changed to 0.6. The employment environment has experienced a dramatic change in supply and demand due to the financial crisis.</td>
</tr>
<tr>
<td>Question 2</td>
<td>What are the important employability indicators for business practice to you?</td>
</tr>
<tr>
<td>Question 3</td>
<td>Does our government provide subvention to schools for programs to upgrade the level of student employability in business practice?</td>
</tr>
<tr>
<td>Expert opinions summarized</td>
<td>1. The 3 common core courses provided by the Bureau of Employment and Vocational Training, which tends to inspire employee teamwork spirit. 2. With academic and industry cooperation, 2,000 companies offered internship opportunities for full-time college students before graduation. 3. Curriculum redesign implementation for college students, evaluation systems, and course selection consultation, should all be taken into account.</td>
</tr>
<tr>
<td>Question 4</td>
<td>What would be the major employability indicators of business practice in your company?</td>
</tr>
<tr>
<td>Expert opinions summarized</td>
<td>1. Finance: committed to work, continuous learning, high-pressure resistance. 2. Insurance: high-pressure resistance, linguistic ability, teamwork, problem solving skills. 3. Information Technology: Goal-orientated, time management, communication and negotiation skill, teamwork and responsibility.</td>
</tr>
<tr>
<td>Question 5</td>
<td>What would be a required quality of an interviewee that you value or weight most?</td>
</tr>
<tr>
<td>Expert opinions summarized</td>
<td>1. Finance: the characteristics of integrity, responsibility and ambition- attitude makes altitude. 2. Insurance: high-pressure resistance, linguistic ability, teamwork, problem-solving skills. 3. Information Technology: possess responsibility, problem solving ability and continuous learning ability, enthusiasm and teamwork spirit for work and customers.</td>
</tr>
<tr>
<td>Question 6</td>
<td>What would be the teaching strategy you would use to improve the employability of students in your courses?</td>
</tr>
<tr>
<td>Expert opinions summarized</td>
<td>Use case studies, as the Harvard Business School has implemented, for students as a practical business teaching method.</td>
</tr>
<tr>
<td>Question 7</td>
<td>To strengthen students’ employability through business practice, does your school have that incorporate employability into courses?</td>
</tr>
<tr>
<td>Expert opinions summarized</td>
<td>The cooperation between industry and academics offers students and teachers a source of practical learning through teaching projects for professional certificates and technical checks.</td>
</tr>
</tbody>
</table>
Table 3: The definitions of each domain and indicator are described

<table>
<thead>
<tr>
<th>Domain I</th>
<th>Personal Effectiveness Competency - the basic competency everyone should obtain; it’s different from professional ability and hard skills, but it is considered by employers to be basic workplace competencies or soft skills, which is a key factor to success in the workplace.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Communication and Conflict Management – Shows sincere interest in others and their concerns, and demonstrates sensitivity to the needs and feelings of others.</td>
</tr>
<tr>
<td>2.</td>
<td>Work Ethics – Obtains the integrity of discipline, and displays the sound social values and behaviors, and strictly abstains from behaviors that harm individual and company image.</td>
</tr>
<tr>
<td>3.</td>
<td>Emotional Adaptability and Stress Management – Perceives appropriate action and controls oneself in response to ambiguity and stress at work, and adapts to changing situations with a positive attitude.</td>
</tr>
<tr>
<td>4.</td>
<td>Proactive Attitude – Exhibits a high enthusiasm for work; performs aggressively and seeks opportunity to achieve planned goals.</td>
</tr>
<tr>
<td>5.</td>
<td>Responsibility – Responsible for achieving job goals; understands the relationship between the individual and the company.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Domain II</th>
<th>Learning Competency - key competency for individual’s success, cognitive and thinking style for every organization and industry</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.</td>
<td>Reading Comprehension – Understands and interprets documents, noticing the details and points in documents and organizing them into systematic, usable information.</td>
</tr>
<tr>
<td>7.</td>
<td>Business Writing – Takes an appropriate tone in writing business documents, while also correcting spelling by using appropriate sentence structure.</td>
</tr>
<tr>
<td>8.</td>
<td>Critical and Analytic Thinking – Possesses sufficient inductive and deductive reasoning abilities to critically review, analyze and interpret information.</td>
</tr>
<tr>
<td>9.</td>
<td>Basic Computer Skills – Understands and efficiently uses basic computer and to perform tasks; understands common computer terminology.</td>
</tr>
<tr>
<td>10.</td>
<td>Lifelong Learning – Takes advanced educational opportunities, or willingly participates in community for the improvement of self-ability and professional development.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Domain III</th>
<th>Workplace development competency - possesses skills which are needed at workplace, and the ability to apply those to perform tasks.</th>
</tr>
</thead>
<tbody>
<tr>
<td>11.</td>
<td>Business Fundamentals – Understands the environment in which businesses operates. Has knowledge of the industry at large and of information about new and/or competitors.</td>
</tr>
<tr>
<td>12.</td>
<td>Teamwork – Accepts membership and identifies with the goals of a team; respects and collaborates with others to formulate team objectives, culture and consensus for the best outcome.</td>
</tr>
<tr>
<td>13.</td>
<td>Interpersonal Network – Actively addresses concerns of others with an open mind; respects the differences between others and works with others to establish an interpersonal network.</td>
</tr>
<tr>
<td>14.</td>
<td>Customer Orientation – Understands customer needs, offer custom-made service, and maintains a fine relationship with customers.</td>
</tr>
<tr>
<td>15.</td>
<td>Problem Solving – Anticipates or recognizes the existence of a problem and identifies the nature of the problem.</td>
</tr>
<tr>
<td>16.</td>
<td>Innovative Thinking – Entertains wide-ranging possibilities to develop unique approaches and innovative ideas in complex areas.</td>
</tr>
<tr>
<td>17.</td>
<td>Crisis Management – Prevents or provides effective solutions to potential and existing crises, and resolves the crises.</td>
</tr>
</tbody>
</table>
Table 4: The result of Fuzzy Delphi Method

<table>
<thead>
<tr>
<th>Domain</th>
<th>Key indicator</th>
<th>Defuzzification number</th>
<th>Order Overall</th>
<th>Order domain</th>
<th>α=0.7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personal Effectiveness Competency</td>
<td>Communication and Conflict Management</td>
<td>0.7763</td>
<td>6</td>
<td>3</td>
<td>◐</td>
</tr>
<tr>
<td></td>
<td>Work Ethics</td>
<td>0.7894</td>
<td>2</td>
<td>1</td>
<td>◐</td>
</tr>
<tr>
<td>Practical Business Employability Competency</td>
<td>Emotional Adaptability and Stress Management</td>
<td>0.7408</td>
<td>10</td>
<td>5</td>
<td>◐</td>
</tr>
<tr>
<td></td>
<td>Proactive Attitude</td>
<td>0.7639</td>
<td>8</td>
<td>4</td>
<td>◐</td>
</tr>
<tr>
<td></td>
<td>Responsibility</td>
<td>0.7894</td>
<td>2</td>
<td>1</td>
<td>◐</td>
</tr>
<tr>
<td>Learning Competency</td>
<td>Reading Comprehension</td>
<td>0.7763</td>
<td>6</td>
<td>1</td>
<td>◐</td>
</tr>
<tr>
<td></td>
<td>Business Writing</td>
<td>0.7096</td>
<td>17</td>
<td>5</td>
<td>◐</td>
</tr>
<tr>
<td></td>
<td>Critical and Analytical Thinking</td>
<td>0.7639</td>
<td>8</td>
<td>2</td>
<td>◐</td>
</tr>
<tr>
<td></td>
<td>Basic Computer Skills</td>
<td>0.7299</td>
<td>12</td>
<td>4</td>
<td>◐</td>
</tr>
<tr>
<td></td>
<td>Lifelong Learning</td>
<td>0.7408</td>
<td>10</td>
<td>3</td>
<td>◐</td>
</tr>
<tr>
<td>Workplace Development Competency</td>
<td>Business Fundamentals</td>
<td>0.7299</td>
<td>12</td>
<td>4</td>
<td>◐</td>
</tr>
<tr>
<td></td>
<td>Teamwork</td>
<td>0.7894</td>
<td>2</td>
<td>2</td>
<td>◐</td>
</tr>
<tr>
<td></td>
<td>Interpersonal Network</td>
<td>0.7196</td>
<td>16</td>
<td>7</td>
<td>◐</td>
</tr>
<tr>
<td></td>
<td>Customer Oriented</td>
<td>0.7894</td>
<td>2</td>
<td>2</td>
<td>◐</td>
</tr>
<tr>
<td></td>
<td>Problem Solving</td>
<td>0.8032</td>
<td>1</td>
<td>1</td>
<td>◐</td>
</tr>
<tr>
<td></td>
<td>Innovative Thinking</td>
<td>0.7299</td>
<td>12</td>
<td>4</td>
<td>◐</td>
</tr>
<tr>
<td></td>
<td>Crisis Management</td>
<td>0.7299</td>
<td>12</td>
<td>4</td>
<td>◐</td>
</tr>
</tbody>
</table>

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A Canonical Correlation Analysis among Students’ Personality Traits, Class Students’ Behaviors and Academic Achievement

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Abstract

This study aims to understand the relation among junior high school students’ personality traits, class students’ behaviors, and the academic achievement on computer courses in Changhua County. In order to effectively achieve the research purpose, 716 questionnaires were distributed to second grade students of public and private junior high schools in Changhua County and total 594 copies were retrieved. Apart from 6 invalid questionnaires, 588 samples were received with the retrieval rate of 83%. Canonical correlation analysis is applied to the data set and the results show that (1) better performance in class students’ behaviors when the personality traits of junior high school students in Changhua County were inclined to “extraversion”, “agreeableness”, “openness”, and “conscientiousness” in addition to “neuroticism”, (2) significant correlation between personality traits and academic achievement of junior high school students in Changhua County, and (3) significant correlation between class students’ behaviors and academic achievement of junior high school students in Changhua County.

Keywords: Personality traits, Class students’ behaviors, Academic Achievement

INTRODUCTION

In the process of educational development in Taiwan, junior high school is the important stage of settling knowledge and abilities as well as the critical time of grounding information and computer education. For this reason, cultivating students with the ability of information application has become the planning direction to which school education constructively endeavors. Ministry of Education therefore takes information education as the emphasis in order to cultivate students’ abilities of information capture, application and analysis as well as have them possess correct learning attitudes to information (Ministry of Education, 2009). The above goals can be implemented with the promotion of computer courses; and further achieve the practicable effects with students’ academic achievement on information and computer education.

Ministry of Education emphasizes that teachers should adjust academic contents deliberating upon students’ learning abilities as well as should provide appropriate instructions aiming at students’ special aptitudes and individual difference on learning abilities (Ministry, 2009). Nevertheless, external factors like learning environment and teachers’ instruction models and internal factors as personality traits and learning motivations, which affect individual learning performance, are different (Phares & Chaplin, 1997; Zimmerman, 1995). Within the factors, personality traits of the internal factors receive the most attention. Personality traits mean a unique thinking and behavior reaction model which a person keeps and don’t change with any different learning environments. The personality traits are distinct from others’ thinking and behaviors and have diverse dynamic characteristic reactions with the change of the environment. The personality traits of responsibility and initiative could effectively enhance academic achievement (Chamorro-Premuzic & Furnham, 2003). Some research also indicated that there were correlations between learning methods and personalities that openness presented the most significantly (Tomas & Adrian, 2009). Junior high school is considered the more complex and rapid period for physical and psychological development of the youth. Students with agreeableness could effectively reflect on the learning performance, when learning in pleasant environment (Miranda, Margaretha, Hans & Jolijn, 2010). Accordingly, junior high school students’ personality traits are correlated with the academic achievement.

A class is consisted of a teacher and a group of students with diverse backgrounds and similar ages. With class rules, social orders, organizational structures, and authoritative hierarchies, a class is a small but complex organization and a miniature social system where the members have shared values (consensus) and stably complicated interactive relationship (Wu, 2006). The enhancement of students’ academic achievement appears correlations with the participation in classes and the cooperation among teams (Jerome & Henk, 2009). The behaviors of not asking for reward, voluntary, and beneficial for the class are in accordance with the
organizational citizenship behavior (OCB) proposed by Organ (1998) that individuals are willing to spontaneously perform over the standard of the role without any external force, do not ask for rewards from the organization, and help others to enhance the performance of the organization. The concept of class students’ behaviors are therefore generated in this study. Furthermore, the performance with the identification and acceptance of peers in the class will affect the academic achievement (Berndt, 1982; Buhrmester, 1990). For this reason, the behaviors of a student in a class will intangibly affect the academic achievement.

Academic achievement is considered one of the criteria checking on students’ learning objectives, where the personality traits present great influence on the performance. Meanwhile, they could adapt to the learning environment and further enhance the academic achievement. Moreover, students experience most of their time in classes, which is similar to an organizational group, that students could be affected by several internal and external factors and further result in effect on the psychological dimension. As a result, the behaviors which students perform in classes often are the factors in learning performance.

Based on the above factors, this study aims to discuss the relation among junior high school students’ personality traits, class students’ behaviors, and academic achievement on computer courses in Changhua County.

**LITERATURE REVIEW & HYPOTHESES**

**Personality Traits**

Allport considered that “personality” was the dynamic organization within individual psychological system which could determine individually unique “thoughts and behaviors” and “adaptation to external environment”; while “traits” were different from temporary, simple, and external environment-affected psychological status and activities (Pervin et al., 2005). Consequently, individual behaviors would reflect the unique characters that, when these characters continuously appear in different situations, they are regarded as personality traits (McCrae & Costa, 1992). It is a character different from others’ thoughts and behaviors that it would appear distinct reactions with the change of the environment and would present synthetic performance of different attitudes and external behaviors to respond to various environments (Allport, 1961). In this case, personality traits are a unique form with stable and sustainable internal and external characters of an individual and can reflect the behaviors of the individual on various situations.

Research on personality traits originated from the pioneers in Trait Theory (Norman, 1963). With statistical analyses, various types of personality traits were concluded. Most applied personality traits dimensions at present were proposed by McCrae and Costa in 1987, including openness, meaning open-minded, imaginary, curious, creative, favor to thinking, and changeable; conscientiousness, meaning responsible and obedient, good behavior, cautious with responsibility, and careful; extraversion, as good at sociable, favor to liveliness, and outgoing; agreeableness, as being polite, reliable, friendly, easy to get along, and lenient; and neuroticism, meaning anxious, impulsive, sensitive, angry, and self-aware (Allik & McCrae, 2002; McCrae, 2002; Konstabel, Realo & Kallasmaa, 2002; Rolland, 2002).

**Class Students’ Behaviors**

The class students’ behaviors indicated in this study are quoted from the concept of organizational citizenship behavior (OCB), proposed by Organ in 1988. The theoretical bases came from social exchange theory and individual positive affection (Bateman & Organ, 1983). With the successive research and development, more scholars proposed different points of view, such as psychological contract proposed by Robinson & Morrison (1995) and covenantal relationship proposed by Van Dyne, Graham & Dienesch et al in 1994. The relationship indicated that individuals presented the behaviors transcending the role standard; they did not ask for rewards from the organization, but were still willing to help others and enhance the organizational performance.

From the concept of “social system”, Parsons (1595) analyzed the characteristics of classes that 1. a class was a social system; 2. a class was a power system; and 3. a class was a psychological group. Students in a class presented common goals and collective regulations, interacted and depended on each others under the situation of class identity, and achieved the common goals organizationally and in order that it was considered a sturdy class group. Students appearing behaviors transcending the roles was derived from the identity to the class and the interactions among peers. A class, as the major organizational in schools, is consisted of teachers and students. Aiming at learning and growth among members in the organization, the interactions between the “instruction” of teachers and the “learning” of students could lead to effective learning.

To sum up, the concept of organizational citizenship behaviors and class students’ behaviors are matched. The class students’ behaviors are therefore defined as students present the behaviors transcending the roles and the behaviors are not formally regulated, such as school regulations and class regulations. Besides, without any rewards, students automatically appear behaviors contributive to the class or other classmates and beneficial to the operation of the class and the enhancement of the performance.
Academic Achievement

“Learning” is the change of individual disposition or capability that the change would continue for a period of time and cannot be simply considered as the process of growth (Gagné, 1985). Brown (1981) considered that “achievement” was the knowledge, comprehension, or skills obtained from specific educational experiences with formal curriculum and instructional design. In conclusion, “learning achievement” is the grade or recognition which learners require from academic achievement tests or evaluations after a period of learning.

Moreover, Peggy, Kenytta, Wendy & Monica (2008) considered the factors in academic achievement, including individual factors of students, peers, and family background. Fatih & Hafize (2009) also regarded learning environment as one of the factors in academic achievement. As a result, the direct behaviors of students devoting to learning and psychological traits are the primary factors in academic achievement. According to the above literatures, academic achievement is the index to evaluate the learning outcome of learners as well as one of the necessary tasks in the process of education, aiming to examine what students have learnt and to what extent they have learnt. Although the factors and evaluation methods for the evaluation of academic achievement are abundant, the key is to apply fair and objective tests to the presentation of the learning outcome. In this case, the academic achievement indicated in this study is the total grade of a subject at the end of a semester for research and discussions.

In more recent years, a growing number of research studies are now available to shed some light on the relationships among personality traits, organizational citizenship behavior (OCB), and academic achievement. For example, the purpose of the research was to investigate the relationship between OCB and the dimensions of personality among 213 expert staffs from Tehran University by Mahdiiun, Ghahramani and Sharif (2010), and the results of Pearson correlation indicated that OCB had positive relations with personality dimensions including: agreeableness, conscientiousness, openness, and extraversion; however, the relation between neuroticism and OCB seemed to be negative. In addition, Llies, Fulmer, Spitzmuller and Johnson (2009) using meta-analytic path analysis to test several structural models linking agreeableness and conscientiousness to organizational citizenship behavior, the results showed agreeableness had both direct and indirect effects on OCB. Furthermore, Li, Liang and Crant (2010) examined the quality of leader-member exchange as a mediator and the procedural justice climate as a contextual moderator for understanding the role of proactive personality in job satisfaction and organizational citizenship behavior by 200 Chinese employees within 54 work groups. The results showed the relationship between proactive personality and organizational citizenship behavior being positively moderated.

One of the earliest applications of personality assessments was the prediction of academic achievement. For example, Farsides and Woodfield (2003) showed a correlation of -.36 between absenteeism and final-year percentage. Lubbers, Weff, Kuyper and Hendriks (2010) investigated the relation between personality and academic performance by 9812 students, and the results indicated that personality was related to end-of-year grades in math and Dutch language. In brief, reviews of past research has consistently shown that there is a relation between personality and academic performance.

Most of the research on the relationship between organizational citizenship behavior (OCB) and performance has been conducted at the individual level. Khalid, Jusoff, Othman, Ismail, and Rahman (2010) employed social exchange theory to examine the relation between lecturers’ OCB and students’ academic achievement. Analysis was conducted on a survey data of 196 undergraduate students who enrolled in courses in the Faculty of Business Management in one of the local public institutions in Malaysia. The results revealed that OCB dimension of altruism and courtesy were significantly related to students’ academic achievement. In addition, conscientiousness positively predicted students’ academic achievement among students with high needs for achievement.

However, Nielsen, Hrvnak, and Shaw (2009) adopted meta-analyses to review 38 independent samples (N = 3,097) in which the relationship between OCB and performance was studied in group. The result showed a positive relationship between OCB and performance (ρ = .29), as well as the presence of several moderating variables.

Therefore, the following hypotheses were proposed.
H1: OCB is associated with personality traits.
H2: Personality traits are associated with academic achievement.
H3: OCB is associated with academic achievement.

PARTICIPANTS

Within fourteen public and private junior high schools in Changhua County, seven schools and three classes in each school were selected as the samples by proportional sampling according to regions. Total 716 questionnaires were distributed and 594 copies retrieved.

MEASUREMENTS

Questionnaires were used to study the variables in this research. In addition to the scores of computer courses in the academic years of 2007 and 2008 directly provided from the tested schools for academic achievements,
personality traits and class students’ behaviors were measured by Likert five-scale for “very conformable” to “very unconformable” and “always” to “never” with 5 to 1 respectively.

**Personality Traits Scale**

The personality traits scale, (Tomas and Adrian, 2008) was used to assess students’ personality traits. With reliability and availability analyses, the overall measure Cronbach α was 0.909 and the sub-measurements included “extraversion” 0.759 (6 items), “agreeableness” 0.781 (6 items), “openness” 0.789 (6 items), “conscientiousness” 0.826 (6 items), and “neuroticism” 0.615 (3 items).

**Class students’ Behaviors scale**

This scale was adopted by Chen, Lee, and Tsai (2010) for the attributes of class organizations. With reliability and availability analyses, the overall measure Cronbach α was 0.928 and the sub-measurements included “class identification” 0.755 (5 items), “interpersonal interaction” 0.817 (7 items), “earnestness and being dutiful” 0.787 (5 items), and “self-enrichment” 0.785 (5 items).

**DATA ANALYSIS AND FINDINGS**

This study aims at analyzing the questionnaire data and testing the hypotheses with statistical analyses. The major contents include the canonical correlation analyses on junior high school students, class students’ behaviors, and academic achievement.

**Canonical correlation analysis on junior high school students’ personality traits and class students’ behaviors in Changehua County**

From Table 1, four groups of canonical correlation coefficients between personality traits and class students’ behaviors are significant, including the first group $\rho^2=0.811$ (Wilk’s $\lambda=0.239$, $p<0.001$), the second group $\rho^2=0.422$ (Wilk’s $\lambda=0.701$, $p<0.001$), the third group $\rho^2=0.336$ (Wilk’s $\lambda=0.871$, $p<0.001$), and the fourth group $\rho^2=0.132$ (Wilk’s $\lambda=0.982$, $p>0.01$). It shows the five predicted variables of personality traits and the four variables of class students’ behaviors existing significant correlation.

The demonstration of canonical correlation in each group is sorted as Table 2 and shown as follows.

In the canonical correlation in the first group, $\chi^1$ can explain the overall measure of variation $\eta_1$ being 65.9%, $\eta_1$ can explain the overall measure of variation in Y variables being 74.231%, and X variables can explain the overall measure of variation in Y variables being 48.822% by canonical variation $\chi^1$ (overlap measure of variation). The canonical weighted coefficients between $\chi^1$ and “extraversion”, “agreeableness”, “openness”, “conscientiousness”, and “neuroticism” are -0.313, -0.041, -0.333, -0.483, and -0.019, respectively; while the canonical weighted coefficients between $\eta_1$ and “class identification”, “interpersonal interaction”, “earnestness and being dutiful”, and “self-enrichment” are -0.012, -0.306, -0.174, and -0.602, respectively. In this case, variation $\chi^1$ of personality traits and variation $\eta_1$ of class students’ behaviors have significant correlation.

In the canonical correlation in the second group, $\chi^2$ can explain the overall measure of variation $\eta_2$ being 19.5%, $\eta_2$ can explain the overall measure of variation in Y variables being 8.992%, and X variables can explain the overall measure of variation in Y variables being 1.743% by canonical variation $\chi^2$. The canonical weighted coefficients between $\chi^2$ and “extraversion”, “agreeableness”, “openness”, “conscientiousness”, and “neuroticism” are 0.627, 0.586, 0.021, -1.173, and -0.004, respectively; while the canonical weighted coefficients between $\eta_2$ and “class identification”, “interpersonal interaction”, “earnestness and being dutiful”, and “self-enrichment” are 0.577, 1.146, -1.046, and -0.562, respectively. In this case, variation $\chi^2$ of personality traits and variation $\eta_2$ of class students’ behaviors have significant correlation.

In the canonical correlation in the third group, $\chi^3$ can explain the overall measure of variation $\eta_3$ being 11.3%, $\eta_3$ can explain the overall measure of variation in Y variables being 9.224%, and X variables can explain the overall measure of variation in Y variables being 1.043% by canonical variation $\chi^3$. The canonical weighted coefficients between $\chi^3$ and “extraversion”, “agreeableness”, “openness”, “conscientiousness”, and “neuroticism” are 0.119, 1.056, -1.270, 0.197, and -0.036, respectively; while the canonical weighted coefficients between $\eta_3$ and “class identification”, “interpersonal interaction”, “earnestness and being dutiful”, and “self-enrichment” are 0.159, 0.184, 1.265, and -1.409, respectively. In this case, variation $\chi^3$ of personality traits and variation $\eta_3$ of class students’ behaviors have significant correlation.

In the canonical correlation in the fourth group, $\chi^4$ can explain the overall measure of variation $\eta_4$ being 1.7%, $\eta_4$ can explain the overall measure of variation in Y variables being 7.622%, and X variables can explain the overall measure of variation in Y variables being 0.133% by canonical variation $\chi^4$. The canonical weighted coefficients between $\chi^4$ and “extraversion”, “agreeableness”, “openness”, “conscientiousness”, and “neuroticism” are 0.986, -0.770, -0.516, 0.316, and -0.757, respectively; while the canonical weighted coefficients between $\eta_4$ and “class identification”, “interpersonal interaction”, “earnestness and being dutiful”, and “self-enrichment” are 1.510, -1.233, -0.602, and 0.101, respectively. In this case, variation $\chi^4$ of personality traits and variation $\eta_4$ of class students’ behaviors have significant correlation.
Table 1: Canonical correlation between personality traits and class students’ behaviors

<table>
<thead>
<tr>
<th>Model</th>
<th>Features</th>
<th>$\rho$</th>
<th>$\rho^2$</th>
<th>Wilks’ $\lambda$</th>
<th>F</th>
<th>p</th>
<th>Overlap index (x) %</th>
<th>Overlap index (y) %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.928</td>
<td>.811</td>
<td>.659</td>
<td>.239</td>
<td>51.751</td>
<td>.000***</td>
<td>37.121</td>
<td>48.882</td>
</tr>
<tr>
<td>2</td>
<td>.243</td>
<td>.422</td>
<td>.195</td>
<td>.701</td>
<td>18.358</td>
<td>.000***</td>
<td>2.154</td>
<td>1.743</td>
</tr>
<tr>
<td>3</td>
<td>.127</td>
<td>.336</td>
<td>.113</td>
<td>.871</td>
<td>13.788</td>
<td>.000***</td>
<td>.893</td>
<td>1.043</td>
</tr>
<tr>
<td>4</td>
<td>.018</td>
<td>.132</td>
<td>.017</td>
<td>.982</td>
<td>5.171</td>
<td>.006**</td>
<td>.230</td>
<td>.133</td>
</tr>
</tbody>
</table>

**p<.01 , ***p<.001

Table 2: Canonical correlation between personality traits and class students’ behaviors

<table>
<thead>
<tr>
<th>Canonical weight</th>
<th>Canonical weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>X variable</td>
<td>Y variable</td>
</tr>
<tr>
<td>$\chi_1$</td>
<td>$\chi_2$</td>
</tr>
<tr>
<td>extraversion (X1)</td>
<td>-.313</td>
</tr>
<tr>
<td>agreeableness (X2)</td>
<td>-.041</td>
</tr>
<tr>
<td>openness (X3)</td>
<td>-.333</td>
</tr>
<tr>
<td>conscientiousness (X4)</td>
<td>-.483</td>
</tr>
<tr>
<td>neuroticism (X5)</td>
<td>-.019</td>
</tr>
</tbody>
</table>

| Variation percentage | 56.371 | 11.027 | 7.901 | 13.183 |
| Overlap percentage | 37.121 | 2.154 | 0.893 | .230 |

| Canonical correlation ($\rho^2$) | .659 | .195 | .113 | .017 |

**p<.01 , ***p<.001

Examining the paths of canonical correction analyses in Fig. 1, the canonical variation ($\chi_4 \eta_4$) $\rho^2$ in the fourth group is 0.017, less than 0.1, showing the insufficient explanation. Therefore, the structures of the canonical variation ($\chi_1 \eta_1$) in the first group, ($\chi_2 \eta_2$) in the second group, and ($\chi_3 \eta_3$) in the third group are demonstrated as follows.

Referring to Fig. 1, in the canonical variation ($\chi_1 \eta_1$) in the first group, the factor loading carrying capacity of “neuroticism” in personality traits is -0.068, less than the explainable standard of 0.4; and all the canonical factor loading of the other four in personality traits and class students’ behaviors conforms to the standard with the error coefficient (1-$\rho^2$) 0.341. In this case, “extraversion”, “agreeableness”, “openness”, and “conscientiousness” in personality traits, by canonical variation ($\chi_1 \eta_1$), can affect the behaviors of “class identification”, “interpersonal interaction”, “earnestness and being dutiful”, and “self-enrichment” in class students’ behaviors, meaning that the more the junior high school students’ personality traits incline to “extraversion”, “agreeableness”, “openness”, and “conscientiousness”, the better performance of junior high school students in Changhua County on “class identification”, “interpersonal interaction”, “earnestness and being dutiful”, and “self-enrichment” in class students’ behaviors.

Referring to Fig. 1, in the canonical variation ($\chi_2 \eta_2$) in the second group, “extraversion” and “conscientiousness” in personality traits and “interpersonal interaction” in class students’ behaviors have the absolute values over 0.4 with the error coefficient (1-$\rho^2$) 0.805. Therefore, “extraversion” and “conscientiousness” in personality traits, by canonical variation ($\chi_2 \eta_2$), can affect the behavior of “interpersonal interaction” in class students’ behaviors, meaning that the more the junior high school students’ personality traits tend to “extraversion” and “conscientiousness”, the better performance of junior high school students in Changhua County on “interpersonal interaction” in class students’ behaviors.

Referring to Fig. 1, in the canonical variation ($\chi_3 \eta_3$) in the third group, only “agreeableness” in personality traits and “earnestness and being dutiful” in class students’ behaviors have the absolute values over 0.4 with the error coefficient (1-$\rho^2$) 0.887. Obviously, “agreeableness” in personality traits, by canonical variation ($\chi_3 \eta_3$), can affect the behavior of “earnestness and being dutiful” in class students’ behaviors, meaning that the more the junior high school students’ personality traits incline to “agreeableness”, the better performance of junior high school students in Changhua County on “earnestness and being dutiful” in class students’ behaviors.

Referring to Fig. 1, in the canonical variation ($\chi_4 \eta_4$) in the fourth group, “extraversion” and “conscientiousness” in personality traits and “interpersonal interaction” in class students’ behaviors have the absolute values over 0.4 with the error coefficient (1-$\rho^2$) 0.805. Therefore, “extraversion” and “conscientiousness” in personality traits, by canonical variation ($\chi_4 \eta_4$), can affect the behavior of “interpersonal interaction” in class students’ behaviors, meaning that the more the junior high school students’ personality traits incline to “extraversion” and “conscientiousness”, the better performance of junior high school students in Changhua County on “interpersonal interaction” in class students’ behaviors.
A Canonical Correlation Analysis among Students’ Personality Traits, Class Students’ Behaviors and Academic Achievement

Fig. 1: Canonical correlation analysis path between junior high school students’ personality traits and class students’ behaviors in Changhua County

Table 3: Canonical correlation analysis between personality traits and academic achievements.

<table>
<thead>
<tr>
<th>Model</th>
<th>Feature</th>
<th>ρ</th>
<th>ρ²</th>
<th>Wilks’λ</th>
<th>F</th>
<th>p</th>
<th>Overlap index (x) %</th>
<th>Overlap index (y) %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td>.034</td>
<td>.182</td>
<td>.033</td>
<td>.962</td>
<td>2.225</td>
<td>.015*</td>
<td>1.206</td>
</tr>
</tbody>
</table>

*p<.05

Canonical correlation analysis between junior high school students’ personality traits and academic achievement

From Table 3, only one group of the canonical correlation coefficient in personality traits and academic achievements is significant with the coefficient $ρ_1=0.182$ (Wilk’s $λ=0.962$, $p<0.05$). It shows the remarkable correlation between the variables of personality traits and academic achievements.

The explanation of the canonical correlation is sorted as Table 4 and stated as follows.

In the canonical correlation in the group, $χ_1$ can explain the overall measure of variation $η_1$ being 3.3%, and $η_1$ can explain the overall measure of variation in Y variables being 72.083%, and X variables can explain the overall measure of variation in Y variables being 2.376% by canonical variation $χ_1$. The canonical weighted coefficients between $χ_1$ and “extraversion”, “agreeableness”, “openness”, “conscientiousness”, and “neuroticism” are 0.547, -0.734, 0.394, 0.727, and 0.153, respectively; while the canonical weighted coefficients between $η_1$ and score variables of the first grade and the second grade are 0.732 and 0.422, respectively. In this case, variation $χ_1$ of personality traits and variation $η_1$ of academic achievements show significant correlation.

From Table 4, the canonical variable in personality traits and academic achievement ($χ_1$, $η_1$) $ρ^2$ is 0.033, less than 0.1, showing the insufficiency of explanation. It is therefore not discussed.

Canonical correlation analysis on class students’ behaviors and academic achievements of junior high schools students in Changhua County

From Table 5, only one group of canonical correlation coefficient in class students’ behaviors and academic achievement is significant, with the coefficient $ρ_1=0.166$ (Wilk’s $λ=0.969$, $p<0.05$). It shows the four predicted variables in class students’ behaviors existing significant correlation by the variables of canonical correlation ($χ_1$ and $η_1$) and academic achievements.
Table 4: Canonical correlation analysis between personality traits and academic achievements

<table>
<thead>
<tr>
<th>Canonical weight</th>
<th>X variation</th>
<th>Y variation</th>
<th>Canonical weight</th>
<th>Y variation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>χ₁</td>
<td>η₁</td>
<td></td>
<td></td>
</tr>
<tr>
<td>extraversion (X1)</td>
<td>.547</td>
<td>.732</td>
<td></td>
<td></td>
</tr>
<tr>
<td>agreeableness (X2)</td>
<td>-.734</td>
<td>.422</td>
<td></td>
<td></td>
</tr>
<tr>
<td>openness (X3)</td>
<td>.394</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>conscientiousness (X4)</td>
<td>.727</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>neuroticism (X5)</td>
<td>.153</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Variation percentage</td>
<td>36.572</td>
<td>Variation percentage</td>
<td>72.038</td>
<td></td>
</tr>
<tr>
<td>Overlap percentage</td>
<td>1.206</td>
<td>Overlap percentage</td>
<td>2.376</td>
<td></td>
</tr>
<tr>
<td>ρ²</td>
<td>.033</td>
<td></td>
<td>Canonical correlation (ρ)</td>
<td>.182*</td>
</tr>
</tbody>
</table>

*p<.05

Table 5: Canonical correlation between personality traits and academic achievements

<table>
<thead>
<tr>
<th>Model</th>
<th>Feature</th>
<th>ρ</th>
<th>ρ²</th>
<th>Wilks' λ</th>
<th>F</th>
<th>p</th>
<th>Overlap index (x) %</th>
<th>Overlap index (y) %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td>.028</td>
<td>.166</td>
<td>.028</td>
<td>.969</td>
<td>.2300</td>
<td>.019*</td>
<td>1.122</td>
</tr>
</tbody>
</table>

*p<.05

Table 6: Canonical correlation analysis between class students’ behaviors and academic achievement

<table>
<thead>
<tr>
<th>Canonical weight</th>
<th>X variation</th>
<th>Y variation</th>
<th>Canonical weight</th>
<th>Y variation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>χ₁</td>
<td>η₁</td>
<td></td>
<td></td>
</tr>
<tr>
<td>class identification (X1)</td>
<td>-.336</td>
<td>.455</td>
<td></td>
<td></td>
</tr>
<tr>
<td>interpersonal interaction (X2)</td>
<td>-.143</td>
<td>.704</td>
<td></td>
<td></td>
</tr>
<tr>
<td>earnestness and being dutiful (X3)</td>
<td>-.057</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>self-enrichment (X4)</td>
<td>1.310</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Variation percentage</td>
<td>40.604</td>
<td>Variation percentage</td>
<td>72.457</td>
<td></td>
</tr>
<tr>
<td>Overlap percentage</td>
<td>1.122</td>
<td>Overlap percentage</td>
<td>2.003</td>
<td></td>
</tr>
<tr>
<td>ρ²</td>
<td>.028</td>
<td></td>
<td>Canonical correlation (ρ)</td>
<td>.166*</td>
</tr>
</tbody>
</table>

*p<.05

The explanation of the canonical correlation is sorted in Table 6 and stated as follows.

In the canonical correlation in the group, χ₁ can explain the overall measure of variation η₁ being 2.8%, η₁ can explain the overall measure of variation in Y variables being 72.457%, and X variables can explain the overall measure of variation in Y variables being 2.003% by canonical variation χ₁. The canonical weighted coefficients between χ₁ and “class identification”, “interpersonal interaction”, “earnestness and being dutiful”, and “self-enrichment” are -.336, -.143, -.057, and 1.310, respectively; while the canonical weighted coefficients between η₁ and score variables of the first grade and the second grade are 0.455 and 0.704, respectively. In this case, variation χ₁ of class students’ behaviors and variation η₁ of academic achievements have significant correlation.

From Table 6, the canonical variable in class students’ behaviors and academic achievement (χ₁, η₁) ρ² is 0.028, less than 0.1, showing the insufficiency of explanation. It is therefore not discussed.

DISCUSSIONS

According to the above data analysis, various conclusions are given as follows.

In addition to “neuroticism”, the more the junior high school students in Changhua County incline to “extraversion”, “agreeableness”, “openness”, and “conscientiousness” in personality traits, the better performance of “class identification”, “interpersonal interaction”, “earnestness and being dutiful”, and “self-enrichment” in class students’ behaviors they present.

The findings show the significant correlation between personality traits of junior high school students in Changhua County, including “extraversion”, “agreeableness”, “openness”, “conscientiousness”, and “neuroticism”, and class students’ behaviors, as “class identification”, “interpersonal interaction”, “earnestness and being dutiful”, and “self-enrichment”. Furthermore, the more the junior high school students in Changhua County tend to “extraversion”, “agreeableness”, “openness”, and “conscientiousness” in personality traits,
the better performance of “class identification”, “interpersonal interaction”, “earnestness and being dutiful”, and “self-enrichment” in class students’ behaviors is show. Particularly, the more the personality traits tend to “extraversion” and “conscientiousness”, the better performance of “interpersonal interaction” and “self-enrichment” in class students’ behaviors is presented. Most scholars consider personality traits having important influence on the establishment of the interaction between individuals and others (Diane & Jane, 1996; Pervin & John, 1997; Chen, 2002). Students with the trait of “extraversion” perform more naturally on “interpersonal interaction”, as they are actively and positively dealing with things, good at displaying themselves, and good at social activities due to their optimistic attitudes. On the other hand, conscientious and autonomic students perform more frequently on “interpersonal interaction” and “self-enrichment”, as they are initiative and voluntary at work, follow the prescribed order, plan things in advance, pay attention to self-achievement, and be competent for a job that make them easily receive classmates’ favor in class.

**Personality traits of junior high school students in Changhua County and their academic achievements have significant correlation.**

The findings show the significant correlation between personality traits of junior high school students in Changhua County, including “extraversion”, “agreeableness”, “openness”, “conscientiousness”, and “neuroticism”, and the academic achievements as the scores on computer courses.

Ridgell and Lounsbury (2004) found correlations between academic achievement and personality traits. When learners are highly confident of or favor to the learning, the academic achievement is likely to be better. Besides, when agreeable students could learn in pleasant learning environment, the academic achievement would be effectively reflected (Miranda, Margaretha, Hans&Jolijn, 2010). In this study, ones with the personality trait of “agreeableness” are more optimistic and aggressive so that they have higher endurance to frustrations with their high conformity and tolerance toward norms. Openness appears the most significant effect on academic achievement (Tomas & Adrian, 2009). The more apparent “agreeableness” and “conscientiousness” in personality traits are performed, the better performance on academic achievement of computer courses becomes.

**Class students’ behaviors of junior high school students in Changhua County and their academic achievements have significant correlation.**

The findings show the significant correlation between class students’ behaviors of junior high school students in Changhua County, including “class identification”, “interpersonal interaction”, “earnestness and being dutiful”, and “self-enrichment”, and the academic achievements as the scores on computer courses.

A class is consisted of a teacher, a group of students, and the environment, together achieving the educational goal with interaction, assistance, and integration among the teacher and students (Ulrich, Oliver, Olaf & Jurgen, 2006). Students acquire new concepts and knowledge and promote their academic achievements by interpersonal interaction, automatic participation, coordination and communication, mutual help and cooperation, as well as share and discussion in the class. For this reason, class students’ behaviors have great impact on academic achievement.

From the aspect of individuals, when students engage in class students’ behaviors, better class situation and atmosphere would be built with the interactions among class members, better interpersonal interactions would be promoted, and the harmony and the centripetal force of the entire class would be enhanced that each member could sense positive learning atmosphere and further enhance the academic achievement.

**CONCLUSIONS AND LIMITATIONS**

From the research findings, the personality traits of “extraversion”, “agreeableness”, “openness”, and “conscientiousness”, except “neuroticism”, are presented more apparently, the class students’ behaviors and the academic achievement would appear higher. Besides, as personality traits are internalized and not easily cultivated, both personality traits and class students’ behaviors are the factors in academic achievement. When learners could have primary understanding on the characteristics and meanings of personality traits, further understand their own personality traits and cultivate positive personality traits in the process of learning, they will present better directions on interactions with others and could overcome frustrations in future learning process. Teachers appear the most interactions with students in schools. If teachers could consider the individualities of students, the interactions, the wholeness of the class, and the authenticity of the learning environment, the teaching quality would be enhanced and the instructions become more efficient that students would be enhanced the academic achievement. What is more, if learners’ personality traits could be understood by relevant testing tools before the instructional process, and the results are considered as the bases of curriculum arrangement, instructional activities, and educational guidance, students’ learning interests and capabilities would be increased to receive better academic achievement.

This study merely aimed at the second Grade students in public junior high schools in Changhua County as the research subjects to discuss the personality traits, learning styles, class students’ behaviors, and academic achievement. The research result might not be inferred to
SUGGESTIONS FOR FUTURE RESEARCH

This study merely discusses the relations among personality traits, class students’ behaviors, and academic achievement. Nonetheless, as the development of mind, behaviors, and thoughts of junior high students is not mature, the factors in academic achievement are more changeable than the factors shall be increased. Besides, the professional capabilities in teaching, the styles in class management, personalities, and experiences of teachers could affect the academic achievement of students. Consequently, it is suggested that successive researchers could include these factors to the research; and, with observations and interviews to further understand the interactions among students and the teacher, and peers. Furthermore, the potential variables to affect the academic achievement of students shall be discussed so that the relevant factors in the academic achievement of junior high school students could be further understood.

What is more, under different learning situations, the academic achievement would be distinct; however, this study merely discussed the academic achievement on computer courses. It is therefore suggested that future researchers could aim at different regions, various curriculum, and distinct learning stages to precede the discussions so that the research data will be more abundant and representative.

In the personality traits scale, questions in the dimension of “neuroticism” were deleted in the pre-test and only three were left. In canonical correlation analysis, it appeared irrelevant with class students’ behaviors; and, the canonical correlation coefficient was .182, p=<.05 in the canonical correlation analyses of personality traits and academic achievement, showing low correlation. In this case, the effect of the dimension is worth further discussing. It is therefore suggested that future researchers could study toward the direction to find out the personality traits dimensions for junior high school students in the 21st century.

Finally, it is suggested that “class students’ behaviors” could be regarded as the mediator variable in future research to discuss the effects of mediating on personality traits and academic achievement. Or, it could be further verified by adjusted test, and further proceeded structural equation model with statistical software, like AMOS, to analyze and discuss the effects of relevant potential variables.

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**AUTHOR**

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A Planning Process for Photonics and Daily Life Curriculum at Technical Institute with Delphi Analysis

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Abstract

The purpose of research was to construct the photonics and daily life curriculum content for technological and vocational college students. First, draw up the core concept of photonics technology and daily life curriculum by literature review. Second, generalize the photonics and daily life curriculum content by document analysis and interview. Five experts were invited to an expert panel for revising and confirming the suitability of indicators and content. Finally, carried out three times of Delphi Method to conclude opinions from twenty experts. Following were study findings: five competence items including basic competence for photonics, application competence for optoelectronics devices technique, application competence for basic technique of display, application competence for solar cell technique and application competence for biophotonics, 15 knowledge units and 59 knowledge indicators.

Keywords: technological and vocational college students, photonics and daily life, curriculum content

INTRODUCTION

The twenty-first century has been referred to as the "technopoly" (Postman, 1993). To face this culture, technological literacy will be the main basis for adapting to the technopoly in the future. In the year 2000, the global photovoltaic market increased to a new level. The optoelectronics industry features technology that is capital-intensive, has a low level of energy dependency, and includes industrial applications. Hence, the government proposed the “Two Trillion & Twin Star Project” in 2002, hoping to enhance the high-tech industry output value and the competitiveness of Taiwan in the optoelectronics industry (Lee & Chen, 2008).

In recent years, photonics has played an important role in various fields and has connection with everyday life. The industries that have benefited from photonics include virtually every industry of significance: Telecommunications, semiconductors and computers, manufacturing, medicine, entertainment, and defense. Photonics has also contributed to rapid changes in social structure and culture (Gupta & Ballato, 2007). Mainstream involvement began with computer peripherals and communication in 1990; in 2000 there was a shift to focusing on consumer electronics products application; 2004 the focus was displays, image sensors, DVD, and even optical communications; all of these advancements were applied in the car. While energy environmental issues heated up in 2005, the solar cell rose like a meteor overnight; in 2008, the display and the LED started a technology and application development milestone. Optical technology is not only an important scientific issue but also the key industry for economic growth (Yang, 2001).

In light of the high-tech era, technological and vocational education development is closely linked to the industrial structure and technological changes; and adjustments in the departments and content occur at any time in order to train high-quality practical and technical personnel. As industrial technology rapidly upgrades, technological and vocational colleges will face strong reform and temporary pressure. In addition, the mission of technical and vocational education is to foster professional personnel required by society and industry. Moreover, the curriculum is the core factor of technological and vocational schools. Therefore, this research summarizes the competence indicators of optoelectronics and daily lives by Delphi, and further assists in planning curriculum content for technological and vocational colleges.

The Delphi technique made it possible to obtain opinions from diverse groups at relatively low cost and effort. This study used a three round Delphi process to ascertain and prioritize the essential concepts of photonics and daily lives for the technological and vocational college curriculum. The technique was best suited because of the equal weighting of all responders, large content of material to review, and the multi-tiered process. Furthermore, descriptive and ordinal level data collection and analysis were used to interpret panel suggestions and opinions into a collection of descriptive information for decision making. In this study, no prior research had
been done to plan the needed curricular components of photonics and daily lives for technical and vocational education. Therefore, the Delphi technique was deemed the best research strategy to ascertain a starting knowledge base for this topic.

LITERATURE REVIEW

Delphi and Curriculum

The curriculum represents the expression of educational ideas in practice. The origin of the word has its roots in the Latin word for racetrack or racing chariot (Ross, 2000). Curriculum reflects the state of knowledge, skills, and learning experiences that are provided to students within the school program, moreover, curriculum was to be taught in specific content and conceptual structure, and is a key element in the educational process (Lund & Tannehill, 2009; Rojewski, 2002). The definition is much wider and used for many different kinds of program of teaching and instruction includes all educational institution in these days (Kelly, 2009).

According to several studies, the entire curriculum contents and topics were based on the Delphi technique (Seagle and Iversen, 2002; Philips et al., 2003; Gatchell et al., 2004; Shah, 2003, 2004; ). In undergraduate clinical education, Stritter, Tresolini & Reeb (1994) used the Delphi technique in obtaining a variety of opinions from 12 full-time faculty members to form the new program's curriculum elements. Simon et al (2005) implemented three-round Delphi technique from 30 individuals to identify the topics and curriculum areas which a master’s level agricultural communications curriculum should include. The results produced 90 curriculum areas within the 23 topic. Eskandari et al. (2007) identified the undergraduate Industrial Engineering curriculum for the future workforce needs in various industrial sectors by modified three-round Delphi technique. Wicklein, Smith & Kim (2009) used four-round Delphi research process to realize the essential aspects and academic concepts of an engineering design process in secondary technology education curriculum. Ritz (2009) generates a set of goals to guide curriculum development and instruction for technological literacy by four round modified Delphi methodology from 33 leaders from the technology education profession.

The Characteristic of Technological and Vocational Education Student

The goal of technological and vocational education in Taiwan is to develop all levels of practical and technical personnel, which is different from the general education of the foundation and basic skills (Yang, 2005). In addition, science and technology universities and technical institutes are training more students with a focus on scientific applications, technology development, and technology creation (Wu & Liao, 2009). Fan (1999) pointed out that technological and vocational education should train technical students as the primary goal that society needs and should take into account cognition content and processes. Zhang (2002) pointed out that the technological and vocational courses are more similar to workplace practices, which is the convergence of learners living in the world and the world of work (Chen, Hsiao & Wang, 2005). Meanwhile, Smith (1982) pointed out that adults play multiple roles and have multiple responsibilities due to the different required tasks and adaptation to environment, which leads to learning, but is also affected by the life-centered learning approach. Therefore, we can assume that technological and vocational students are learning practical life skills and combining life and the work world.

Photonics Curriculum Content

The experts from industry and academic fields say that the electro-optical courses at the technological university in the future five years are supposed to include the program of Optoelectronic Semiconductor, Optoelectronic Materials and Devices, Image Display Technology, Photovoltaic, Electro-Optical Patent and intellectual property rights, and Biophotonics. Furthermore, the research findings will be the initial Optical Technology is divided into 10 professional courses, including, Image Display Technology Program, Biomedical Optics Program, optoelectronic semiconductors Program, optoelectronic materials and components, fiber optic communications, optical information, light mechanical and electrical system integration courses, optical automated inspection, PV courses, English Program and so on.

Lin and Chen (2008) proposed that optical technology curriculum content to be divided into photovoltaic technology, optics, optical components, optical systems, optical components, optical systems, optical components and optical disc production work, night vision systems, infrared detection technology, satellite optical remote sensing systems, optical fiber theory and applications, virtual reality and digital imaging and optical signal processing 13 major items.

Lee and Yang (2008) distinguish two types of optical technology, basic knowledge, including geometric optics, wave optics, interference optics, Fourier optics, optical science, photonic materials and radiation and detection; advanced courses, including holographic, laser, nonlinear, optical inspection, thin film optics, color science, optoelectronic semiconductors, integrated optics and photonic crystal; Applications include micro nano optics, MOEMS, display technology, optical communications, solid-state lighting, optical storage and solar Optoelectronics.

Sun (2008) classified as geometric optics, wave optics, laser, optical semiconductor components, optical fiber, Fourier optics and holography and crystal optics. The
Optical engineering of National Science Council (2010) based on current optical research into the following ten categories: 1. Fiber-optic communication and Guided Wave Optics- advanced active and passive fiber optic communication devices and modules, optical wave guide and technology, optical communication transmission and system technology. 2. Information Optics - Advanced optical storage and retrieval technology, opto and image processing, optical computing, optical links, holography. 3. Quantum Electronics and Laser- advanced laser, ultrafast optics and optoelectronics, quantum optics, nonlinear optics, laser applications. 4. Optoelectronic materials, devices and modules - Semiconductor laser, optical sensors, OEIC, optoelectronic semiconductor materials and devices, packaging, MOEM, organic electroluminescent materials and devices, recording device, nanophotonics. 5. PV–solar cell, energy saving optoelectronic. 6. White lighting - LED, color light modulation, packaging, light extraction technology. 7. Display technology - image capture, storage and processing, contrast processing, color science. 8. Optical Engineering - Optics design and test, optical system design and assembly, optical films, optical measurements, micro-optics design, microscopy, optical lithography etching technology, infrared engineering and other applications. 9. Biophotonics - the various applications of optical engineering in biology and medicine. 10. Others.

From energy to health care, from life to entertainment, photovoltaic technology has not only brought us more applications, even became a major promoter of industrial development. In this study, optical technology and daily life is divided into the dimensions of the basics of optical science and technology capacity, optical device application technology capacity, home appliances display technology capability, solar-powered technology capability and biomedical applications capacity, the following were their knowledge units and knowledge items.

Basic Knowledge of Photonics

In view of increasing photonics and the need for science education, the first task was to lay the foundation of basic optical knowledge to photoelectric talent in technological and vocational colleges. Optoelectronics is the merger of optical and electrical, optical history aims to introduce the optics development process, moreover, to describe the color of the bias, depth and shading, and explain the sun or the planet changing, we must understand the characteristics of light and spectrum. Finally, in 1905, Einstein used quantum theory to explain the photoelectric effect and this is considered the foundation of modern science, while the "solar cell" has also greatly contributed to society (Tsai, 2005).

Photonics Devices Technology

The optical component is called semiconductor components, which are made from optical technology (Gu, 2003). As the government works to promote energy conservation policies, as well as LED manufacturing technology advances, radiate intensity enhance and decrease the cost of lighting, helping encourage energy-saving opportunities. In optoelectronic devices LD, LED, PD, CCD, and CMOS image sensors, the most abundantly used was LED applications, particularly in white LED lighting, so that the LED lighting industry will be the next target (Lin, 2008). Actually, our lives are full of infrared because the objects are issued as long as hot thermal radiation, the wavelength of thermal radiation, varies slightly with temperature. So everything around us is sent via infrared. Infrared is not visible, but can be converted into visible light by a charge coupled device (CCD) (Lin, 2006), and according to different wavelengths with a night vision system can be more widely used. Virtual reality (VR) is a term that applies to computer-simulated environments that can simulate places in the real world as well as in imaginary worlds; users can experience, through a variety of sensors for vision, hearing, touch, taste, and smell, an immersive feeling (Burdea, 1994, 1996, 1999). VR's related applications include games, entertainment, education, art, museum displays, e-commerce, medical simulation, visual simulation, scientific visualization, military and aerospace, robotics, etc. (Wang, Liu, & Chen, 2009).

Home Appliance Display Technology

Home appliance displays are used abundantly, whether it is television, computers, mobile phones, PDAs, digital photo frames, etc., they are everywhere in the home. In modern life, it is difficult to imagine no displays, also, the displays act as important interfaces to access information and communication. Display is the one industry that supports our government's "Two Trillion, Twin Stars Project". In terms of the application, the flat panel display (FPD) is still the highest proportion of Taiwan's optoelectronics industry (Won, 2008). Not only is the FPD the industry integrate of high-tech industries and a large amount of investment, but involve more applications in consumers’ daily lives, hence, it has an unlimited potential of characteristics (Ministry of Economic Affairs, 2008). Although the display has become quite common, the larger size and weight can be quite cumbersome. In order to overcome this problem, flexible displays not only can replace the traditional LCD, but can be used in screen displays, advertising billboards, and handheld devices, and be used as electronic paper, e-books, and a variety of indoor and outdoor exhibitions. At the same time, in order to meet human needs for vision and be more interactive and realistic, 3D stereoscopic images are also a major focus of technology development areas in recent years (Wei, 2009).

Solar Energy Supply Technology

As global warming and energy problems caused by environmental pollution continue to arise from energy
consumption, increasing growing international attention, solar energy is a clean and inexhaustible energy. Solar energy is a free energy that can be converted into electrical energy via the photoelectric effect. In 1960, the United States launched a satellite of the solar cells that has been used as an energy source since. At present, solar cells have been widely used on the ground as well as in commercial aspects. With the increase in solar cell efficiency, reducing costs and heightening environmental awareness, solar cells have been widely used in daily life; including watches, computers, cars, aircraft, buildings, etc. Obviously, the solar cell can play an important role for the future (Yang & Tsai, 2005).

Biomedical Technology Applications

As the optical and other information industries experience a long period of development, they have also accumulated considerable capital and technology. The human life span increases every year, chronic diseases and preventive medicine have become a modern axis. Early diagnosis of various diseases and real-time monitoring has become the key for long-term maintenance and quality of life. Taiwan has always been attracted to the medical profession, combining the two areas is undoubtedly very attractive. In this context, Biophotonics is an appealing new field within "Biomedical Electronics," "biotechnology," and "network health (e-care)" (Gau, 2007). Biophotonics is an integrated field of electrical and electronics, IT, biotechnology, bio-medicine, physics, chemistry, precision machinery, and nano science.

METHOD

Through photonics framework is basically the industry classification for the standard photonics capability. The photonics industry personnel does not fully comply with the current situation caused by the continuous advancement in technology, hence, training photonics industry personnel still the core curriculum content from the original and proceed with the future industry needs. In order to develop the photonics and daily life curriculum, a combination of document analysis, interview, expert panel, and Delphi methodology was applied.

This study used the classification of photonics as a major concept, followed by the development of knowledge units and items from literature, and then used document analysis and interviews with five photonics professionals, examined the curriculum content for students in technological and vocational colleges, and selected five scholars and experts in photonics and daily life to revise and confirm the appropriateness of photonics in daily life. In order to sum up their views, we adopted the Delphi questionnaires from 20 experts and scholars. In total, the questionnaire has five knowledge areas, namely, basic knowledge of photonics, photonics devices technology, home appliance display technology, solar energy supply technology, and medical applications; along with 22 knowledge units and 115 knowledge items.

Document Analysis

In addition to obtain from those directly involved with the curriculum, we reviewed pertinent curriculum documents, such as curriculum theory, syllabus, instructional design plans, teaching objectives and curriculum content. A document analysis on elements of photonics and daily life curriculum was performed in order to make use of the available knowledge and international perspectives. The procedures include 1.collecting the curriculum theories and the teaching goals related to photonics and daily life curriculum; 2.collecting the curriculum contents related to photonics and daily life; 3.inducing the above data for the Delphi questionnaire which could provide the curriculum goals and curriculum contents for experts to examine students’ photonics and daily life at technical institutes.

Interview

An interview is a one by one directed conversation with an individual using a series of questions for realizing into one person’s ideas about some subject (Davis, 2004). The following procedures in this research were: 1. Formulate the broad interview outline and conduct with three industrial experts and two professors at the end of the document analysis to gather data on the knowledge units and knowledge items that we planning the photonics and daily life curriculum. 2. According to the respondents’ working experience or research, provide advice for photonics and daily life.

Experts Panel

This study established an expert forum to discuss the outline, selecting two industries and three academic scholars, whom through their discussions and recommendations, modified and confirmed the photonics and daily life index and content after literature review and expert interviews. The expert forum would follow the procedures as: 1.confirming the discussion guides of the expert forum; 2.inviting and confirming the experts; 3.disussing students’ capacity for photonics and daily life at technical institutes.

Delphi

The Delphi technique is a version of survey analysis that carried out to improve, complete and restrict the list of elements from the literature study (Linston & Turoff, 1975; Franklin & Hart, 2007) which involves repetitive questioning of respondents(Bell, 2000). It’s also a structured means of facilitating communication among experts to deal with a complicated topic to arrive at the best possible solution (Mullen, 2003). This study invited 10 industry and 10 academic scholars to conduct a three times questionnaire after expert discussion in order to
sum up their view on curriculum content of photonics and daily life for technological and vocational college students.

**Drawing up the Questionnaire**

Based on the research objective, document analysis, interview, and expert panel were proceeded to complete the first revision of Delphi questionnaire on “Curriculum contents of photonics and daily life for students at technical institutes”. The structure of the questionnaire was divided into three parts of a letter for the research, description on answering questions, and answering questions. The second and the third formal Delphi questionnaires were revised according to the result of the first questionnaire and the feedback of experts. The questionnaire was scored with Likert five-point scale, including “very important” 5 points, “important” 4 points, “ordinary” 3 points, “unimportant” 2 points, and “very unimportant” 1 point.

**Expert Choice**

Wiersma and Jurs (2008) indicated that the number of Delphi members shall be 10-15 when they were with high homogeneity, but 20-25 were the limit. This study invited ten experts from the industry and another ten from the academia, who concluded the curriculum contents of photonics and daily life for students at technical institutes.

**RESULT**

Each item on the survey that was brought forward from previous rounds had the associated statistical data (mean, standard deviation, and interquartile range). The mean indicate the concentration of each competence items; standard deviation indicate the consistence of experts respondents. According to Faherty (1979), an interquartile range score of < 0.5 (Q≦0.5) is considered that the item has reached an acceptable degree of consensus. In the end, according to Kolmogorov-Smirnov one sample test, if p<.05, the score indicating that the consistency of the items reached a consensus, otherwise, delete.

**Basic Knowledge of Photonics**

The results of all respondents on "basic knowledge of photonics" shows that the mean ranged from 3.2 to 4.05; interquartile range were less than 0.5; the K-S of light wave stage, wave optics, coatings, interference devices, imaging theory, telescope lens and eyepiece, digital camera lens design, remote control doesn’t reach a significant level. Therefore, remove these seven knowledge items; furthermore, imaging theory is knowledge unit, so their knowledge items will be deleted.

<table>
<thead>
<tr>
<th>mode</th>
<th>mean</th>
<th>SD</th>
<th>OD</th>
<th>K-S</th>
</tr>
</thead>
<tbody>
<tr>
<td>The history of optics</td>
<td>4</td>
<td>3.6</td>
<td>0.681</td>
<td>0.5</td>
</tr>
<tr>
<td>1. Enlightenment</td>
<td>3</td>
<td>3.35</td>
<td>0.671</td>
<td>0.5</td>
</tr>
<tr>
<td>2. Geometrical optics</td>
<td>4</td>
<td>3.75</td>
<td>0.55</td>
<td>0.5</td>
</tr>
<tr>
<td>3. The wave period</td>
<td>4</td>
<td>4</td>
<td>0.649</td>
<td>0</td>
</tr>
<tr>
<td>4. Quantum period</td>
<td>3</td>
<td>3.9</td>
<td>0.553</td>
<td>0</td>
</tr>
<tr>
<td>5. Modern Optics Period</td>
<td>3</td>
<td>3.8</td>
<td>0.616</td>
<td>0</td>
</tr>
</tbody>
</table>

**Photonics Devices Technology**

The results of all respondents on " photonics devices technology" shows that the mean ranged from 3.1 to 4.2; interquartile range were less than 0.5; the K-S of optical components and disc manufacture, lens manufacture, active infrared headlights doesn’t reach a significant level. Therefore, remove these two knowledge items; furthermore, optical components and disc manufacture are knowledge units, so their knowledge items will be deleted.

**Home Appliance Display Technology**

The results of all respondents on " home appliance display technology" shows that the mean ranged from 3.3 to 4.15; interquartile range were less than 0.5; the K-S of mobile phone LCD screen, mobile phone, ATM, navigation system, touch teaching system doesn’t reach a significant level. Therefore, remove these five knowledge items.
Table 2: photonics devices technology curriculum content analysis

<table>
<thead>
<tr>
<th></th>
<th>mode</th>
<th>mean</th>
<th>SD</th>
<th>QD</th>
<th>K-S</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lighting and LED</td>
<td>4</td>
<td>4.1</td>
<td>0.447</td>
<td>0</td>
<td>1.96i*</td>
</tr>
<tr>
<td>1. LCD Backlight Module</td>
<td>4</td>
<td>4.2</td>
<td>0.523</td>
<td>0.375</td>
<td>1.784**</td>
</tr>
<tr>
<td>2. Portable illuminator</td>
<td>4</td>
<td>3.55</td>
<td>0.51</td>
<td>0.5</td>
<td>1.614*</td>
</tr>
<tr>
<td>3. Emergency illuminator</td>
<td>4</td>
<td>3.4</td>
<td>0.681</td>
<td>0.5</td>
<td>1.391*</td>
</tr>
<tr>
<td>4. Outside and inside lighting</td>
<td>4</td>
<td>3.5</td>
<td>0.827</td>
<td>0.5</td>
<td>1.463*</td>
</tr>
<tr>
<td>5. Car luminaire</td>
<td>4</td>
<td>3.55</td>
<td>0.759</td>
<td>0.5</td>
<td>1.446*</td>
</tr>
<tr>
<td>Optical device and CD</td>
<td>4</td>
<td>3.45</td>
<td>0.826</td>
<td>0.5</td>
<td>1.330</td>
</tr>
<tr>
<td>1. glass</td>
<td>4</td>
<td>3.15</td>
<td>0.875</td>
<td>1</td>
<td>1.271</td>
</tr>
<tr>
<td>2. Display Hologram</td>
<td>4</td>
<td>3.35</td>
<td>0.813</td>
<td>0.5</td>
<td>1.512*</td>
</tr>
<tr>
<td>3. CD</td>
<td>4</td>
<td>3.1</td>
<td>0.968</td>
<td>1</td>
<td>1.448*</td>
</tr>
<tr>
<td>Infrared and night vision system</td>
<td>4</td>
<td>3.9</td>
<td>0.553</td>
<td>0</td>
<td>2.110***</td>
</tr>
<tr>
<td>1. CCD camera</td>
<td>4</td>
<td>3.8</td>
<td>0.523</td>
<td>0</td>
<td>2.231***</td>
</tr>
<tr>
<td>2. twin-beam infrared sensor</td>
<td>3</td>
<td>3.4</td>
<td>0.598</td>
<td>0.5</td>
<td>1.333</td>
</tr>
<tr>
<td>3. head-up display</td>
<td>4</td>
<td>3.65</td>
<td>0.587</td>
<td>0.5</td>
<td>1.898**</td>
</tr>
<tr>
<td>4. uncooled camera</td>
<td>4</td>
<td>3.6</td>
<td>0.681</td>
<td>0.5</td>
<td>1.886**</td>
</tr>
<tr>
<td>5. Infrared Search and Track System(RST)</td>
<td>4</td>
<td>3.7</td>
<td>0.801</td>
<td>0.5</td>
<td>1.547*</td>
</tr>
<tr>
<td>Laser system</td>
<td>4</td>
<td>3.55</td>
<td>0.686</td>
<td>0.5</td>
<td>1.762**</td>
</tr>
<tr>
<td>1. barcode scanner</td>
<td>4</td>
<td>3.5</td>
<td>0.688</td>
<td>0.5</td>
<td>1.638**</td>
</tr>
<tr>
<td>2. laser printer</td>
<td>4</td>
<td>3.75</td>
<td>0.444</td>
<td>0.375</td>
<td>2.071***</td>
</tr>
<tr>
<td>3. laser carving machine</td>
<td>4</td>
<td>3.55</td>
<td>0.759</td>
<td>0.5</td>
<td>1.893**</td>
</tr>
<tr>
<td>4. laser doppler flowmetry</td>
<td>4</td>
<td>3.5</td>
<td>0.688</td>
<td>0.5</td>
<td>1.638**</td>
</tr>
<tr>
<td>5. video disc player</td>
<td>4</td>
<td>3.35</td>
<td>0.875</td>
<td>0.875</td>
<td>1.660**</td>
</tr>
<tr>
<td>Virtual reality</td>
<td>4</td>
<td>3.6</td>
<td>0.598</td>
<td>0.5</td>
<td>1.781**</td>
</tr>
<tr>
<td>1. helmet display</td>
<td>4</td>
<td>3.55</td>
<td>0.826</td>
<td>0.5</td>
<td>1.597*</td>
</tr>
<tr>
<td>2. data glove</td>
<td>4</td>
<td>3.5</td>
<td>0.607</td>
<td>0.5</td>
<td>1.543*</td>
</tr>
<tr>
<td>3. shutter glasses</td>
<td>3</td>
<td>3.6</td>
<td>0.503</td>
<td>0.5</td>
<td>1.730*</td>
</tr>
<tr>
<td>4. 3D mouse</td>
<td>4</td>
<td>3.65</td>
<td>0.489</td>
<td>0.5</td>
<td>1.846**</td>
</tr>
<tr>
<td>5. Wi</td>
<td>4</td>
<td>3.65</td>
<td>0.671</td>
<td>0.5</td>
<td>1.561*</td>
</tr>
</tbody>
</table>

Table 3: home appliance display technology curriculum content analysis

<table>
<thead>
<tr>
<th></th>
<th>mode</th>
<th>mean</th>
<th>SD</th>
<th>QD</th>
<th>K-S</th>
</tr>
</thead>
<tbody>
<tr>
<td>Display</td>
<td>4</td>
<td>4.15</td>
<td>0.587</td>
<td>0.375</td>
<td>1.569*</td>
</tr>
<tr>
<td>1. mobile LCD</td>
<td>4</td>
<td>4.1</td>
<td>0.718</td>
<td>0.5</td>
<td>1.142</td>
</tr>
<tr>
<td>2. NB monitor</td>
<td>4</td>
<td>4.2</td>
<td>0.616</td>
<td>0.5</td>
<td>1.464*</td>
</tr>
<tr>
<td>3. ultra-thin computer</td>
<td>4</td>
<td>4.1</td>
<td>0.641</td>
<td>0.375</td>
<td>1.395*</td>
</tr>
<tr>
<td>4. large-size LCD TV screen</td>
<td>4</td>
<td>4.1</td>
<td>0.641</td>
<td>0.375</td>
<td>1.395*</td>
</tr>
<tr>
<td>5. Plasma Display</td>
<td>4</td>
<td>3.65</td>
<td>0.489</td>
<td>0.5</td>
<td>1.846**</td>
</tr>
<tr>
<td>6. E-paper</td>
<td>4</td>
<td>4.1</td>
<td>0.553</td>
<td>0</td>
<td>1.663**</td>
</tr>
<tr>
<td>7. CRT TV</td>
<td>4</td>
<td>3.55</td>
<td>0.51</td>
<td>0.5</td>
<td>1.614*</td>
</tr>
<tr>
<td>8. OLED</td>
<td>4</td>
<td>4.15</td>
<td>0.489</td>
<td>0</td>
<td>1.880**</td>
</tr>
<tr>
<td>Digital light and touch panel</td>
<td>4</td>
<td>3.95</td>
<td>0.394</td>
<td>0</td>
<td>2.015**</td>
</tr>
<tr>
<td>1. PDA</td>
<td>4</td>
<td>3.9</td>
<td>0.497</td>
<td>0</td>
<td>1.961**</td>
</tr>
<tr>
<td>2. Tablet PC</td>
<td>4</td>
<td>3.75</td>
<td>0.444</td>
<td>0.375</td>
<td>2.071***</td>
</tr>
<tr>
<td>3. GPS</td>
<td>4</td>
<td>3.8</td>
<td>0.523</td>
<td>0.375</td>
<td>1.784**</td>
</tr>
<tr>
<td>4. mobile</td>
<td>4</td>
<td>3.9</td>
<td>0.718</td>
<td>0.5</td>
<td>1.142</td>
</tr>
<tr>
<td>5. ATM</td>
<td>3</td>
<td>3.9</td>
<td>0.657</td>
<td>0.5</td>
<td>1.234</td>
</tr>
<tr>
<td>6. POS</td>
<td>4</td>
<td>3.45</td>
<td>0.686</td>
<td>0.5</td>
<td>1.514*</td>
</tr>
<tr>
<td>7. tour system</td>
<td>4</td>
<td>3.5</td>
<td>0.761</td>
<td>0.5</td>
<td>1.317</td>
</tr>
<tr>
<td>8. Touch Learning System</td>
<td>4</td>
<td>3.9</td>
<td>0.788</td>
<td>0.375</td>
<td>1.344</td>
</tr>
<tr>
<td>9. Digital Signage</td>
<td>4</td>
<td>3.9</td>
<td>0.308</td>
<td>0</td>
<td>2.358***</td>
</tr>
<tr>
<td>3D stereoscopy</td>
<td>4</td>
<td>3.65</td>
<td>0.489</td>
<td>0.5</td>
<td>1.846**</td>
</tr>
<tr>
<td>1. digital photo frame</td>
<td>4</td>
<td>3.45</td>
<td>0.826</td>
<td>0.5</td>
<td>1.533*</td>
</tr>
<tr>
<td>2. Signage</td>
<td>4</td>
<td>3.55</td>
<td>0.51</td>
<td>0.5</td>
<td>1.614*</td>
</tr>
<tr>
<td>3. 3D stereoscope television</td>
<td>4</td>
<td>3.85</td>
<td>0.366</td>
<td>0</td>
<td>2.276***</td>
</tr>
<tr>
<td>4. 3D player</td>
<td>4</td>
<td>3.8</td>
<td>0.41</td>
<td>0</td>
<td>2.178***</td>
</tr>
<tr>
<td>5. full-color technology 3D</td>
<td>4</td>
<td>3.85</td>
<td>0.489</td>
<td>0</td>
<td>1.88*</td>
</tr>
</tbody>
</table>

Table 4: solar energy supply technology curriculum content analysis

<table>
<thead>
<tr>
<th></th>
<th>mode</th>
<th>mean</th>
<th>SD</th>
<th>QD</th>
<th>K-S</th>
</tr>
</thead>
<tbody>
<tr>
<td>solar energy and transportation</td>
<td>4</td>
<td>4</td>
<td>0.562</td>
<td>0</td>
<td>1.565*</td>
</tr>
<tr>
<td>1. solar car</td>
<td>4</td>
<td>3.85</td>
<td>0.671</td>
<td>0.5</td>
<td>1.290</td>
</tr>
<tr>
<td>2. solar boat</td>
<td>4</td>
<td>3.75</td>
<td>0.55</td>
<td>0.5</td>
<td>1.678**</td>
</tr>
<tr>
<td>3. solar airplane</td>
<td>4</td>
<td>3.75</td>
<td>0.716</td>
<td>0.5</td>
<td>1.129</td>
</tr>
<tr>
<td>4. solar station</td>
<td>4</td>
<td>3.95</td>
<td>0.605</td>
<td>0</td>
<td>1.489**</td>
</tr>
</tbody>
</table>

Solar Energy Supply Technology

The results of all respondents on "solar energy supply technology" shows that the mean ranged from 3.5 to 4.15; interquartile range were less than 0.5; the K-S of solar cars, solar airplane, solar water pumping systems doesn’t reach a significant level. Therefore, remove these knowledge items.

Biomedical Technology Applications

The results of all respondents on "Biomedical Technology applications" shows that the mean ranged from 3.1 to 3.95; interquartile range were less than 0.5; only virtual work environment occupational therapy greater than 0.5; the K-S of biomedical optical circuits, light therapy profiles, video-assisted navigation systems, smart homes, laser health care system, the electronic eye, the dynamic visual virtual reality postural control, environmental adaptation in physical therapy machine, virtual work environment occupational therapy doesn’t reach a significant level. Therefore, remove these nine knowledge items.

Through three Delphi survey analysis, conduct an expert discussion again, to confirm the appropriateness of curriculum content of the photonics and daily life. The result of expert discussion, the original 22 knowledge units and 115 knowledge items was reduced to 15 knowledge units and 57 knowledge items, shown as Table 6 and Table 7.
| Table 5: Biomedical Technology Applications Curriculum Content Analysis |
|---------------------------------|------|------|------|------|------|
| **Mode** | **Mean** | **SD** | **QD** | **K-S** |
| Introduction for biophonics | 4 | 3.7 | 0.657 | 0.5 | 1.234 |
| 1. Biophonics circuit | 4 | 3.7 | 0.657 | 0.5 | 1.234 |
| 2. Medicine device | 4 | 3.7 | 0.571 | 0.5 | 1.566 |
| 3. Light therapy | 3 | 3.4 | 0.754 | 0.5 | 1.128 |
| 4. Photodynamic therapy | 4 | 3.6 | 0.503 | 0.5 | 1.73 ** |
| 5. Spectrum of transmit and scatter | 4 | 3.7 | 0.657 | 0.5 | 1.682 ** |
| Imaging and sensor | 4 | 3.75 | 0.444 | 0.375 | 2.071 *** |
| 1. Cellulary tissue imaging | 4 | 3.6 | 0.503 | 0.5 | 1.566 |
| 2. Organ imaging | 4 | 3.7 | 0.47 | 0.5 | 1.960 *** |
| 3. Automatic optical inspection | 4 | 3.8 | 0.523 | 0.375 | 1.784 ** |
| 4. Medical image principle | 4 | 3.95 | 0.51 | 0 | 1.740 *** |
| 5. Microbiomedical sensors system | 4 | 3.95 | 0.605 | 0 | 1.489 * |
| 6. Image-aided system | 4 | 3.5 | 0.761 | 0.5 | 1.317 |
| Gerontechnology and smart living | 4 | 3.45 | 0.605 | 0.5 | 1.424 |
| 1. Smart residence | 4 | 3.6 | 0.754 | 0.5 | 1.128 |
| 2. Service robot | 4 | 3.5 | 0.607 | 0.5 | 1.543 |
| 3. Laser health system | 3 | 3.25 | 0.786 | 0.5 | 1.231 |
| 4. Electron eye | 4 | 3.2 | 0.894 | 0.5 | 1.183 |
| Virtual reality and rehabilitation | 4 | 3.4 | 0.681 | 0.5 | 1.391 |
| 1. VR dynamic postural control | 4 | 3.3 | 0.733 | 0.5 | 1.254 |
| 2. Ecobiotic adaptation rehabilitation | 3 | 3.2 | 0.834 | 0.5 | 1.195 |
| 3. Wheelchair control training | 3 | 3.2 | 0.616 | 0.5 | 1.464 |
| 4. VR occupational therapy training | 3 | 3.1 | 0.788 | 0.875 | 0.999 |
| 5. Telemedicine | 3 | 3.55 | 0.51 | 0.5 | 1.614 |
| 6. Telehealthcare | 3 | 3.35 | 0.587 | 0.5 | 1.451 |
| 7. Ambulance emergency | 3 | 3.5 | 0.513 | 0.5 | 1.499 |
| 8. Tele surgery | 3 | 3.25 | 0.639 | 0.5 | 1.352 |
| 9. HIS/PACS | 3 | 3.35 | 0.671 | 0.5 | 1.269 |

| Table 6: The Old and New Knowledge Units and Items in Photonics and Daily Life |
|-------------------------------|-----|-----|-----|-----|
| **Competence Item** | **Knowledge Units** | **Old** | **New** | **Old** | **New** |
| Basic knowledge of photonics | 5 | 3 | 27 | 12 |
| Photonics devices technology | 5 | 3 | 23 | 12 |
| Home appliance display technology | 3 | 3 | 22 | 15 |
| Solar energy supply technology | 4 | 3 | 19 | 9 |
| Biomedical applications technology | 5 | 3 | 24 | 9 |
| Total | 22 | 15 | 115 | 57 |

| Table 7: Photonics and Daily Life Curriculum Content |
|-----------------|-----------------|-----------------|
| **Competence Item** | **Knowledge Units** | **Knowledge Items** |
| The history of optics | Enlightenment | Geometrical optics |
| Modern Optics Period | Electro-optical spectrum | HF |
| Visible spectrum apparatus | Semiconductor Laser | Optical detector |
| Radar speedometer | LCD Backlight Module | Portable illuminator |
| Emergency illuminator | Outside and inside lighting | Car luminaire |
| Light and LED | Infrared detection and night vision systems | Infrared Search and Track System (IRST) |
| Virtual reality | Helmet display | Data glove |
| 3D mouse | Wi | Ultra-thin computer |
| Display | E-paper | LCD TV screen |
| CR TV | PDA | Digital Signage |
| OL | Tablet PC | Digital Photo Frame |
| GPS | Sales System | Billboards |
| Digital Signage | 3D stereoscopic image display | 3D video player |
| Full-color technology | 3-D | Solar boat |
| Solar energy supply system | Solar station | Emergency power supply system |
| Solar energy and green building | Solar panels | BIPV |
| Solar energy and household appliance | Solar Charger | Fiber-guided system |
| Solar water heaters | Solar tracker system | Biophotonics circuit |
| Solar tracker system | Light Therapy | Photodynamic treatment technology |
| Biophotonics circuit | Medical image principle | Microbiomedical sensors system |
| Imaging and sensor | Telemedicine | Telehealthcare |
| e-care | Telehealthcare | Ambulance emergency |
| E-care | HIS/PACS |
CONCLUSION

The curriculum content involved many aspects of photonics and daily life for technological and vocational colleges. This study adopted a Delphi survey, which consisted of 5 competence items, 15 knowledge units, and 59 knowledge items.

The most important knowledge units, namely "Lighting and LED," "display," and "Solar and Transport" of photonics and daily life for technological and vocational colleges

According to Lin (2008) study, the government is seeking efforts to promote energy conservation policies. In the optical semiconductor components, LED manufacturing technology enhances luminescence intensity, decreasing the cost of lighting, which will promote energy-saving opportunities. LED applications are the most abundant, particularly in the issue of white light LED and backlight; therefore, the future of the LED lighting industry will be popular. Furthermore, the display industry is the one industry that is fully supported by our government's "Two Trillion, Twin Stars Project." For the application feature, the flat panel display has the highest proportion of Taiwan's optoelectronics industry (Wong, 2008). Because panel displays involve a combination of high-tech industries with a large amount of investment, and are intimately involved with the daily lives of consumers, it has unlimited potential characteristics (Ministry of Economic Affairs, 2008). Additionally, they can use solar energy, which can improve the ecological environment and global warming issues; solar is a clean, free, and inexhaustible energy that can be converted into electrical energy via the photoelectric effect, therefore, we can realize the important role of solar cell in energy consumption (Yang & Tsai, 2005).

The most important knowledge items, namely "Electromagnetic spectrum distribution" in basic knowledge of photonics of photonics and daily life for technological and vocational colleges students

"Light" is not only a visible light, broadly speaking, the entire electromagnetic spectrum could be referred to as "light," including visible light, ultraviolet, infrared, microwave, X-Ray, γ-Ray and so on. The entire electromagnetic spectrum of different bands can help us further understand the world in which we live. Such as the longest wave length is radio and is suitable for observing the big stars in the universe; microwave can be used to observe aircraft, ships, and typhoons; infrared is suitable for night vision systems and missile tracking; ultraviolet rays can observe gas molecules, condensed matter physics, and electronic structure; X-Ray is an excellent tool to study the crystal structure, the shortest wavelength of the γ-Ray may be used to explore the world within the nucleus (Fu, 2007).

The most important knowledge items, namely "LCD backlight Module" in photonics devices technology of photonics and daily life for technological and vocational colleges students

TFT-LCD is a type of flat-panel display with many other advantages: Small in size, light weight, thin, low power consumption, no flicker, no radiation, and environmental protection. Backlight module is a key component of liquid crystal displays and also refers to components that can provide back light sources of a product that are currently used in a variety of information, communications, and consumer products as the light source component of the liquid crystal display in large markets (Lin, 2006). Therefore, both industry and academia consider the LCD backlight module as the important knowledge item in photonics and daily life for technological and vocational college students.

The most important knowledge items, namely "NB monitor", “ultra-thin computer,” “Large size LCD TV screen,” “E-Paper” and “OLED” in home appliance display technology of photonics and daily life for technological and vocational colleges' students

In this modern society, whether it is televisions, computers, mobile phones, PDAs, etc., people cannot avoid displays in either work or leisure activities. It is also explains the importance of displays as an interface to access information and communication (Wong, 2008). Additionally, in most displays, FED is small in size and has high resolution and rapid response characteristics, which are the most competitive products in the display market of the future (Hsueh, 2005). It breaks the limit of CRT's big size and saves more space; therefore, it is often used in thin computers and small TV areas. Furthermore, OLED has advantages in light weight, low profile, and low power consumption, and can be flexible, highly portable, have high contrast, high brightness, and high response speed along with a wide viewing angle (Hsieh, 2007). Finally, electronic paper with low power consumption, convenience, lightweight, thin, and impact resistance characteristics will play an important role in the consumer market, such as in watches, clocks, various labeling, e-books, and billboards. However, Kuo (2008) considered that changing from paper to e-paper as a great conversion; possibly needing time to adapt, but in any case, the e-paper era should be forthcoming.

The most important knowledge items, namely "Solar panels" in solar energy supply technology of photonics and daily life for technological and vocational colleges' students

Solar is the mature technology industry, it can be applied extensively, such as in solar lights, solar water heaters, and especially in architecture. BIPV is a building design approach for building solar panel systems into housing construction, so that system components cannot only generate electricity, but also be a part of the building.
shell. If the solar panels can be integrated together with the sun visor set, it will also generate power and reduce direct sunlight. (Hsieh, 2004). To tie in architectural design with energy conservation, solar panel roof structure is a very important design for the building.

The most important knowledge items, namely "Principles of Medical Imaging Technology" and "Micro Biomedical Sensor System" in biomedical technology applications of photonics and daily life for technological and vocational colleges students

In the medical field, in addition to patient physiological signals, the other important information is the patient's medical imaging, including X-rays, CT, MR, Ultrasound, PET and so forth. Doctors can diagnose a patient's disease via medical imaging and be able to provide relevant treatment. In addition, people-oriented, technology-oriented visions will advance development of the basic tenets of national industry, and assist in our next wave of industrial development. Finally, facing a globally aging society, care for elderly people services will be quite imminent in the future. The micro biomedical sensor system used in home care and hospital care may provide a more reliable care quality and reduce medical expenses.

SUGGESTIONS FOR FURTHER STUDY

This study applied Delphi technique to construct the curriculum contents of photonics and daily life for students at technical institutes. Nevertheless, the indicators to measure the curriculum contents often affected by the qualitative characteristics and evaluators’ subjective experience so that the evaluation value could not be expressed with clear values. For this reason, Bellman and Zadeh (1970) proposed the decision making in Fuzzy environment which applied Fuzzy set theory to deal with the problems of fuzzy situation and fuzzy criteria. It is suggested to apply linguistic variable to express evaluators’ subjective evaluation values in future research so as to reduce the fuzziness and to combine Fuzzy theory and multiple criteria decision making. With expert questionnaires to select the suitable evaluation criteria, a more precise curriculum content of photonics and daily life at technical institutes could be constructed. It would further enhance the integrity and rationality of the curriculum contents to become a reference of curriculum arrangements for curriculum organizers.

IMPLICATIONS FOR PRACTICE

Photonics is a new and emerging science and technology mainly applied to optical communications, displays, storage, illumination, sensing, and bio-medicine. With continuous breakthrough of photonics in the basic research, it has resulted in great influence in the daily life. Present photonics curriculum in colleges primarily emphasizes the development of technology, but ignores the integration with daily life. Technological and vocational education aims to cultivate students focusing on both learning and practice as well as integrating the life with the work. For this reason, this study plans the curriculum contents corresponding photonics and daily life at technical institutes, expects to satisfy the demands of the talents in optoelectronics technology as well as cultivates professionals with the capability to connect the integrated curriculum framework with daily life.

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Education Paradise of International Students: Strategic Factors that Determine the Selection of Schools by International Students

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Abstract

This paper aims to find out the dynamics attracting foreign students in choosing Taiwan for higher education study. Internationalization in higher education has been a topic of interest for many researchers. A significant body of literature focused on the dynamics behind student mobility. In general, these studies used pull-push terminology to explain student mobility, as well as suggest that there are factors in the host countries pulling the students to choose particular destinations and/or there are push factors in home country pushing the students to choose a particular host country. However, what attracts students from developing or developed countries to choose a developing country for higher education study remains less investigated. This research uses the Stratified Random Sampling Method and selected 130 international students from northern, southern and central Taiwan as samples. Fuzzy Importance-Performance Analysis was used to understand the degrees of importance and satisfaction of the various factors of the education environment the international students give to when they choose their schools. The related information can be provided as references to various educational units to attract international students to come and study in universities in Taiwan.

Keywords: International Student, Satisfaction, Fuzzy Importance-Performance Analysis

INTRODUCTION

Education is considered to be important for people to attain knowledge, look for a job, as well as to have a better position in organizations and societies. Nowadays, more and more students are undertaking graduate courses. Education has become a global industry where more and more people are choosing to have an international education, so as to increase their competitive strength in the global market. One of the major goals of universities is student satisfaction. The source of competitive advantage comes from a satisfied student population with positive outcomes such as positive word of mouth (WOM) communication, student retention and loyalty (Arambewela & Hall, 2009). Besides providing superior educational services, universities are expected to overcome challenges like cultural diversity, differences in learning styles, changing demands of students who are provided with a more choices of study destinations, educational programs and study environments. Therefore, service quality is an important performance measure of excellent education, as well as a major strategic variable for universities to provide quality service to increase their market share in the education market.

With the wide variety of choices for students as to which universities and countries to choose for their education, universities face challenges caused by an increase in the mobility of students worldwide. Universities should view these challenges as threats as well as opportunities. International education has widened the scope in cross-border education with increasing student mobility, academic mobility, program mobility and institution mobility (Naidoo, 2006).

LITERATURE REVIEW

The developments and changes in the international education environment include increased availability of higher educational opportunities in source countries due to reductions in local capacity constraints, slower rates of participation and access to international education than previously expected (Arambewela & Hall, 2009). The need for international education may arise from doubts whether some countries are able to provide increased physical capacity required and train academics within a short period, therefore, the need of international education is increasing day by day.

The choice of a study destination is normally a two-stage process, where students either choose a country first and then the educational institution, or choose both the country and the educational institution separately and independently. Socio-economic and environmental factors such as safety, lifestyles, cost of living, transportation, racial discrimination, visas and immigration potential, friends and family, climate and culture (Veloutsou, Paton & Lewis, 2005; Arambewela, 2003; Lawley, 1998; Duan, 1997; International Development Programs, 1995) are associated with the choice of a country as a study destination, while individual level factors such as study programs and courses, fees, facilities and support services, intellectual climate, teaching quality, teaching staff and methods, recognition of courses, image and prestige of the university (Veloutsou, Paton & Lewis, 2005; Arambewela, 2003; Smith, Morey, Teedes, 2002; Townley, 2001; Geall, 2000; DETYA, 2000) are associated with the choice of a university as a study destination.
Table 1: Strategic factor that international students use in their selection.

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>Education</td>
<td>Valuable feedback from lecturers</td>
</tr>
<tr>
<td></td>
<td>Good access to lecturers</td>
</tr>
<tr>
<td></td>
<td>High standards of teaching by quality lecturers</td>
</tr>
<tr>
<td>Social orientation</td>
<td>Counseling services</td>
</tr>
<tr>
<td></td>
<td>Social activities</td>
</tr>
<tr>
<td></td>
<td>Close working relationships with all students</td>
</tr>
<tr>
<td></td>
<td>International orientation programs</td>
</tr>
<tr>
<td>Economic considerations</td>
<td>Cost of living</td>
</tr>
<tr>
<td></td>
<td>Opportunities for migration</td>
</tr>
<tr>
<td>Safety</td>
<td>Safety</td>
</tr>
<tr>
<td></td>
<td>Life-style</td>
</tr>
<tr>
<td>Image and prestige</td>
<td>Image and prestige internationally</td>
</tr>
<tr>
<td></td>
<td>Image and prestige in Taiwan</td>
</tr>
<tr>
<td></td>
<td>Image and prestige in home country</td>
</tr>
<tr>
<td>Technology</td>
<td>Access to computer facilities</td>
</tr>
<tr>
<td></td>
<td>Availability of modern facilities</td>
</tr>
<tr>
<td>Accommodation</td>
<td>Reasonable cost</td>
</tr>
<tr>
<td></td>
<td>Good standards</td>
</tr>
</tbody>
</table>

University education falls into the domain of services marketing, where service performances are considered situation specific and two service cannot be treated as identical if they are performed in different settings and by different individuals (Lovelock, Patterson & Walker, 2003; Zeithaml & Bitner, 2000). Given the student diversity, differences in learning styles, previous life experiences and the variation in service facilities offered by universities, the perceptions of the overall service performance will be different. (Dawson & Conti-Bekkers, 2002; Patterson & Smith, 2001). The perceptions of the students on the service performance can be either positive or negative through their attitudes as well as their expectations on the delivery of the performance (Keaveney, 1999; Boshoff, 1997). If a positive attitude is formed, Positive WMO (word of mouth) promotion, student retention and loyalty are achieved, and vice-versa, if a negative attitude is formed (Kau & Loh, 2006; Maxham & Netemeyer, 2002).

Seven constructs were identified in the study: education, social orientation, technology, economic consideration, accommodation, safety, prestige and image.

Fuzzy sets and Fuzzy Numbers

Definition 1: Fuzzy set

Let X be a universe of discourse, \( \tilde{A} \) is a fuzzy subset of X such that for all \( x \in X \). There is a number \( \mu_{\tilde{A}}(x) \) which is assigned to represent the membership of x to \( \tilde{A} \), and \( \mu_{\tilde{A}}(x) \) is called the membership function of \( \tilde{A} \) (Zadeh, 1965).

Definition 2: Fuzzy number

A fuzzy number \( \tilde{A} \) is a normal and convex fuzzy subset of X. Here, the ‘convex’ set implies that (Zadeh, 1965)

\[
\forall x_1, x_2 \in X, \quad \forall \alpha \in [0,1] \quad \mu_{\tilde{A}}(ax_1 + (1-a)x_2) \geq \min(\mu_{\tilde{A}}(x_1), \mu_{\tilde{A}}(x_2))
\]

Definition 3: Triangular fuzzy number

A triangular fuzzy number \( \tilde{A} \) can be defined by a triplet \((a, b, c)\). The membership function is defined as

\[
\mu_{\tilde{A}}(x) = \begin{cases} 
(x-a), & a \leq x \leq b, \\
(b-a), & b \leq x \leq c, \\
(c-b), & c \leq x, \\
0, & \text{otherwise}
\end{cases} \quad (1)
\]

The addition, multiplication, subtraction and division operations of the triangular fuzzy numbers are expressed below (Oliveira, 1997).

Fuzzy number addition \( \oplus \)

\[(a_1, b_1, c_1) \oplus (a_2, b_2, c_2) = (a_1 + a_2, b_1 + b_2, c_1 + c_2) \quad (2)\]

Fuzzy number multiplication \( \otimes \)

\[(a_1, b_1, c_1) \otimes (a_2, b_2, c_2) = (a_1 \times a_2, b_1 \times b_2, c_1 \times c_2) \quad (3)\]
Definition 4: A linguistic variable is characterized by a quintuple \((x, T(x), U, G, \tilde{M})\). \(x\) is the name of value. \(U\) is the universe of discourse, which is associated with the base variable. \(T(x)\) denotes the term set of \(x\), that is, the set of the name of linguistic value of \(x\), with each value being a fuzzy variable generically denoted by \(x\) and ranging over \(U\). \(G\) is the syntactic rule for generating the name \(X\), of values of \(x\). A particular \(X\), that is name generated by \(G\), is called term. \(M\) is semantic rule for associating with each \(X\) its meaning, \(\tilde{M}(x)\), \(T\) which is fuzzy subset \(U\) (Zimmermann, 1987).

Definition 5: Yager’s weighted goals method: let \(X = \{x_1, x_2, \ldots, x_n\}\), \(i = 1, 2, \ldots, n\), be a set of alternatives, The goal is represented by fuzzy sets \(G_j\). The importance weight of goal is expressed by \(w_j\), \(j = 1, 2, \ldots, m\). The attainment of goal by alternative is expressed by degree of membership \(m_{gj}\). The fuzzy set decision, \(D\), as then intersection of all fuzzy goals, that is, \(\mu_g(x_i) = \min \{\mu_{gj}(x_i)\}\), Yager allows for different importance of the goals and expresses this by exponentially weighting of the membership function of the goals. Importance of weights is determined by AHP method (Yager, 1994).

\[
\mu_{gj}(x_i) = \left(\mu_{gj}(x_i)^{\mu_i}\right)
\]

(4)

Cheng, Yang and Hwang (1999) proposed a new method for evaluating weapon systems by AHP with fuzzy variable based on Yager’s weighted goal method.

Fuzzy Importance-Performance Analysis

IPA has been applied as an effective means of evaluating a firm’s competitive position in the market, identifying improvement opportunities, and guiding strategic planning efforts (Hawes & Rao, 1985; Myers, 1999). IPA, first introduced by Martilla and James (1977), identifies which product or service attributes a firm should focus on to enhance customer satisfaction (Matzler, Fuchs & Schubert, 2004). Recently, Matzler, Bailom, Hinterhuber, Renzl and Pichler (2004) noted between the single attribute variables a rather strong multicollinearity is to be expected. Therefore, he declares multiple regression analysis is an inappropriate tool for deriving reliable impact measures when multicollinearity exists within independent variables. As suggested by Hair, Anderson, Tatham and Black (1995), partial correlation analysis is more suitable than regression analysis for quantifying the influence of independent variables on dependent variables when multicollinearity exists within independent variables. Therefore, Matzler et al. (2004) used dichotomized partial correlation analysis with dummy variables to identify the three factors category of each single attribute.

Generally, surveys examining customer perceptions of satisfaction or service quality have used questionnaires in which respondents indicate their feelings with reference to selected linguistic terms. But human judgments of events may vary significantly according to the subjective perceptions or personality of individuals, even when the same linguistic term is used (Chiou, Tzeng & Cheng, 2005). Thus, when using fuzzy number to represent specific linguistic terms, researchers must consider differences among survey respondents.

RESEARCH DESIGN

Importance-Performance analysis commenced from the late 1970s and is widely used in the various SWOT analyses of the manufacturing industries, service industries, tourism and retail businesses. (Cheron, McTavish & Perrien, 1989; Chapman, 1993; Kozak & Nield, 1998; Chu & Choi, 2000). O’Sullivan(1991) emphasized that this method has simple characteristics and is convenient to use. Its processes include the following four steps:

(1) Lists out the attributes of the service items and develops them into questionnaire questions.

(2) Allows the international students to appraise the degrees of “importance” and “performance” they give to these attributes. The degree of importance points at the importance the participants give to the activities of the attributes (prior to expectations); whereas, the degree of performance points at the performance on the attributes given by the providers (practical experience).

(3) The degree of importance is placed on the vertical axis and the degree of performance is placed on the horizontal axis. The values of the various attributes of the degrees of importance and performance are viewed as the coordinates and are shown in two dimensional spaces.

(4) The total average of the coordinates of the various attributes is used as the separation point and the spaces are divided into four quadrants (fig. 1).

This research gathered the international students of colleges in northern, central and southern Taiwan and used them as the surveying targets. The analysis results show the following 8 items: A2. Good access to lecturers, A3. High standards of teaching by quality lecturers, B3. Close working relationships with all students, C2. Cost of living, D1. Safety, D2. Life-style, F1. Access to computer facilities, F2. Availability of modern facilities. The continuous maintenance of these items can maintain the competitive advantage of Taiwan in attracting international students. However, A1. Valuable feedback from lecturers, and G2. Good standards still need to be improved (table 2).
Table 2: IPA analysis table of the “strategic factor used by international students in their selection”

<table>
<thead>
<tr>
<th>IPA dimension</th>
<th>Service items and contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>“keep up the good work” quadrant</td>
<td>A2. Good access to lecturers, A3. High standards of teaching by quality lecturers, B3. Close working relationships with all students, C2. Cost of living, D1. Safety, D2. Life-style, F1. Access to computer facilities, F2. Availability of modern facilities</td>
</tr>
<tr>
<td>“Concentrate Here” quadrant</td>
<td>A1. Valuable feedback from lecturers, G2. Good standards</td>
</tr>
</tbody>
</table>

The results of the importance-performance analysis of this research are placed into four quadrants. The 1st quadrant shows the high degrees of importance and satisfaction given to the methods in this quadrant by the international students. In other words, the measure for the various items in this quadrant should be “keep up the good work”. The 2nd quadrant shows the general recognition and high importance given to the measures in this quadrant by the international students and the satisfaction results are not up to the mark and belongs to the need to “concentrate here”, and therefore, must be rapidly improved. The 3rd quadrant shows a low degree of importance and satisfaction given by the international students and the measures showed “low priority” and are secondary to the improvement domain. The 4th quadrant shows low expectations, but high satisfaction of the international students and the measures in this quadrant are already able to satisfy the needs of the international students and belong to “possible overkill”. The information analysis results of this research influenced the relationship of importance-performance of the educational factors of the international students (figure 1).

1st quadrant (keep up the good work)

The related measures in quadrant 1 include A2. Good access to lecturers, A3. High standards of teaching by quality lecturers, B3. Close working relationships with all students, C2. Cost of living, D1. Safety, D2. Life-style, F1. Access to computer facilities, F2. Availability of modern facilities. This is the advantage of niche of the educational environment in Taiwan and should be “keep up the good work”. “D1. Safety” received the most approval from the students and the degrees of importance and satisfaction is 0.736 and 0.665, respectively, which is apparently higher than the other measures in the same quadrant (figure 1).

2nd quadrant (concentrate here)

In the 2nd quadrant, the expectations of the international students are high, but the degree of agreement is low and this quadrant requires “concentrate here”. Integrating the results, A1. Valuable feedback from lecturers, and G2. Good standards require improvement and the prioritized investment of resources must be immediately improved.

3rd quadrant (low priority)

In the 2nd quadrant, the expectations of the international students are high, but the degree of agreement is low and this quadrant requires “concentrate here”. This shows that the needs of the students for these measures were low and are dissatisfied with the practical performance of these measures. Compiling the research results, B1. Counseling services, C1. Casual jobs, C3. Opportunities for migration, E1. Image and prestige internationally, E3. Image and prestige in home country, G1. Reasonable cost must be appropriately incorporated into secondary priority for improvement.

4th quadrant (possible overkill)

In the 4th quadrant, the expectations of the international students are low and the degree of agreement is high, and this quadrant belongs to the “possible overkill” domain. Integrating the results, B2. Social activities, B4. International orientation programs, E2. Image and prestige in Taiwan showed the highest degree of satisfaction for the international students and is not considered to be important influencing factors.

Generalizing the above research results, the present advantage of Taiwan include the “safety” and “modern facilities” factors, whereas the “valuable feedback from lecturers” and “good standards” are the important items that require improvement.
**DISCUSSIONS & CONCLUSIONS**

International students consider that safety must have the highest degrees of importance and satisfaction in their strategic factors.

This research found out that safety is the most important strategic item when international students select the countries they want to study in and Taiwan achieves the highest degree of satisfaction. This shows the advantage of niche in Taiwan when attracting international students and is worth it to be continuously maintained. Moreover, due to the unfamiliarity of the place, international students relatively give importance to the affinity of the teachers (A2. Good access to lecturers), and this item belongs to the advantage item of the research. F2. Availability of modern facilities also belongs to one of the important factors of effectively attracting international students. Moreover, even though B3. Close working relationships with all students is not included in this quadrant; it is relatively required to be strengthened as compared to the other factors. This is also worth it for colleges in Taiwan to pay attention to and strengthen in order to attract international students.

“Valuable feedback from lecturers” and “Good standards” require strengthening and improvement in the strategic factors.

This research found out that “valuable feedback from lecturers” and “good standards” are considered by international students that requires improvement. From the second random interview results, it was found that some of the international students were passive in their interaction with classmates and teachers because of their inability to communicate verbally as well as their inability to write and read. This may cause the international students to be dissatisfied with the present valuable feedback from lecturers. Moreover, some international students come from countries where the standards of living are lower than those in Taiwan; therefore, most of them are dissatisfied with the living standards in Taiwan where the rent may be higher. Moreover, due to their inability to communicate effectively and read the contracts for renting, they are dissatisfied with the living standards in Taiwan.
“C3. Opportunities for migration” is the secondary point for improving, “B2. Social activities” is oversupplied

Another factor that international students select Taiwan to study is the chances of finding a job or the probability of immigration after they graduate. However, the research results showed that the present law does not approve of such factors, thereby, international students list this as the second point for improving. This also provides references to business units in their future strategies. Moreover, “social activities” is oversupplied and attention is worth it to be paid to. This can be due to the fact that many international students are already prepared when they choose the place to study and friendship and love among their own can assist the international students to settle. This measure is already saturated and oversupplied.

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Developing Engineering Majors’ Intuitive Thinking of Calculus
with Interactive Visualization Tools

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Abstract

Engineering majors usually show their deficiency in dealing with variable quantities and transforming algebraic concepts into pictorial thinking in calculus. In this study, we designed an interactive tool to encourage learners’ intuitive thinking and enhance their visualization ability in calculus. The purpose of our study was to investigate whether the interactive visualization tool can make mathematical concepts easier to learn and help learners get a greater comprehensive understanding of significant conceptions in calculus. We found that the interactive visualization tool generally can inspire students to explore nontrivial mathematical concepts and improve their intuitive understanding of calculus concepts.

Keywords: Calculus, Computer-Based Learning, Interactive Visualization Tool (IVT).

INTRODUCTION AND BACKGROUND

With its wide range of applications in scientific and technological disciplines, calculus is fundamental for all engineering majors. Calculus is also necessary for the success in several subjects at the undergraduate level (Biza & Zachariades, 2007). But relevant research has consistently indicated that it is difficult for beginners to intuitively grasp the abstract concepts, and the majority of students struggle in understanding basic calculus concepts (e.g., Harel, Selden, & Selden, 2006; Artigue, Batanero, & Kent, 2007). Students often revealed their barriers in understanding the dynamic concepts of differentiation and integration. Engineering majors usually have a deficiency in dealing with variable quantities and transforming algebraic concepts into pictorial thinking. Though several reform programs have been implemented and reform-based textbooks have been created, the output of calculus reform should not only be focused around textbooks. Rather, it could be a learning platform bridging the gap between preliminary and advanced concepts and knowledge (Liu et al., 2009). Among all approaches, the use of technology in improving calculus learning has received much discussion.

Modern technology, especially computer assisted instruction, is widely used in teaching and learning. Sedig and Liang (2006) indicated that computer-based mathematical cognitive tools are a category of external aids intended to support and enhance learning and cognitive processes of learners. Computer-based mathematical cognitive tools often contain interactive visual mathematical representations, which are graphical representations that encode properties and relationships of mathematical concepts. It empowers students with more flexibility for implementing the dynamic interface.

Regarding technological issues in mathematics education, the interaction among representation, visualization, and mental imagery is a fundamental concern (Drijvers et al., 2010). Following Kaput’s advocacy of potential notations of dynamic interactive media (Kaput, 1998), a considerable amount of research has focused on the relationship between visualization and students’ analytical thinking. Taking this issue into account, we designed an interactive visualization tool (IVT) by using Java applets to encourage learners’ intuitive thinking and enhance their visualization ability in calculus. As “fun is the driving force behind learning,” IVT created an online learning environment that was free, interesting, and easy-to-use.

Liang and Sedig (2010) proposed two primary features of IVTs: (1) they maintain and display information in the form of visual representations or visualizations; and (2) they allow students to operate upon or interact with these visualizations via a human-computer interface. Because iterative methods are important in solving real world problems, students’ first exposure to iterative methods is required to be as positive and simple, yet as complete, as possible (Strong, 2006). Likewise, IVT allows easy visualization and experimentation in learning and teaching calculus.

The main goal of this study was to explore whether the computer-based IVT can make mathematical concepts easier to learn and help college students obtain a more comprehensive understanding of significant conceptions in calculus. We constructed a computer-based IVT with the assistance of tutorials to present calculus concepts graphically. In order to achieve our goal, an online IVT was designed and implemented. The tool, a computer-based clinical instruction through Java applets, was intended to develop an appropriate understanding of the dynamic nature of differentiation and integration in calculus. The strengths and weaknesses of the developed interactive visualization tool will be discussed in our
study and several concerns are also addressed.
In Section 2, we describe the methodology of the study, including a brief description of the mathematical domain and IVT used in the study. We then report in detail the results of our study and some sensitivity analyses in Section 3. Finally, in the last section we conclude our work and reveal some current and future extensions.

RESEARCH METHODOLOGY

Participants

Overall, 12 college freshmen (4 females and 8 males), demonstrating difficulties in grasping differential and integral concepts, were invited to participate in the study. They were engineering majors with ages ranging from 18 to 20 years old and were enrolled in a midsize 4-year technological university in central Taiwan. They all graduated from vocational high schools and 25% of them failed calculus in the first semester.

Computer-Based IVT

Liang and Sedig (2010) suggest that visualization tools play an important role in enhancing students’ learning experiences, especially when dealing with more difficult, abstract concepts. The IVT designed in this study was implemented through Java applets aimed to encourage learners’ intuitive thinking and enhance their visualization ability in calculus. All content was set up with Java or Java 3D and students were required to download a Java virtual machine to activate the system. For more details about our Computer-Based IVT, please refer to the website: http://math.ncut.edu.tw/mathjava/Java_App_2010/java.php


On the operating platform of IVT, users were first shown concepts relative to each topic followed by instructions for implementing the interactive applets. Some illustrative concepts of calculus with animation or interactive Java interface then appeared (see Figure 1).

Because “differentiation” and “integration” are two fundamental operations of calculus, the first two of the following examples are typical. In the third example, we use 3-dimensional (3D) interactive visualization demonstrations to present the procedure for the computation of the volume of the revolving solid by the disk method.

Topic 1: Secant and Tangent Lines of a Function

The notion of a limit is fundamental to the study of calculus. The purpose of our first example is to improve students’ understanding of the limit by grasping the connection between secant lines and tangent lines. In this IVT, as shown in Figure 2, we can specify any four real numbers \( c_0, c_1, c_2, c_3 \), to graph the polynomial function of the form

\[
f(x) = c_0 + c_1x + c_2x^2 + c_3x^3
\]

Then we choose a real number \( c \) by moving the slider. Fix the number \( c \) and let \( P(c, f(c)) \) be the point of tangency on the graph of \( f \). The tangent line (red line) to the graph \( f \) at the point \( P \) is shown in Figure 2.
The problem with finding the tangent line at point $P$ boils down to the problem of finding the “slope” of the tangent line at point $P$, and we then can approximate this slope using a secant line through the point $P$ and a second point on the graph $f$. In this IVT, as second point $Q(c+h, f(c+h))$ moves along the curve $f$ towards point $P$ by changing the value of $h$ from 1 to 0, the secant line through points $P$ and $Q$ will approach the tangent line at point $P$ (see Figure 2).

The specific value of the right-hand side of this equation is a difference quotient. As point $Q$ moves along the curve $f$ towards point $P$, that is, as $Q$ approaches $P$, the slope $m_{sec}$ of the secant line will approach the slope $m_{tan}$ of the tangent line.

Students were allowed to implement this dynamic figure (see Figure 2, Figure 3, & Figure 4) to explore how the different quotient $m_{sec}$ approximates to the slope $m_{tan}$ by changing the value $h$ from 1 to 0 as point $Q$ moves along the curve $f$ towards point $P$. Thus

$$m_{tan} = \lim_{h \to 0} m_{sec} = \lim_{h \to 0} \frac{f(c+h) - f(c)}{h}.$$  

The limit process used to define the slope of a tangent line is also used to define one of the two fundamental operations of Calculus - “differentiation”.

**Topic 2: Riemann Sums.**

In Topic 1, we visualize how the limit process is applied to the slope of a secant line to find the slope of the tangent to a general curve. A second classic problem in calculus is finding the “area” of a plane region bounded by the graphs of functions. We also designed an IVT to help students understand this problem. In this problem, the dynamic figure is applied to the area of a rectangle to find the area of the region that is bounded by the graph of a function.
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Figure 7: The upper sum of the area with \( n = 10 \).

Figure 5: The area of the region that is bounded by the graph of the polynomial function \( f(x) = x^2 \) on the interval \([0, 2]\).

As shown in Figure 6, we specify six real numbers \( c_0 = 0, c_1 = 0, c_2 = 1, c_3 = 0, a = 0, b = 2 \), and \( n = 10 \), that is the polynomial function \( f(x) = x^2 \) with a partition \( P \) that breaks up the interval \([0, 2]\) into 10 subintervals. Clearly the graph of \( f(x) = x^2 \) on the interval \([0, 2]\) is increasing. If we choose \( x_i \) to be the right point \( x_i \) (or left point \( x_{i-1} \)) then the Riemann Sum

\[
R_U = \sum_{i=1}^{n} f(x_i) \cdot \frac{b-a}{n}
\]

\[
R_L = \sum_{i=1}^{n} f(x_{i-1}) \cdot \frac{b-a}{n}
\]

is an upper (or lower) sum of the area bounded by the graph of \( f(x) = x^2 \), the \( x \)-axis, the vertical line \( x = 0 \) and \( x = 2 \). As shown in Figure 6 & 7, the area of the region is between the Riemann sums \( R_U \) and \( R_L \). Using the dynamic figure, as we increase the number \( n \) of rectangles, the approximation tends to become better and better because the amount of area missed by the rectangles decreases (Figure 5).

Applying the limit to the Riemann sum can also help students understand the definition of “definite integral”, the fundamental operation of calculus.

**Topic 3: Volume: The Disk Method.**

If a region in the plane is revolved about a line, the resulting solid is called a solid of revolution (Figure 8), and the line is called the axis of revolution. In this IVT, several functions defined on the plane can be illustrated. One may choose a function \( f(x) \), the vertical lines \( x = a, x = b \), and \( x \)-axis to form a closed region (Figure 9), we can revolve it about the \( x \)-axis by angle \( \theta \). Using a slider of \( n \), we have a partition that breaks up \([a, b]\) into \( n \) subintervals.
We see that the radius of the disk is a value of the function $f(x)$ describing the curve and the thickness as an increment along the $x$-axis. In general, we point out that the solid is sliced into approximating cylindrical disks. The $i$th disk has a radius of $f(x_i)$ with thickness $\Delta x_i$. Therefore, a solid generated by revolving about the $x$-axis, the volume of the $i$th approximating disk is

$$V_i = \pi f^2(x_i) \Delta x_i.$$ 

Summing up the volumes of all disks (Figure 11), coupled with the concept of the definite integral, will lead to the standard integral formula for the disk method

$$\int_a^b \pi f^2(x) \, dx.$$ 

Design

A mixed method (quantitative and qualitative) research design was used in the present study. To investigate participants’ initial understanding, they were asked to answer a set of multiple-choice questions on a worksheet concerning three topics given above (see Figure 12 for some sample tasks), follow-up interviews were conducted to detect their misconceptions. To avoid distortion of the test results, students were instructed not to make guesses, hence there is an “I don’t know” option in every question. After the pre-test, participants then partook in a computer-based clinical instruction through IVT in a computer lab.

Following the clinical instruction, participants were asked to respond to the second worksheet containing equivalent but different problems with the first worksheet and post-interviews. All three stages were
videotaped and a qualitative investigation was made to explore in what way and to what extent, if any, IVT assisted them in correcting their misconceptions or developing an appropriate understanding about the dynamic nature of differentiation and integration. The pre- and post- interviews and other instruments in the pilot study were used for the development of a quantitative questionnaire. The data were intended to complement the quantitative assessment of students’ general understanding through the use of the pre-test and post-test.

![Figure 12: Sample task for Topic 1: Secant and Tangent Lines of a Function.](image)

1. Secant and Tangent Lines of a Function

The graph of the function $y = f(x) = x^2$ is shown above, and the function passes through three points, $A(1,1)$, $B(2,4)$ and $C(c, c^2)$. Please answer the following questions:

- ( ) 1. How many tangent lines will be at point $A$?
  (a) 0 (b) 1 (c) 2 (d) Infinity (e) I don’t know

- ( ) 2. What is the geometric concept of the expression $\frac{x-2}{x-1}$?
  (a) The slope of the recant line passes through points $A$ and $C$.
  (b) The slope of the normal line passes through point $A$.
  (c) The slope of the tangent line passes through point $A$.
  (d) I don’t know.

- ( ) 3. What is the geometric concept of the expression $\frac{c^2-10}{c-2}$?
  (a) The slope of the recant line passes through points $A$ and $C$.
  (b) The slope of the tangent line passes through points $A$ and $C$.
  (c) The slope of the normal line passes through point $A$.
  (d) The slope of the tangent line passes through point $A$.
  (e) I don’t know.

RESULTS

In this section, we report participants’ performance in three stages, (1) pre-test, (2) computer-based clinical instruction, (3) post-test, and sensitivity analyses.

Performance in Three Stages

The results from this study are positive for the use of IVT in teaching and learning calculus. Generally speaking, participants achieved higher scores on the post-test than on the pre-test. As shown in the modified boxplot, Figure 13, the post-test box’s lower bound is a little higher than the pre-test box’s upper bound. There are two extreme outliers on the post-test because two students achieved full mark and the score 100% is higher than $Q_i + 1.5(Q_3 - Q_1)$, where $Q_i$ is the $i$th quartile, $i=1, 3$.

![Figure 13: Modified boxplot of pre- and post-test results in % of total.](image)

Table 1 displays the descriptive statistical data of the Topic 1 test, Topic 2 test, Topic 3 test, and total results. The arithmetic mean increased in the post-test. The standard deviations of the pre-test and post-tests are quite large. The reason for this large variability can be explained by the small number of participants and the ability of the participants (25% of the participants failed calculus in the first semester). Participants’ mathematical abilities varied and the performance of participants had large variations.

![Table 1: The descriptive statistical data in % of test.](image)

Table 2 shows the results of paired-sample t test in % between pre-test and post-test results. It shows the differences between scores of the pre-test and post-test results for each case and reveals that the average difference is significantly different from zero. The test results of Topic 1 and 2 both show p-values less than 0.05; hence, there is a significant difference. Namely, the overall performance of all participants had improved after interacting with IVT on Topic 1 & 2. The results of Topic 3, however, indicate insignificant differences between the pre-test and post-test. Though our computer-based clinical instruction showed no effects on Topic 3, there is a significant difference in the overall test.

![Table 2: Paired-sample t test in % on pre-test and post-test results of test.](image)
Sensitivity Analyses

By the time of the pre-test (the middle of the second semester), the students had learned the topics of limit, derivative, and Riemann sums and they had just begun to study the introduction of Volume: The Disk Method, the central concept of Topic 3. As shown in Table 2, the difference of the means between pre-test and post-test results on the Topic 3 test was the smallest, suggesting that more time was allowed for students to learn and think, creating a greater effect achieved by IVT.

Additionally, in order to get more insight into students’ conceptions, we interviewed the students to detect their misconceptions with questions such as: “What is a tangent line?” and “What is a secant line?”

[S3]: The tangent line is a line that has one common point with the graph.

Then we asked them to give an example on a graph. After they plotted the tangent line at the point of tangency, we extended the graph such that the constructed tangent line could cut the curve at another point.

[I]: What do you think right now? Is it still a tangent line?
[S3]: Hum… I don't know.

It appeared that some students’ understanding of the tangent line remained naive.

On the other hand, it was easy for participants to compute the value of \( \lim_{c \to 1} \frac{c^2 - 1}{c - 1} \), but when asked about the geometric meaning of this limit, most of them failed to answer. Compared to students at general high schools, the participants received more professional and practical training, with less mathematics and general education. Mathematics, as an academic subject in technical and vocational institutes, is usually regarded as a knowledge source for a profession instead of a discipline for training one’s mathematical thinking. When they took the multiple-choice test of abstract problems, they were usually inclined to eliminate the wrong options rather than compute the correct answers. They often failed to demonstrate a clear conceptual understanding and, in this manner, memorizing and using formulas became dominant ways of learning mathematics.

Note that, even after working with IVT, some of the students still demonstrated difficulties in grasping abstract mathematical concepts. For example, few of them were able to answer questions like: Suppose there is a point \((a, f(a))\) on the graph of the function \(y = f(x)\). “What is the geometric concept of the expression:

\[ \lim_{b \to a} \frac{f(b) - f(a)}{b - a} \] ?”

At the end of the last interview question, participants were asked to respond to the following question: “This computer-based interactive visualization tool could help me learn this topic’s concepts.” The question was rated on a 5-point Likert scale, where strongly positive responses were assigned a value of 5, and strongly negative responses were assigned a value of 1. Table 3 shows participants’ responses are very positive for each topic.

Table 3: Participants’ responses to IVT.

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<th>Topic 1</th>
<th>Topic 2</th>
<th>Topic 3</th>
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<tr>
<td>Mean</td>
<td>4.30</td>
<td>4.25</td>
<td>4.17</td>
<td>4.31</td>
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Participants also stated that IVT has the potential to assist the studying of certain calculus concepts and they can benefit from integrating the interactive visualization demonstrations into “traditional” calculus curriculum in the classroom.

CONCLUSIONS AND IMPLICATIONS

In this paper, we have presented a computer-based learning environment with IVT through Java applets to learn mathematical concepts both in the classroom and at home without any restrictions. Some examples of how computer-based IVT can be used to explore basic concepts of differentiation and integration in calculus were provided. We also attempted to study whether the computer-based IVT can make calculus concepts easier to learn and help college students get a more comprehensive understanding of significant concepts.

Results from the study provide evidential support for the effect of using IVT for college students. In particular, participants suggest that IVT can be used to develop an appropriate understanding about the dynamic nature of differentiation and integration in calculus. Results also imply that the IVT generally can inspire participants to explore nontrivial mathematical concepts and improve their intuitive understanding of mathematical concepts, especially when dealing with more difficult and abstract concepts.

However, we also found some limitations in our research, (1) the sampling method of the participants; (2) the small number of participants; (3) only three calculus topics were investigated, and (4) students’ difficulties in making a meaningful connection between algebraic expressions and visual representations. Further studies with more comprehensive designs are needed to gain more information about the benefit of using IVT.

We plan to extend our research in two stages. The first stage includes: (1) exploring more new ideas for improving the design of IVT; (2) studying how to integrate IVT into the calculus curriculum in the classroom; (3) assessing what topics are the most appropriate and can benefit the most through the use of IVT; (4) investigating different ways of assessing

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students’ learning in IVT. After the first stage, we will continue to develop in: (5) designing a new experimental model to integrate IVT into the teaching of calculus; (6) testing the effectiveness of the experimental model by involving control and experimental groups; (7) spreading IVT around and helping more students in learning calculus. It is hoped that the research can be further extended to make IVT more helpful and useful in mathematical learning.

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   Top: 3 cm | Header: 1.5 cm | 2 Columns
   Bottom: 2 cm | Footer: 1.5 cm
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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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