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Learning Environments – Laboratories at the Cross Roads

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ABSTRACT: Laboratories and technical hands on learning have always been a part of Engineering and Science based university courses. They provide the interface where theory meets practice and students may develop professional skills through interacting with real objects in an environment that models appropriate standards and systems.
Laboratories in many countries are facing challenges to their sustainable operation and effectiveness. In some countries such as Australia, significantly reduced funding and staff reduction is eroding a once strong base of technical infrastructure. Other countries such as Thailand are seeking to develop their laboratory infrastructure and are in need of staff skill development, management and staff structure in technical areas. In this paper the authors will address the need for technical development with reference to work undertaken in Thailand and Australia. The authors identify the roads which their respective university sectors are on and point out problems and opportunities. It is hoped that the cross roads where we meet will result in better directions for both.

INTRODUCTION

When we think of higher education in technology fields such as engineering and science the vision of interactive learning environments, especially laboratories, is prominent. When visitors come we show them around our facilities and when we advertise, a key selling point is often the diverse learning experience students can expect. Laboratories feature highly in our profile. Are we living up to our own rhetoric? Are universities in countries such as Australia allowing the squeeze on resources and funding to kill off a valuable and already established learning environment? Are universities in countries that are seeking to develop their laboratory infrastructure, such as Thailand, investing appropriately?

It is apparent, that in Australia many university laboratories are on the road to decline. In Thailand the direction is to develop laboratory infrastructure, however the way ahead may not be too clear. Many other countries are in similar positions to either Australia or Thailand. There are also some notable examples of individual universities investing significant resources into their technical facilities [1].

To be effective learning environments, technical areas need strengthening and developing. A partnership model is required between teaching and technical staff.

In this world of the IT super highway, we may be speeding past the reality of practical based, hands on learning. The kind of learning that those who research it tell us is most effective [2]. Let's take an off ramp and look at the need for strengthening and developing technical areas.

SIGNPOSTS TO TAKE NOTICE OF

Saying that laboratories and practical work are important may be stating the obvious however we need to remind ourselves of their value and look for ways to gain more value if they are to be sustained.

The value of laboratory learning is well recognised and prescribed as requirements for accreditation of engineering courses by bodies such as the Institution of Engineers Australia (IEAust) and the Accreditation Board for Engineering and Technology (ABET) in the USA [3&4]. Accreditation teams are very critical if they perceive inadequacies in practical experiences but not as critical as students whose expectations are not met.

Signposts abound that point to the benefits of hands on learning. It is not a new destination. It is so familiar that we may be guilty of treating it with contempt or being forced to leave it for other destinations.

AUSTRALIAN UNIVERSITY LABORATORIES HIT A DETOUR

Current difficulties in most Australian university laboratories may be a detour with some hard times ahead or it may be a dead end. Most will agree that hands on learning is suffering. Decline in Australian universities is not a reflection on the personal high standards of individual staff, academic and general. It is the result of many things including reduced overall funding. This decline impacts on all areas of university operation, especially laboratories. The ability to maintain high standards and good laboratory practice is severely strained to the point of failure.

A review was undertaken in 2001 into the capacity of public universities to meet Australia's higher education needs. The title of the report is "Universities in Crisis" (2001) [5]. The title sets the tone of their findings and articulates the view of most in the sector.

The reader's attention is drawn to sections in this report that indicate the level of concern in practical teaching and laboratories.

- Chapter five, Quality and diversity of teaching
- Chapter six, The funding and management of research

Two quotes from submissions in the report illustrate the point.

- Professor John Agnew (Australian Council of Engineering Deans), Hansard, Perth, p.645 *"I would say that laboratory work is being cut back in all schools. How you can produce an engineering graduate who has not had hands-on experience in laboratory work is beyond me. It is getting to the point where it is not possible to maintain the facilities for the number of students and not update those facilities—in other words, not provide current equipment and current technology. The trend has to be to cut back. The lectures are still given and we still have the quality teaching but it is that practical component and, also, the support that the staff are able to give the students in the learning process that is suffering"*

- Relating to research infrastructure, Professor Ian Chubb (AVCC), Hansard, Sydney, 17 July 2001, p. 987, stated *"When you see all your equipment and your capacity to provide the resources you need for the staff to do the work that they want to be able to do slowly but surely degrading, then that does not make me—or a majority of my colleagues—very happy at all."*

THE ROAD TO TECHNICAL DEVELOPMENT IN THAILAND

The Royal Thai Government has recognised the need to build capacity in the education of engineering and science students. Since 1997 projects have been underway to purchase equipment and strengthen public university faculties in these disciplines. Australia has assisted in being a part of the Thailand-Australia Science & Engineering Assistance Project (TASEAP). One of the major objectives has been to modernise laboratories and strengthen their management.

In opening comments to one of the technical development workshops, the Dean of Engineering, King Mongkut's Institute of Technology - North Bangkok said; *"I don't think I need to underscore the importance of technical support in the context of an engineering faculty. Without it, I simply cannot imagine how our laboratory classes, research and development activities, testing and consultancy services and maintenance of laboratory and utility facilities can be carried out effectively. These tasks can not be performed without a proper technical support structure, proper management and some degree of quality assurance."*

As part of TASEAP programs, workshops, forums and discussions were held all over Thailand during 1998 to 2000. Thai staff also spent a month in Australian university technical areas in 2000. Enthusiasm was high and attendance strong. All who participated were keen to see their technical areas develop to provide high quality learning environments and research facilities. Despite this, significant obstacles were identified and hope was not high that anything would happen in the near future, if at all. For change to take place across such a wide area (36 faculties) there really needs to be a high level of commitment by staff from all levels of all universities.

STANDING AT THE CROSS ROADS

The examples given of Australia and Thailand seem quite divergent. One is a historically strong infrastructure of technical areas being eroded by economic constraints. The other is a desire to develop better infrastructure however many obstacles stand in the way. The authors recognise the differences very well and have concern for their own situation and that of the other. We may be on different roads however we are standing together at a cross road in that we have a similar ultimate need. That need is to develop and strengthen technical areas.

Why does the desire for change, rhetoric and evidence point one way while we continue on the same old road?
Is it because;

1. It really isn't as important or worthwhile as we think?
2. The people who are in a position to do something are too busy and placing their efforts elsewhere.
3. The SYSTEM is so rigid and embedded that it takes a lot to change it?
4. Technical staff are not skilled enough or do not have the skills needed to achieve the change required?
5. Technical staff are not encouraged or allowed to do what is required?
6. The concept of learning by doing is great but it is not being put into practice effectively?
7. Virtual laboratories will take over?
8. There is just not enough money?

Which ever of the above apply, unless it is the first one, we should be doing something to head in the right direction. An old Chinese proverb says, "If we don't change our direction, we might end up where we are headed".

TECHNICAL DEVELOPMENT IN MAEJO UNIVERSITY, THAILAND: A CASE STUDY

The Maejo University case study provides a clear example of what can be done. Co author Nopmanee Topoonyanont presents this case.

In October and November, 2000 along with five other Thai university staff I participated in a TASEAP technical development program with Australian university laboratory managers. One month was spent in Australia and one month in Thailand. The aim was to gain knowledge and practical skills in technical management including: management of laboratory areas, asset management, health and safety, staff issues, organisational structure and development of personal networks. In addition to the learning aspects I was able to observe the differences between Thai and Australian technical staff work practices including management and relationship to student learning. This was one of the key outcomes for success of the program.

Our team of three Australian laboratory managers and six Thai staff from science and engineering conducted a four week program in Thailand during November. The team visited twenty one participating Thai universities to promote technical development Network Forums and discuss needs. Four one day forums were held in November and a fifth was held in December by the Thai staff alone. Academic and technical staff attended and participated in presentations, group discussion, problem identification and networking. Participants were enthusiastic on the issues covered, but felt that the knowledge

gained from these forums was not enough for changing the laboratory system in Thailand.
Recommendations relating to problems identified in the network forums aimed at enhancing the overall management of laboratory areas, technical staff and processes and procedures.

- Universities should consider re-organising support staff structures including the development of a senior non-academic position as departmental technical manager. Responsibility would be for all technical staff, laboratory management and work closely with the academic head.
- Implement an effective staff development program that identifies training needs and allows career advancement. Specifically it is recommended that technical management staff are given appropriate training in areas of human resource management, quality assurance and occupational health and safety.
- Organise and promote future technical development network forums, conferences and discussion groups, focusing on specific issues and developing personal networks of like staff.
- Universities to consider, individually or jointly, sponsoring advisers to conduct workshops or training sessions on specific topics to enhance technical development.
- Gain support and commitment from deans and heads regarding these recommendations. Without this support the future success of such programs will be in doubt.

The success of the TASEAP program and especially the enthusiasm of staff in the forums encouraged me to start a technical development program at Maejo University. On December 28, 2000 the first forum was held in the Biology Department, Maejo University Chiangmai (MJU). The prime purpose was to raise the awareness of laboratory management in MJU. The activities in this forum were divided into three parts;

- Lectures - importance of laboratory management and waste water treatment in MJU,
- Small group discussion - laboratory waste management, maintenance of chemicals and equipment and safety in the laboratory,
- Action planning – including MSDS preparation.

The participants included eighteen academic staff and eleven technical staff from seven departments in various faculties. Problems and action strategies for each topic were recorded. A major outcome was the very positive interaction between academic and technical staff. All agreed on the importance of improving the laboratory environment in all aspects and requested to work on specific issues to report at the next forum.

A second forum was held on January 26, 2001. All of the participants from the first forum attended plus some new staff. The activities included;

- Lecture on emergency response planning,
- Demonstration of MSDS documentation,
- Checklist exercise relating to the Plant tissue culture laboratory and
- Presenting chemical lists from seven departments.

Information from the forum was given to all participants.

In April, 2001 the Associate Dean Faculty of Science and I visited Australia to discuss technical development issues and collaboration with the staff from QUT who had been involved in the TASEAP programs. A successful outcome was raising awareness among senior managers in our university of the importance of technical development. This lead to senior management support and encouragement of the working group to continue their activities in our Faculty.

On October 29, 2001 Gary Rasmussen from QUT, presented lectures on the importance of laboratory support staff in the university and minimising risks in laboratories. Discussions were held on establishment of testing service unit.

During April - May 2002, regulations on occupational health and safety were included in the practical exercise manuals for the subjects, general biology, and principles of plant tissue culture. The general biology course is compulsory for all students undertaking a BSc at MJU.

On July 4, 2002 a health and safety working group was set up by the MJU board. This working group consists of twelve staff, both academic and technical, who are in charge of laboratory management. Most members have been actively involved in the previous forums. Other staff who are responsible for laboratory management are invited as well. The main purpose of the working group is to establish regulations, action planning for improving OHS and laboratory waste management for the university. The group meets every two months with an implementation timeframe of two years.

This example shows that changes of this type are possible and can have a university wide impact.
Imperative aspects are;

- Awareness - of the problems and wish to improve.
- Partnership - academic and technical staff work together.
- Support - senior management are supportive and recognise the needs.
- Drive - mechanism to initiate and progress the development.

In this case the change process has been a bottom up approach. It is proving most successful due to the enthusiasm and ownership of staff at the operational level where the needs can be met.

INTEGRATING TECHNICAL ASPECTS INTO LEARNING

In the Maejo case, health and safety systems development has been a primary focus to date. It may be asked, what has this to do with learning? Health and safety in engineering and science education has two distinctly identifiable elements that need to be addressed;

1. Management – ensuring the safety of those in the facilities, including student awareness and compliance and that activities of the facilities do not harm the environment.
2. Education – ensuring students learn about management of health and safety as part of their professional development.

The case shows work being done primarily on element 1 with element 2 building on the first. It is important to recognise the need to model best practice of health and safety, quality, operational systems and management in laboratories to enable them to be integrated into learning for students. These principles are common to all laboratories in all countries. A solid base of well managed and structured laboratories provides the platform to build practical experiences. They provide the interface where theory meets practice. Students develop professional skills by interacting with real objects in an environment modelling appropriate standards and systems.

Integration should not stop at having high quality laboratories with effective systems. What the students do there and the role of technical staff in learning facilitation is critical. Traditionally, in Australia at least, the technical staff role has been very equipment and support focussed. Practical exercises were procedural and industry standard focused. Tables 1 and 2 indicate the changes in the School of Civil Engineering, QUT.

Table 1: Changes in facilities and staff

80s	2004
Large amount of space	Conversion of Laboratory space into student learning environment
Under utilised space	Flexible space
High number of technical staff	Low number of technical staff
Equipment and support focus	Learning facilitation focus
Focus on industry testing	Part of teaching team

Table 2: Changes in practical exercises

80s	2004
Demonstrator centred	Student focused model
Discrete exercises	Integrated projects
High level of technician support	Flexible delivery with minimum technician input
Procedures based	Discovery based
Set times and format	Defined but not so constrained
Uninteresting	Fun

Laboratories are changing along with technical staff who are making the transition from technician to learning facilitator and manager of technical resources. Academic staff will rely more and more on a diverse range of physical and virtual student centred learning resources managed by technical staff. The role of laboratories will be redefined and fully integrated into teaching units or they will be lost. The role of engineering technical staff will still be one of expertise in technical aspects however they will transfer this expertise to students through the variety of resources they manage [6].

In the School of Civil Engineering, QUT, technical staff have been fully involved with academic staff in development of these new learning environments. Providing experiential and practical learning opportunities is a high priority in the School. Learning environments are being developed to provide for hands on experiences that integrate with virtual and web based material. The Student Experiential Learning Centre (SELC) is being set up to integrate and expand a number of initiatives that make practical laboratory work a more exciting and meaningful learning experience. The main aim is to provide rich, student focused facilities that allow interaction with physical equipment and materials. The old style technician or demonstrator lead practical class is being replaced by web based preparatory modules leading to individual or group physical tasks. Instead of replacing important laboratory exercises with virtual experiments we are utilising the power of computer, web and technology to work with and complement practical work. The learning environment is also enhanced by providing "resource rooms" that are integral with the existing laboratory space. These are linked spaces that allow students to study and work on projects that are associated with practical work in the laboratory. Students will complete web based learning modules that include health and safety training, theory related to the exercise, assessment, ordering test specimens and booking the equipment.

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CONCLUSION

Learning environments of a practical and experiential nature are very important for technology based disciplines. Laboratories are experiential learning environments that are facing significant challenges. If the true value of these resources is to be utilised development is required. Development will be achieved by;

- Senior staff recognition and support,
- Building a strong base of technically competent staff including technical managers,
- Modelling appropriate systems and integrating them into student learning,
- Changing the focus of facilities and practical exercises to provide more student centred learning,
- Using IT tools to enhance and complement hands on work,
- Working as a team with academic and technical staff to achieve common goals.

What road typifies your learning environments? There is opportunity to stop and consider the "cross roads" analogy before we get back on the freeway. We are here now with choices to make. One choice may be to continue on exactly the same road and see where we end up. We may however take a change of direction, join with others and end up in a far better place. Don't leave your laboratories by the wayside.

REFERENCES

1. Carlson, L.E. and Sullivan, J.F., Hands-on Engineering: Learning by Doing in the Integrated Teaching and Learning Program, *Inter. J. of Engng Educ*, 15, 1. 20-31. (1999).
2. Schank, R.C. and Cleary, C., *Engines for Education*, Hillsdale, NJ: Lawrence Erlbaum Associates, Publishers..
3. The Institute of Engineers, Australia, *Manual for the Accreditation of Professional Engineering Courses*, November (1999).
4. The Accreditation Board for Engineering and Technology, (USA), *Criteria for Accrediting Engineering Programs.*
5. Parliament of Australia, *Universities in Crisis (2001)*, Senate Report: From www.aph.gov.au/senate/committee/EET_CTTE/public_uni/report/
6. Bullen, F., Dawes, L.A., and Rasmussen, G., Lab-otomy: Producing the virtual engineer. In *Proceedings of 3rd UNESCO Annual Conference on Engineering Education*, pp. 51-56. Hobart, Australia (2000)