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Using a competence analysis to construct curricula for engineering technology education: a case study from Taiwan

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ABSTRACT: In Taiwan, the vocational and technological education system ranges from the vocational high school level to the technological university level. This began in 1974, when the first four-year technological college emerged. Two-year colleges for vocational high school graduates and five-year colleges for junior high graduates were promoted to four-year technological colleges and universities. These institutions have since boomed. However, the goals of technological universities are blurred by faculty recruited from comprehensive universities. Engineering education has been transplanted directly to technological universities. It has been found necessary to re-construct the engineering technology curricula for technological universities. In this article, the author describes how a competence analysis was used to design the curriculum for technological universities in Taiwan. In order to meet the current educational settings, the author utilised general and professional competences to form courses, rather than the modular concept to form instructional packages for teaching. The author also details the problems encountered in designing the curriculum for Taiwanese technological universities.

INTRODUCTION

There are two university systems in Taiwan: comprehensive and technological. Universities of technology recruit students mainly from vocational high schools, while comprehensive universities recruit students primarily from academic high schools.

Theoretically, university curricula should be designed in order to meet students' abilities; thus, curricula at universities of technology should emphasise practical knowledge and skills. However, the recent boom in universities of technology has made it difficult to recruit faculty with real-world experience, except from comprehensive universities directly in Taiwan.

The worst situation is that curricula also translate from comprehensive universities without any modification, due to the educational backgrounds of faculty at comprehensive universities. This not only causes students to be under-achievers, but also makes them unable to become competent technologists. Although the Ministry of Education has undertaken many efforts, such as paying stipends for instructors to gain experience from industry, the problem has not been solved. The reason for this is that curricula are designed internally by universities themselves, and curriculum evaluation by the government is not easy to perform. In addition, the promotion of faculty is evaluated by how many papers each faculty member has published, rather than their contribution to teaching and services.

This problem needs to be urgently addressed. The Ministry of Education in Taiwan has designated curriculum reform at universities of technology as a criterion for obtaining governmental subsidies. There are two key issues: is there a model for universities of technology when designing the curriculum? And what problems may be encountered at the school when implementing curriculum design? This project is supported by the Ministry of Education in Taiwan to establish a model to design curricula for universities of technology and help them implement the curriculum design.

The project first reviewed related literature, such as the definition of engineering technology and curriculum development models, and proposed a curriculum design model for universities of technology in order to implement their curricula. In this article, the author describes the model proposed by the project, the problems experienced during curriculum design stages, and offers suggestions as reference for schools that are likely to utilise this design model.

JUSTIFICATIONS

It is widely believed that universities of technology cultivate technologists for the benefit of society. However, it is instrumental to establish some rationales for faculty at universities of technology in Taiwan to verify this idea. The following paragraph is an attempt to reconsider the reasons for universities of technology to cultivate technologists.

In Tyler's framework of curriculum, there are five criteria for selecting educational purposes, namely: studies of learners, suggestions from subject specialists, studies of contemporary life, the use of psychology in learning, and the use of philosophy [1]. Tyler seems to place greater importance on philosophy than other criteria for the development of educational purposes, that is, what schools are for [2]. Goodlad argued that education is growth for the individual and society [3]. So learners need to be considered first. Learners at universities of technology are those who graduate from vocational high schools with lower achievements in the cognitive areas.

From the viewpoint of the psychology of learning, Gardner argues for a theory of multiple intelligences and contends that there are different mental operations associated with intelligence [4]. He outlines six types of intelligence, namely: linguistic, musical, logical-mathematical, spatial, bodily kinaesthetic and personal/social. It can be concluded that learners at universities of technology tend to be bodily kinaesthetic, since they graduate from vocational high schools with lower cognitive achievements.

Now to turn back to what a university of technology is actually for in society. Universities of technology recruit vocational students who have lower cognitive achievements. Such universities, not just by their name but in consideration of contemporary society, should then be institutes to cultivate technologists, since a technologist lies occupationally at the upper end of the spectrum between a technician and an engineer – but closer to an engineer. A technologist usually has a bachelor degree and must be applications-oriented, building upon a background of applied mathematics, science and technology. Engineering technologists must be able to produce practical and workable results, install and operate technical systems, and develop and produce products. A technologist must be prepared to make independent judgements to work effectively and safely.

In summary, by studying learners and contemporary society, and the use of the psychology of learning, as well as utilising philosophy, the curricula at universities of technology should be able to cultivate technologists.

Saylor and Alexander presented a systematic approach to curriculum development over four stages, as shown in Figure 1 [5]. In this study, the author emphasises stages one and two, eg curriculum goals and design. How does one describe the goals for technologists? Where can one find these goals? Since technologists work for industry, we can then think to use technologists and their supervisors in industry as resources for goal setting. How do we describe goals? Bobbitt's concept can be utilised here in order to obtain the educational goals for universities of technology.

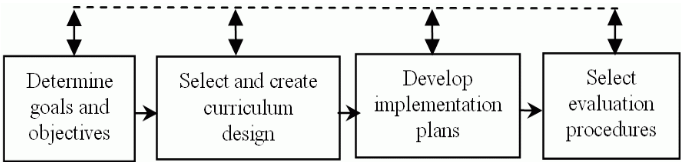

Figure 1: Saylor and Alexander's view of curriculum development.

For Bobbitt, the goals should be derived from the activities that ought to make up the lives of students and, along with these, the abilities and personal qualities considered necessary for proper performance [6]. How can one discover and describe the activities of a specific technologist? The concept of competence, which focuses on what is expected of an employee in the workplace, can be used to describe the activities of a technologist. Competences identify a technologist by a set of attributes, such as knowledge, abilities, skills and attitudes [7]. However, which method should be used to analyse a specific technologist's activities? A job/occupational analysis may be suitable for analysing activities, since a job can be analysed by its tasks, and then identify key attributes, such as knowledge and task attitude. The reason this method was chosen is because vocational students, in general, learn theory by practice, and tasks are the main activities that technologists need to accomplish in industry. Several approaches may be applied to identify a task listing for a specific technologist [8]. Among them, the DACUM model (Developing a Curriculum), developed in Canada, is usually utilised in Taiwan.

A MODEL FOR CURRICULUM DESIGN

A ten-stage model for the design of a work-related curriculum for universities of technology is shown in Figure 2. This has been developed in line with the above-stated justifications and is detailed as follows:

- Carry out a SWOT (strengths, weaknesses, opportunities and threats) analysis for the department;
- Collect and search for job titles that graduates of a department are likely to take;
- Select at least three representative job titles from the selected jobs for a competence analysis;
- Undertake a competence analysis for the representative jobs (competence is analysed into task listing and divided into general and professional competences, with general competence being a generic or essential competence, such as language, mathematics, problem-solving and communication in order to perform a specific job);
- Synthesise these competences into an integrated task listing to reduce repeated competences;
- Identify necessary general knowledge and attitudes for general competence;
- Identify foundation knowledge, safety knowledge, technical knowledge and attitudes for professional competence;
- Group tasks, technical knowledge and attitudes into laboratory or shop courses, and group general knowledge into general subjects, foundation knowledge into theoretical professional courses like applied mechanics or even physics. Steps seven and eight are illustrated in Table 1;
- Determine the credits for each course by how often a task or knowledge is utilised in the job;
- Develop course outlines by collecting the above tasks or knowledge and add necessary the tasks or knowledge into the course outlines (since tasks or knowledge analysis in a competence analysis involves terminal skills, one needs to bridge students' initial abilities and terminal skills for students to learn) [9].

Table 1: Grouping tasks and knowledge in courses.

Duty	Task	Knowledge Attitudes Safety	Subject 1	Subject 2
General-1	G-1-1		X	
	G-1-2		X	
	G-1-3			
Prof-1	P-1-1			x
	P-1-2			
	P-1-3			x
	:	:	:	:
	:	:	:	:
	:	:	:	:

ADVANTAGES OF THE MODEL

Several advantages can be identified from this model in the design of curriculum for universities of technology. The first one is that the model asks the department to collect job titles or professionals that graduates of the particular department will work for and to identify three representatives from these job titles as samples for the competence analysis. These two steps help to ensure that the curriculum of the department is aimed at specific jobs and that course contents are directly obtained from the necessary competences of these jobs. However, since the competences involved in the departmental curriculum design have been obtained from at least three professionals, this will not narrow the cultivation of students and be treated as vocational training.

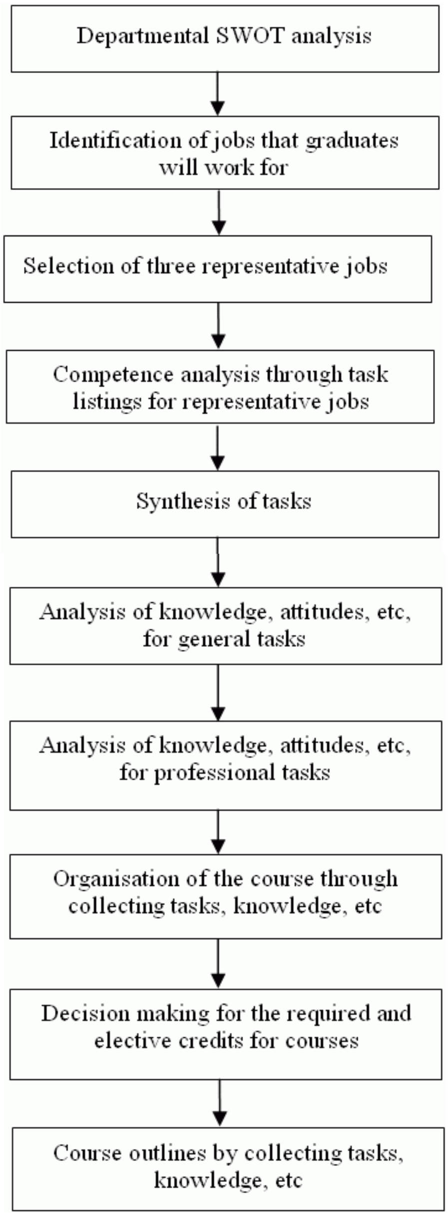

Figure 2: The curriculum design model.

The second advantage is that a competence analysis not only helps in obtaining a task listing for professionals, but also to analyse the necessary knowledge, attitude, safety and so on for a course's contents. This step serves to ensure that teaching focuses on the required skills, knowledge and attitudes that are considered necessary to be successful in the specific jobs.

The third advantage is that a competence analysis usually identifies a job and then helps to develop instructional packages for training use. The model organises tasks and knowledge into subjects, thereby turning back to a traditional teaching mode. That is, tasks are integrated into shop or laboratory courses while knowledge is integrated into theory courses or general courses. In turn, this will be easily adopted in a traditional school setting and will be accepted by instructors as usual without teaching changes.

EXPERIMENTAL STUDY

After the model's approval by a panel of experts, the Ministry of Education then asks universities of technology to use this model to design curriculum for their departments. However, in order to test if the model can be adopted by the departments, several departments from different universities are selected to implement an experimental study following the steps described above to design their curriculum. There are 14 departments in 12 universities that have joining the study under the guidance of a taskforce. These departments include all kinds of fields in universities of technology that target the cultivation of technologists.

Basically, each department follows the designated steps to finalise their curriculum design. Those 14 departments participate at five meetings for the review of implementation in order to make sure that departments utilise the correct procedures to fulfil each step and, if they encounter any problems, the taskforce can be called upon to remedy this. The first meeting facilitates the development of a workable schedule for the plan. This meeting asks the departments to prepare a standard operational procedure (SOP) for the design of the curriculum. The SOP includes rationales to guide the design of the curriculum, the curriculum design committee and the process to develop curriculum. Also, the process of curriculum development should include the following six stages:

- Preparation stage;
- Curriculum design stage;
- Instruction plan stage;
- Implementation stage;
- Evaluation stage;
- Feedback and revision stage.

For the curriculum design stage, job titles should be searched from industry and at least three experts from industry need to be consulted.

The second meeting is set after completing the competence analysis for the representative jobs. These jobs should be selected in consideration of national economic development, student ability, faculty status and departmental facilities. An example of a representative job is a specific technologist job that students can work for. Representative jobs will usually represent at least 70% of other jobs in terms of job activities. The third meeting is set after finishing the knowledge and attitude analysis. The fourth meeting is set after finalising the course framework, with the final meeting set after completing the course outline for each course. This experimental study is then finished within a year.

PROBLEMS ENCOUNTERED AND RESULTS

The SWOT analysis gives the department the opportunity to reconsider where a department should go. The results can also be used as a guide for the department to select job titles that they want to design in the curriculum. Several departments seem to find the way that they plan to go. However, some departments indicate that they cannot identify what their departments looked like before and, therefore, are uncertain which direction to undertake. In particular, faculty may lack certain specialities that result from difficulties in finding specific jobs that their department can cultivate.

At the third stage, some departments have difficulty in selecting three representative jobs. Usually, their thinking goes back to the general terms of a job by using some broad job titles. During the competence analysis stage, they encounter problems when analysing competences or in listing a job's tasks. Some are even unable to use action verbs for a task's description. At the stage of analysing the necessary knowledge required to implement tasks, the committee usually requests too much or profound knowledge, or else uses broad terms or phrases to describe knowledge to implement the tasks.

At stage eight, the committee is supposed to group tasks and knowledge in order to form courses. However, it seems easier for the committee just to pick the course name in use now and find the tasks or knowledge to match that course. However, committee members become conscious of why project work and practice in industry should be taken as required courses for technologists. They also realise that the course or elective should be determined by how often the tasks and knowledge are performed in industry, rather than just by intuition.

After designing the curriculum, those 14 departments realise that courses for a technologist's education must not be just a duplication of an engineer's education. Some courses may even be unnecessary, such as engineering mathematics. Although the concept that instruction for technologists needs more practical experience is quite plausible, it will not be understood without using this model to design a feasible curriculum.

CONCLUSION

In this article, the author justifies the reasons for developing a curriculum design model to be used in Taiwan. A curriculum design model is presented for departments at universities of technology to act as a guideline when designing their curriculum. The strategy used for the model is derived from a competence analysis, and the grouping of tasks and knowledge into courses.

The results indicate that faculty can use this model to develop their curriculum and so that they can realise what should be emphasised in the curriculum for universities of technology. However, a training programme for faculty to use this model is needed. This model may be offered as a reference point for other countries to use if they have similar problems as Taiwan has encountered.

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