COMPETENCY-BASED ENGINEERING CURRICULA – AN INNOVATIVE APPROACH

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Abstract *¾ This condensed paper is a part of the large doctoral thesis* 'Reengineering Technician Education Programmes for Labour Market Orientation through Competency-based Curriculum Development in Polytechnics' *that has been submitted by Prof. Joshua Earnest to the Barkatullah University, Bhopal, India in April, 2001. About 1650 odd technical colleges (called polytechnics in India) offer broad-based engineering diploma programmes for the post-16 year olds. With technological advancements in the industry, they now require in the passouts of these technical colleges a spectrum of core competencies, hitherto not required. How to respond to this scenario was the question. The competency-based curriculum was propounded as one strategy to fulfil their labour market demands. Though world-wide, various competence models were being used by different education and training organisations for specific job-oriented courses, blind copying of these were not found suitable for these unique engineering diploma programmes. This necessitated the analyses of various competence models resulting in the custom-designed 'TTTI - St. Xavier Model' competency-based curriculum for this technical college system and experimented in the St.Xavier's Technical Institute, Mumbai, India. This paper describes the salient features of this model.*

INTRODUCTION

It had been the chronic complaint of the industry that the technical colleges which were producing engineering diploma passouts required to work at the middle level supervisory cadre in the industry were not competent. This was an indicator that their curriculum needed to be reengineered. 'Redesigning the curriculum to emphasise core competencies is undeniably difficult. Those who undertake such a challenge must be willing to put aside long-held beliefs about what a programme must include, raise questions that traditionally have been avoided, and test assumptions about what students know and what curricula now achieve' (Diamond, 1997). Exactly, this was what the author did through this experiment by designing the new competency-based curriculum 'TTTI - St. Xavier Model', while undertaking the doctoral research in *'Reengineering Technician Education Programmes for Labour Market Orientation through Competency-based Curriculum Development in Polytechnics'*.

PHILOSOPHY OF 'TTTI - ST. XAVIER MODEL'

'There is no single version of best practice. External agencies need to be cautious about providing *universal prescriptions***;** problems in any particular country are perhaps best solved by building on the *culture* of TVET which is already well established in the country concerned' (King, 1993). In this backdrop, different definitions were available for the term 'competency'. It is defined differently for different occupations. Wiles & Bondi, (1989) says 'each occupational or professional field needs to develop its own conception and working definition of a competency'. Burke (1989) reiterates that 'each occupational/professional field needs to develop its own concept of a competency-based curriculum'.

Therefore, in the context of the unique technical college system of India and discussions with the industry, the following definition of competency was relevant to the technician education system. This definition evolved is also based on the concept of 'threshold competencies' (Hamlin, 1994) to detail out an operational curriculum for the technical college programmes. Thus, the 'competency' is defined here as *'a statement which describes the integrated demonstration of a cluster of related skills and attitudes that are observable and measurable necessary to perform a job independently at a prescribed proficiency level'* (Earnest, 1997). This definition is illustrated in Figure 1 as a complete system comprising of several sub-systems required performing a given job/task proficiently.

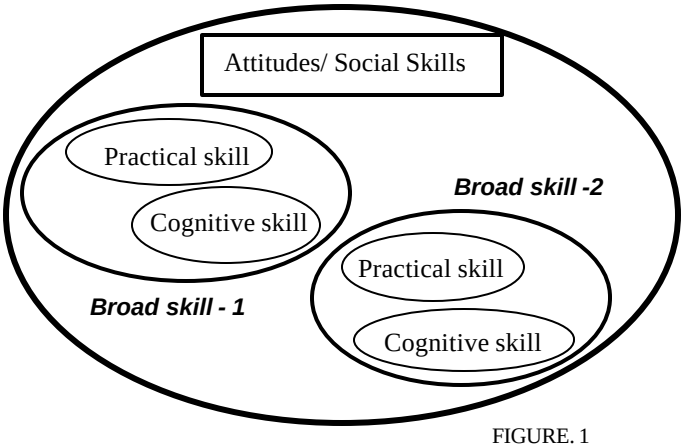

FIGURE. 1
CONCEPT OF A COMPETENCY

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For the industry, the competency logically precipitates out in terms of broad skills and sub-skills about the jobs being performed there. While, the curriculum developer/ teacher thinks in terms of practical skills, cognitive skills and social skills/attitudes to be developed in the students and which are derived from the sub-skills. A few more concepts of this definition explained here adds to its clarity.
This definition means:

- that the competency is an overt and measurable performance in terms of quantity, quality, time, cost or a combination of any of these, for which `action' or `performance' oriented verbs are to be used in writing competency statements.
- a cluster of skills consisting of cognitive(intellectual) skills, practical skills and social skills/attitudes, skilfully weaved together into a whole.
- the skills also involves higher order cognitive skills of Bloom's (1956) taxonomy required to analyse, interpret, design, evaluate, create, plan, troubleshoot, diagnose etc. as well as lower level practical skills of Dave's (1966) taxonomy such as cut, join, machine, measure, solder, paint etc.
- a 'job' is an activity, which has a definite beginning and ending point, that can be performed over a short period of time, independent of other work and which results in a product, service or decision (TAFE, 1988). The job intended of a polytechnic passout will be different from that of a university level graduate engineer and that of a craftsperson, as their competencies lie in between the latter two occupations.
- 'perform' a job at a specified proficiency, means performing a given job successfully every time he/she is asked to do. In other words, tending towards more 'reliability' and 'validity'.
- the 'proficiency level' here is the 'threshold level' i.e. at the entry level to the industry after 3 years of study in the polytechnics.

Related Concepts

The next issue was to establish the relationship between various terms - 'competency', 'aims', 'goals' and 'skills' in this context. David Pratt (1980) defines an ***'aim'*** as something, which provides a basic orientation to the designer/user of a curriculum. The starting point of any curriculum development programme rests on the *aims* of any educational programme. The aims are slogans that excite people about the direction of education. They are orientations - not specific quantifiable outcomes. As the aims are of global quality, only a few aims are necessary to guide education. For example, one of the *aims* of the technical college system could be to *'produce competent technical manpower to man the industries at the supervisory level'.*

'Goals', in contrast to aims, are not open statements. The distinction between aims and goals of education is one of generality (Ornstein, 1988). They are more specific statements written, so that, those responsible for educational/training programme creation can use them as guidelines to achieve particular purposes. Goals are derived from the aims and provide curriculum decision makers and teachers with broad statements of what they should accomplish in terms of student learning as a result of a particular course or educational programme. Generally, they are more in number than aims. They are *'broadcast statements'* that indicate endpoints or expected outcomes of an educational programme. For instance, one of the goals of an electronics engineering diploma programme offered by the technical colleges is *'to produce electronics engineering manpower to work as entrepreneurs and/or supervise the work in the electronics engineering industry and service sector'*

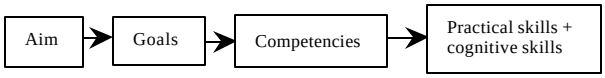


FIGURE. 2
COMPETENCY CONTINUUM

Figure 2 depicts a continuum, wherein, aims are at one end, followed by goals, competencies and different types of skills at the other end. Instructional objectives are behavioral descriptions of learning outcomes in terms of different types of 'skills'- practical skills, cognitive skills and attitudes. On this continuum of aims to skills, competencies lie somewhere in between them. Another way of depicting these concepts could be through figure 3 (Hall, 1976, Soni, 1999).

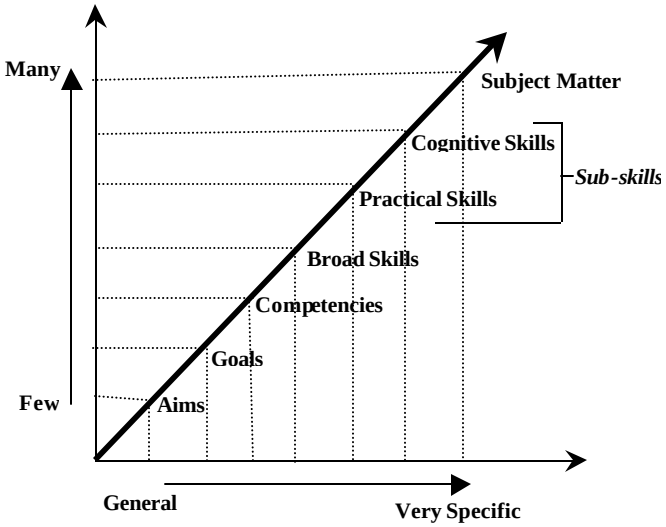


FIGURE 3
AIM-COMPETENCY RELATIONSHIP

For any particular educational programme, the goals, which are derived from the aims, will comparatively have more number of statements generally meant for a whole

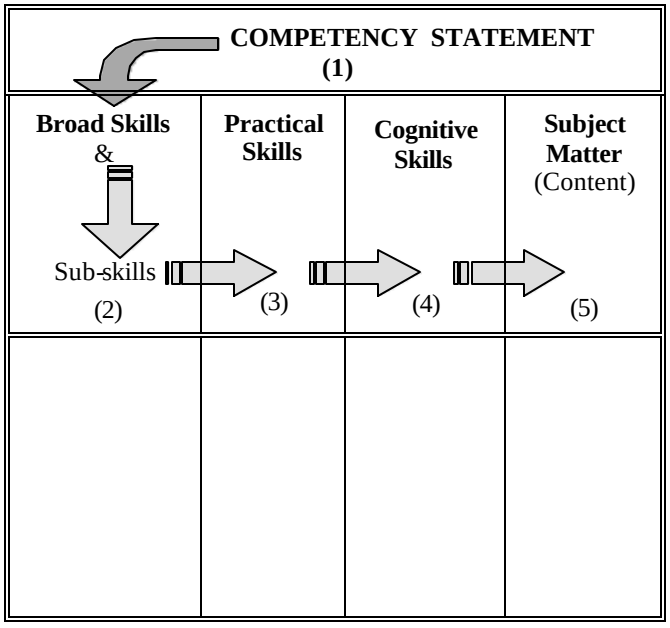
occupation or a branch of engineering. The competencies identified from the industry on the basis of the declared goals will be much more in number and could represent several courses or organised bodies of knowledge. Further, each competency consists of broad skills and relatively more sub-skills (which includes practical skills + cognitive skill + social skills/attitudes).

Curriculum Detailing Format

This new curriculum-detailing format is one of the central pillars of the 'TTTI - St. Xavier Model', of the competency-based curriculum For every competency statement, a competency map illustrated in figure 4 was developed. This formed the basis for the evolution of the *'curriculum detailing format'* shown in Table-I (Earnest, 1997). Here, the placement of each row and column bear a *definite* logical sequence and therefore has been numbered sequentially. Each arrow indicates the origin of a skill from a particular column to end in the next column indicating from where they are derived.

Row No.1 contains the *competency statement* given by the industry. The *curved patterned block arrow* originating from the competency statement in row No.1 of Table 1 and directed to column No.2 indicates that the broad skills are derived from that competency with the help of the competency map also shown in figure 4 shown at the end of this paper. To help in the derivation of practical skills and cognitive skills in column No.3 and No.4, each broad skill was further broken down into a number of *sub-skills* indicated by the vertical striped downward directed block arrow. The industry as a stakeholder is generally interested in row No.1 and column No.2 as discussed earlier in section 2.

TABLE - I
DESIGN FOR CURRICULUM DETAILING



The rest of the columns No. 3, No. 4 and No. 5 are very useful for taking educational decisions and are therefore more crucial to some of the other stakeholders viz. the student, the teacher and the examiner. The sub-skills provide indicators of the type of *practical skills* that are to be stated in column 3, shown by the horizontal dotted block arrow. They also help the teachers to decide the instructional strategy for laboratory/field-work/industry-visit/industrial training. The practical skills are purposefully placed in column 3 and *not* in column 4 as they are derived from column 2 and thereby act as *vehicles* to develop the sub-skills/broad skills.

The continuation of the dotted block arrows from column No.3 to column No.4 further implies that the *cognitive skills* generally a pre-requisite for performing the practical skills are derived on the basis of column No.3 and to a certain extent from column No.2 also. These cognitive skills were written at the 'application level and above' of Bloom's (1956) taxonomy. Here also, it was seen that the cognitive skills function as *vehicles* to develop the broad skills/sub-skills and thereby the competency as in figure 1. This column further helps in deciding the instructional strategy i.e. the type of classroom instructions to be adopted.

The dotted block arrows extending from column 4 into column No.5 indicates that the *subject matter* is derived on the basis of the preceding four columns. These column guides in selecting suitable learning resources, which may be available, based on known 'body of knowledge' or may require to be produced to accelerate the development of the practical and cognitive skills.

When Table-I is seen in its entirety, and when the curriculum document was developed, it could be noted that each competency statement was purposefully made to 'shine out' of every page of the curriculum document. This was deliberately so designed, because the student, teacher and everyone concerned was always reminded that the ultimate focus of the technical college programme is to *develop the competencies* identified by the industry. It also reminded them that all the *intermediate activities* were only *vehicles* contributing towards the acquisition of the competencies, which is another unique feature of this new format. The *student*, when he/she is learning, the *teacher* when planning or delivering instruction, the *examiner* when planning for assessment or actually assessing the student, is reminded that competency is the primary focus of this curriculum.

TTTI - ST. XAVIER MODEL

All these stages of the overall design and implementation of the 'TTTI - St. Xavier Model' including the criteria tests and review blocks lead to the creation of the custom-designed competency–based curriculum development model for the technical colleges education system shown in figure 5 at the end of this paper. This model could be emulated in other

countries where similar technical education programmes are being offered. This is a part of a large doctoral research *'Reengineering Technician Education Programmes for Labour Market Orientation through Competency-based Curriculum Development in Polytechnics'*, submitted by Prof. Joshua Earnest at the Barkatullah University, Bhopal in April 2001. Therefore, the other aspects are beyond the scope of t his paper.

IMPLEMENTATION GUIDE

This document was another unique feature of *the 'TTTI - St. Xavier Model'* to successfully implement this CBC effectively in letter and spirit by all concerned.. Generally, the educational programmes have only a single curriculum document, which is referred to by all stakeholders, rendering it quite voluminous, at times. Since this was a *reengineering* exercise, this CBC was radically a new philosophy for the polytechnic system and to introduce the change successfully necessitated the need of an *'implementation guide'*. Moreover, there were several aspects which were not of much use to the students, but essential for the teacher, examiner and administrator. This document includes the following major sections:

- Competency maps, so that all stakeholders concerned could appreciate the logic of how the practical skills, cognitive skills, attitudes and subject matter were arrived at.
- Suggestions as to what instructional strategies could be adopted in different situations to develop the stipulated competencies.
- Specification table i.e. regarding progressive assessment, end-of-term assessment, summative assessment
- Type of industrial training to be imparted.
- Resources required for the teaching-learning processes
- Media hardware required and their alternatives.
- Media software required and their alternatives
- Laboratory equipment and consumables

THEME PAPERS

This was yet another novel feature introduced for successfully implementing the 'TTTI - St. Xavier Model'. Since this was reengineering exercise and a drastically new design, many of the concepts were quite new to the implementers and therefore, to introduce this 'change' some theme papers *called 'guide documents'* had to be developed, so that all concerned could understand the various dimensions of this new model and always have some documents to 'fall back upon', when in doubt. This seemed essential because all the concerned stakeholders would then become better informed on how to react and behave to this new philosophy of CBC to implement it successfully in letter and spirit. The consultant conceived the various themes, basic designs, trained the faculty and co-authored the following *guide documents* along with the faculty of the polytechnic.

a) Design Philosophy -(Earnest & urjar,1998)
b) Assessment and Certification -(Earnest & Thakur, 1998)
c) Instructional Strategies -(Earnest & Kalsi, 1998)
d) Laboratory Instruction -(Earnest & Joshi, 1998)
e) Industrial Training -(Earnest & Naik, 1998)
f) Counselling of Students -(Earnest & urjar,1998)

CONCLUSION

This innovative competency-based engineering curriculum, designed and implemented in St. Xavier's Institute, Mumbai, a technical college has proved that the competency approach was equally useful for the technical college system offering broad-based engineering diploma programmes.

(As further details are beyond the scope of this paper, samples of the relevant curriculum documents developed through this experiment could be exhibited during the conference).

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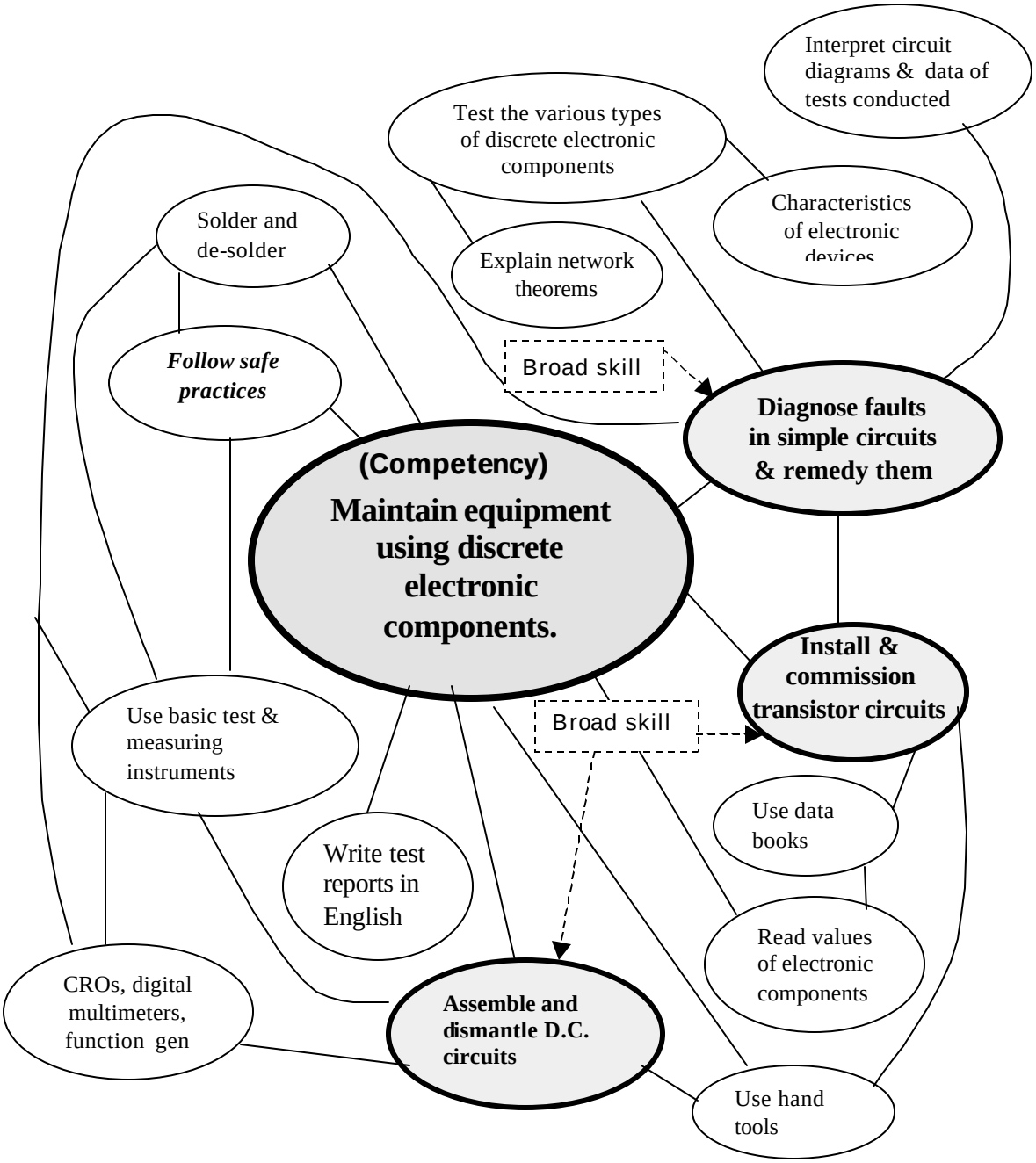

FIGURE 4
COMPETENCY MAP

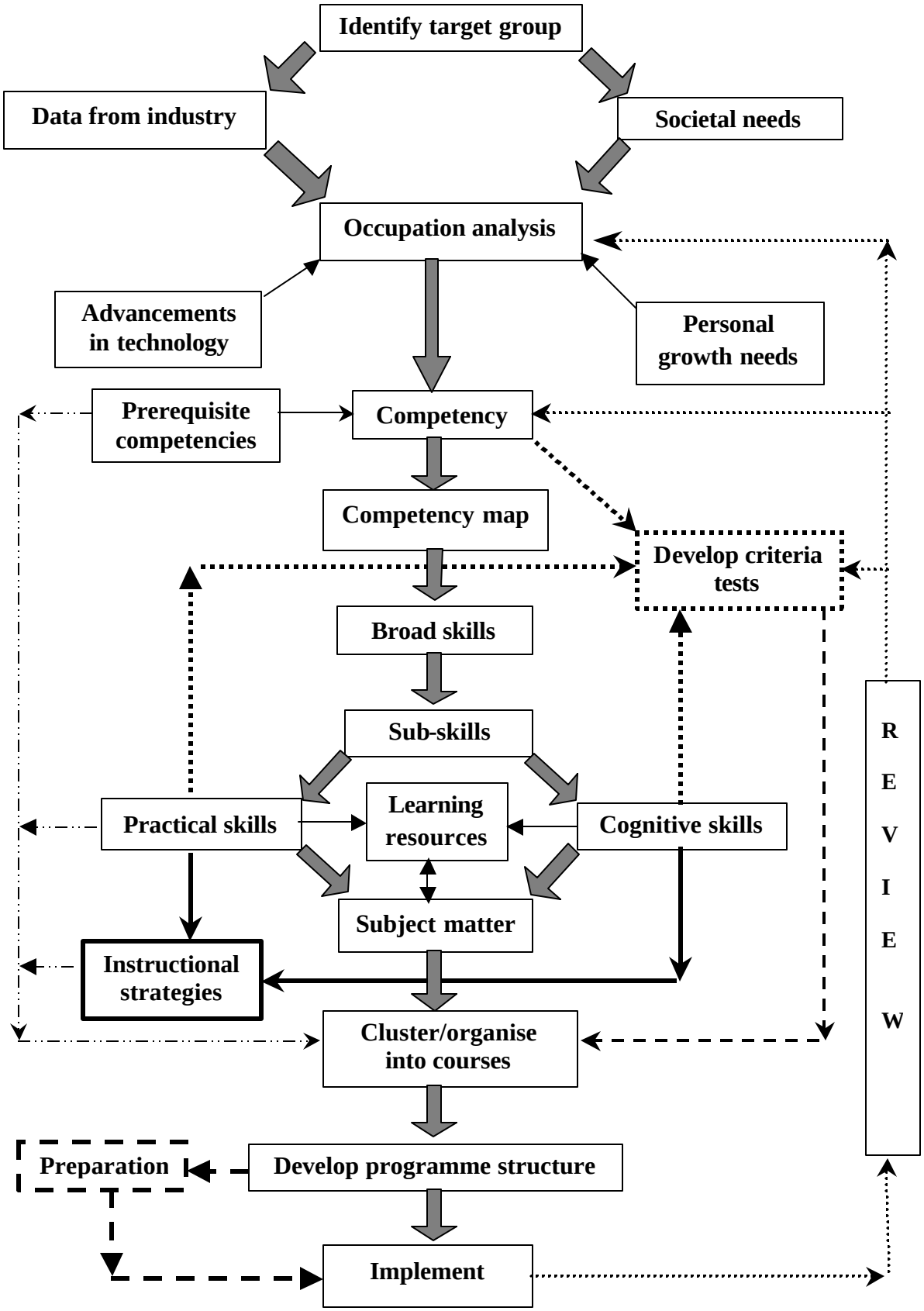

FIGURE.5
TTTI - ST. XAVIER MODEL OF CBC