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Enhancing Thinking for Students in New Times: A Cognitive Modifiability Approach

Introduction

As we approach new times in the 21st century the role of education to bring about a generation of thinkers has been given more emphasis. In order to cope effectively with rapid technological, economic and social changes of tomorrow individuals need to be able to harness their thinking propensities and potentials to learn how to learn, adapt effectively to changing environments, solve problems and confront new challenges. Educators are therefore challenged more than ever before with the need to develop students who would be active, self-motivated and independent thinkers.

Importance of Underpinning Beliefs in Teaching Thinking: The Modifiability of Intelligence

Before one proceed to address approaches to teaching thinking it may be necessary to highlight the importance of one's underpinning belief with regards to the modifiabililty of human intelligence. Gardner (1983) described intelligence as "the ability to solve problems of consequences in a particular cultural setting". How is thinking linked to intelligence? We shall describe intelligence simply as the capacity to think and solve problems. What then is meant by thinking? It is difficult to define or delimit what is meant by thinking and we would take adopt an eclectic

framework. As Swartz and Perkins (1990, p.2) noted we may describe thinking as “including virtually all of those mental acts which one would ordinarily consider to be thinking”. In attempting to enhance thinking we are considering how we could improve the thinking processes and thinking outcomes of individuals. Thinking processes would refer to such mental acts or cognitive functions such as considering more possibilities, challenging assumptions, exercising precision and checking for errors. Thinking outcomes would refer to such consequences such as deeper insights, more reliable conclusions and more reflective habits. In order to invest in such interventions however it is crucial for one to be aware of his/her belief in the modifiability of human intelligence.

Views like those of Murray and Herrnstein (1994) assert that our achievements are directly dependent on the level of our intelligence, as measured by IQ tests, and largely predetermined genetically. This collorary of such a belief appears to be that it is a waste of resources to invest in remedial education, social rehabilitation or interventions as these efforts have little effects on improving intelligence.

What are the implications of such a belief in the modifiability of human intelligence and hence one’s ability to improving his/her thinking and learning? As Feuerstein and Kozulin (1995) noted Murray and Herrnstein’s claims seem to assume amongst other things that human intelligence can basically be reduced to an IQ score which they consider to be immutable, stable and resistance to change whether by education, development or rehabilitation. Fortunately, evidences of previous research has pointed to the modifiabiliy of human

intelligence. Feuerstein et al. (1980) more than half a century work has demonstrated that “except in the most severe instances of genetic and organic impairment, the human organism is open to modifiability at all ages and stages of development.”

Feuerstein’s work (1979, 1980) is probably one of the few thinking programmes with a comprehensive theory and well supported empirical evidences. According to Sternberg (1985, p220) although Feuerstein does not explicitly present a theory of intelligence in his work “most of the ingredients for such a theory appear in his books.”

Feuerstein’s Theory of Structural Cognitive Modifiability (Feuerstein ,1979; Feuerstein, 1980; Feuerstein, 1990; Feuerstein & Kozulin, 1995) has been gaining acceptance amongst both educators and researchers. His theory gives hope that “the human organism is open to modifiability at all ages and stages of development.” Embedded in the Theory of Structural Cognitive Modifiability is the Theory of Mediated Learning Experience (MLE) which propounds that the quality interaction between a learner and an intentional human being can play a significant role in cognitive development of the learner.

Feuerstein’s faith in the modifiability of intelligence is demonstrated in his almost half a century of continuous work and research that has resulted in his popular intervention programme known as the Feuerstein Instrumental Enrichment (FIE) programme (Feuerstein et al , 1980). The ultimate aim of FIE is to transformed low performers by altering their characteristically passive dependent cognitive style so that they become more active, self-motivated and independent thinkers.

The goals of FIE could be described as follows:

To correct weaknesses and deficiencies in cognitive functions

To help students learn and apply the basic concepts, labels, vocabulary and operations essential to effective thought

To produce sound and spontaneous thinking habits leading to greater curiosity, self-confidence and motivation

To motivate students towards task-oriented abstract goals rather than toward objectives of impilsive self-gratification]

To transform poor learners from passive recipients and reproducers of information into active generators of new information.

The Cognitive Modifiability Intervention Study

This research attempts to design a thinking programme known as the Cognitive Modification Intervention (CMI) programme based primarily on the theory propounded by Feuerstein. The term “cognitive modifiability” is used to emphasise the underpinning belief of the facilitator as well as the focus of addressing mental patterns (structures) and attitudes of the participants that could be changed to bring about more effective thinking in them. The purpose of this study is firstly to develop a thinking programme for polytechnic level students based on Feuerstein’s theory of structural cognitive modifiability and mediated learning experience as well as the principles of cognitive intervention used in Feuerstein Instrumental Enrichment programme.

Scope of this Paper

The purpose of this paper is to provide the rationale and scope of the

research project as described above and to demonstrate the applicability of Feuerstein's work to the context of polytechnic engineering students in Singapore. The more extensive data analysis of the quasi-experimental design will not be dwelt with in this paper.

This paper will illustrate how various scenarios of learning in engineering subjects points to the critical need to address cognitive functioning and then provide to an overview of the intervention. Examples of lessons and activities will also be illustrated.

Observations of Cognitive Functioning in Engineering Classes

The following cases represent typical scenarios that occur in engineering classes where students are involved in various learning situations. The researcher's insights and reflections were gained indirectly and informally through his role as a teacher-educator for the development of polytechnic lecturers where he had been involved in the observation of teaching. The researcher has observed a large number of lessons in the last five years of his role as a staff developer. Instead of focusing only on the teacher, however, his foremost question in every observation is "what is the quality of thinking going on in the minds of students?"

Scenario A

In an engineering class, the students were involved in solving logic circuits. When presented with a diagram involving various logic gates. Some students failed to observe the instructions given and went straight into constructing a "truth table". (The instruction was to simplify the circuit.)

In several instances, some students simply asked for the final solution and then use trial-and-error methods to arrive at the solution. The better students, however, checked the instructions, plan the way they would approach the problem and solve the circuit systematically either from top to bottom or from one-end to the other. For those who did not learn the topic well was it a problem of lack of understanding of the content? Of course, it was necessary to know the facts such as which symbol corresponds to which type of gate and what are the particular features and functions of each gate. But having memorised and learn these a number of students still had a great deal of difficulties. Then there are those who could do simple 2-step or 3-step problems especially when very similar examples were given for them to model after. But when there were multiple steps that require the simultaneous handling of a few varying factors some students gave up. Then there were those students who thought they understood the principle but perpetually made mistakes in many steps of their solution. When the lecturer analysed their solutions together with them there would always be some inaccurate substitutions or mistaken perceptions. Very often such a student would simply be told “you tend to be very careless - we need to be very careful and meticulous in solving this kind of problems.” A student even responded with these words, “since primary school every teacher say I am careless that’s why I just managed to pass my O levels.”

The problem as the researcher noted is not just one of dealing with the content or knowledge involved. It even goes beyond emphasizing the “process” aspects of working with the knowledge. Something need to done about the students’ thought processes. Something is lacking in the mental

functioning. Some patterns and habits of thinking have to be changed if the students would become more efficient learners and better problem-solvers.

Scenario B

In a practical session on audio-related circuits students were required to locate and identify possible faults and locate the components that are not functioning. A number students started using various meters and the oscilloscope to tap on various parts of the circuit. The trial-and-error attempts were rather erratic. Some of them became very frustrated with their attempts when they did not seem to get anywhere. In another group, one of the members immediately focused on one area and insisted that the fault is very likely to start there. It appeared that there was a fault there but the problem was not so localised. The other members then insisted that it was also important to consider the circuit as a whole and not just zoom in so impulsively. In another group the students sat down to plan and make a list of the most common faults and then proceeded somewhat systematically.

What can we say about the impulsive behaviour of students in their attempt to solve a problem? How is it that some students have developed better mental habits of planning and making strategies? Are some of these students aware of tendencies to react impulsively? What about those who never have a habit of being systematic? And what about the student that insisted on his narrow perception of the problem location and refuse to look at the “big” picture first?

Scenario C

Students were working on several mathematical problems in calculus. Most of these problems involve the use of the mathematical principles of the mathematical techniques of integration and differentiation as well as the manipulation and simplification of algebraic terms and expressions. In most cases students try to look at examples given and tried to see the same pattern. The teacher tended to tell the students to follow the examples and apply the relevant formulae or method. When it come to the more difficult problems many students were stuck and some gave up rather quickly. Some o the students however were able to proceed when hints and intermediate steps were given to them. The lecturer, when briefly interviewed by the researcher, commented that the majority of students will not be able to solve any problem presented in a novel setting. In other words, students relied heavily on familiar examples. Even in learning by imitation and modelling students do not always understand the steps and hence were not able to approach challenging problem effectively. In learning such mathematical problem solving could students better helped if they are helped to see the meaning and reasons for the techniques and approaches? Do students have a feeling of competence in working with mathematics? Can they learn to develop effective strategies in identifying and searching for appropriate mathematical patterns?

Can we help students see the parts and wholes of the mathematical problem? Can the heuristics and problem solving processes be explicitly taught?

Scenario D

In a computer programming the students are required to develop

programme lines and algorithms. Students are often frustrated when the programme eventually did not work. Very often the students who have worked hard at the programme discovered that it was just one word or punctuation missing or sometimes extra that created the “bug”. Would it help if some of these students who frequently encounter failure in their programme would developed better habits of mind such as being systematic and being precise in gathering data and in outputting of their programme lines?

The scenarios A, B, C and D that have been described and the researcher’s occasional reflections and observations point to the fact that in helping students to learn effectively there is a critical need to address not just the content and process skills related to a topic or subject but also the cognition of the students. In spite of the diverse topics in the engineering course setting there are a number of cognitive functions that are crucial for successful thinking. These cognitive functions of students relate to various aspects of cognition such as the planning behaviours of students, accurate and non-sweeping perception, systematic exploratory thinking, simultaneous handling of various sources of information and broadness of mental field.

Can we have an intervention programme that will help students think better?

How will the intervention programme address the cognitive functions (such as accurate elaboration of data)? How could the teacher as a mediator facilitate the identification of possible deficient cognitive functioning and bring about a change in the cognitive pattern of the learners? Is there a sound theoretical basis and other empirical research

that support such an intervention?

When the researcher first came across the work of Professor Feuerstein documented in two books namely, Instrumental Enrichment: An Intervention Programme for Cognitive Modifiability and Mediated Learning Experience (MLE): Theoretical, Psychological and Learning Implication he was deeply impressed by the potential application of the theory towards diverse populations. The application of the theory to a thinking programme for polytechnic level students would represent a highly appropriate and much needed extension of the “technology” implied and provided by Feuerstein. This research represents an advancement of the application of the theory of structural cognitive modifiablity and mediated learning experience in the polytechnic setting and in Asian (in particular, Singaporean) cultural context.

The Design of the Intervention

Whilst Feuerstein’s theory provided the theoretical foundation for this intervention it should be noted that in documenting this research the author has reflected on the details of the application and re-interpreted many of the terms used by Feuerstein. The broad framework of the theory remains but what is described represents an innovation in the intervention. The researcher’s focus is on the principles rather than the content and procedures related to the instruments found in Feuerstein’s instrumental enrichment package.

In designing the intervention the researcher has based on pilot trials selected those instruments (materials) from the FIE package that would be most relevant in his context of intervention. A large variety of

thinking activities, however, have been adapted from various sources and new designs added by the researcher to constitute this new training package.

The design of the intervention is intimately woven with the theory of structural cognitive modifiability. The facilitator (mediator) underpinning belief is that the existing cognitive structure of the learner can be modified. We also assert that the capacity to be modified can be increased. The mediator also plays a critical role in helping learners into this positive belief system - that their cognitive structure can be positively modified and hence they can become better learners and thinkers. The affective-motivational domain which relates to the cognitive domain of the individual is the first line of attack in the intervention. Following which the learner is involved in working on a number of thinking activities which provide the vehicle for dynamic assessment and mediated learning experiences. The quality of interaction in the mediation plays a critical role in affecting the cognitive structure of the learners.

The broad goals of the intervention are that by the end of the intervention the students will

Gain a better understanding of their abilities to increase their thinking and learning capacities.

Gain a better understanding of their cognitive functions and how these may be further developed, refined and crystallized for effective thinking

Gain greater awareness and insights into their own level of awareness, thinking habits and patterns and attitudes to become more reflective and

insightful learners. Correct their weaknesses and deficiencies in the various cognitive functions and dimensions of thinking. To produce sound and positive thinking habits and patterns resulting from more effective cognitive functioning. Become more active, self-motivated and independent learners and thinkers as a result of cognitive modification.

Become more active generators of new information and more creative thinkers as a result of cognitive modification.

In a typical lesson, we can described three components of the intervention. These are;

The Meta-Awareness Stage (Diagnostic Approach)

The Learning Stage (Mediation Approach)

The Bridging and Application Phase (Empowerment Approach)

Firstly the intervention emphasises the need to pay attention to what is going on in the mind of the learner and what are cognitive functions or sets of cognitive functions that we want to address. The tools or instruments that are used for the lesson provide the learner and mediator the opportunity for both diagnosis (dynamic assessment) and hence self-awareness of cognitive deficiencies as well as a means for learning, acquisition and refinement of one's cognitive functions .

Secondly the intervention emphasise the mediation process. The focus here is the facilitator's (that is the mediator's) behaviours and the design of the learning environment to produce a quality interaction to that impacts on the modifiability of the learner.

Addressing Cognitive Functions

The intervention is directed at eliminating cognitive deficient functions in the individual (resulting form previous lack of positive mediated experiences and other antecendent factors) and enhance the cognitive functions and overall cognitive operations. In our intervention the concern related to the aetiology of factors like socioeconomic background, environmental stimuli, genetic factors, maturation and cultural differences are secondary as these are distal factors to our intervention. That which is proximal is the quality of mediation in the intervention that can provide the learner with experiences that will alter and enhance his/her cognitive structure.

Our earlier discussion have high lighted the fact that where manifest performance is lacking in various learning situations related to acquisition of academic, technical or professional skills we cannot simply attribute it to a lack of content knowledge or the lack of understanding of the principles involved. As Feuertein noted, it is even worse to attribute failure to perform to low intelligence.

As in one of the earlier examples mentioned, failure to handle a fault finding exercise in an audio circuit could be the result of implusive patterns of thought where there is poor planning behaviour and erratic trial and error attempts. Sometimes such manifest behaviours appear consistently in specific or even across various situations for that individual. Whatever the content of thought he/she is involved there appears to be deficiencies in the internalized, representational or operational pattern of thought.

Good habits of planning and systematic exploration are related to cognitive functions that are prerequites of good thinking and problem-solving. In our intervention our concern and focus is to attack the deficient cognitive functions and current patterns and habits of thinking that are clearly weak or contrary to effective thinking. We seek to modify these patterns, increase the flexibility and capacity. The identification of a framework and reference of deficient cognitive functions is essential to help the mediator address such cognitive functioning. The lessons and various materials and tools used in the intervention addresses various groups of cognitive functions shown Tabel 1. The lists of functions is by no means definite or exhaustive. The functions are also not mutually exclusive but simply serves to provide the focus of diagnose and dynamic assessment for a particular lesson in the cognitive modifiability intervention.

Mediated Learning Experience

Whiltst the list of cognitive functions provides a focus for the facilitator (mediator) to concentrate on the quality of thinking in the learners, that is, what is going on in the mind of the learners in terms of their cognitive processes and functioning. Knowing what is in the cognitive structure of the learner and what we hope to modify and enhance in the learner's cognitive structure is only one-side of the coin. The other side of the coin is the behaviours and what is going on in the mind of the facilitator that will bring about a quality mediation resulting in effective learning. In looking at the intervention from the point of the mediator we shall use a repertoire of parameters that has been carefully put together by Feuerstein and

his team. Many of parameters characterised good pedagogy, didactics and facilitation skills.

The first three of these parameters are:

Intentionality and Reciprocity

Mediation of Meaning

Transcendence

Intentionality refers to the deliberate intention and the purposefulness of the mediator in guiding the interaction towards specific learning. How can one teach thinking processes without the clarity of his intention and goals? The mediator has the end in mind and proceed enthusiastically to share and elicit participation. In the case of our intervention this calls for preparation and a keen awareness of the cognitive functions that could be addressed. The mediator however also bears in mind that his intention must be matched by the responsiveness and receptiveness of the learner. The quality of the interaction is critical in ensuring the effectiveness of any intervention.

A mediation must also be characterised by a clear communication of the meaning and significance of the thinking activities. The learners are helped into appreciating and understanding the value of the activities. Meaning is critical in motivating and energising the learner. The mediator must be capable of giving reasons for the activities and demonstate his own beliefs and value system as he attempts to fire-up the interest of the learners.

Transcendence refers to the bridging, transfer, diversification and extrapolation of immediate experiences in the activities to related issues and activities. The mediator thus promote the acquisition of principles, concepts and strategies to be generalised across a variety of situations where the cognitive functions in particular would be employed.

Intentionality and reciprocity, meaning and transcendence are essential ingredients in any CMI lessons.

Apart form these three parameters, the following parameters are incorporated as far as possible at various lessons and would be covered by the total programme. These are in the second ring and include:

Mediation of

Feeling of Comptence

Interdependency

Individuation

Goal Seeking, Setting and Achieving

Challenge (Novelty and Complexity)

Self-Change

Search for Optimistic Alternatives

Feeling of Belonging

Reflective Practice

Bridging

Bridging refers to the transfer and application of the cognitive processes and functions involved in the CMI lessons to specific

subject-matter areas. The whole CMI programme has been designed with a consideration of the relevance of the theory of cognitive modifiability in the light of the kinds of thinking skills required in various polytechnic curricula. The curriculum may involve academic situations, acquisition of technological knowledge and skills, problem solving and simulation of real-life situations as illustrated by the scenarios given at the beginning of this paper. Bridging to specific subject-matter area is thus a natural corollary of the intervention. Although the polytechnic students participating in the programme would be at a level where they could on their own transfer the learning to the learning of their curricula and real-life situations it is an integral part of the intervention to emphasise the applications of the CMI lessons to ensure the development of insights and bridging to content learning and various context. This is often done through good didactics and pedagogy that encourages the students to work in pairs and groups to discuss how they have been helped in the lesson and how they could apply the learning. The mediator then summarizes examples of applying the awareness gained, the learning of specific cognitive functions, extrapolation of the learning as well as the need to conciously practice the positive and productive habits of thoughts.

Example of A Lesson: Organisational Thinking

In a typical lesson such as the first few lessons entitled Organisational Thinking I, II and III we focus on cognitive functions such as clear perception, precision and accuracy in gathering data, planning bahviour, restraint of impulsivity and so on. The materials and instruments include selections from FIE’s organisation of dots and

several thinking activities provided by the researcher. Whilst the design of the materials require tremendous prepaaration and thought our focus is the use of these materials as a “means” or “tools” to effect on those cognitive functions we aim to address. The thinking activities have soon deliberate selected to naturally allow the mediator to focus on the processes of thinking rather than the content. Activities and materials used are therefore content-free, non-routine or novel problems.

To illustrate the intervention we shall look at a typical lesson such as Organisational Thinking I (Lesson Two of the Programme). The description of the lesson objectives, mediation, facilitation and teaching methods, and lesson structure are as follows.

Lesson Objectives

In Organisational Thinking 1 the aims of the lessons are as follows:

To enable participants to

gain a greater awareness of the need to develop their cognitive functions particularly in the following areas

Clarity of perception

Conservation and constancy

Precision and accuracy

Visual Transport

Summative Behaviour

Planning

Restraint of Impulsivity

Systematic Exploration

Elimination of Erratic Trial-and -Error

gain an awareness of the need to modify deficient cognitive functioning

and patterns of thought discovered through the activities

be able to conciously practice positive cognitive behaviours learned

by apply these behaviours in further exercies and across situations

By the end of the session participants be able

to identify a number of cognitive functions particularly those they

found themselves to be deficient

to describe some key elements of thinking (cognitive functions) in a

mental act

identify some key cognitive functions which they like to improve upon

(production of intrinsic motivation - habit formation)

identify and describe academic and life situations where these

cognitive functions are important to them (reflective, insigthful

processes and creation of task-intrinsic motivation)

state what they learn about thinking and what they would practice

(attitude change: passive to active; task intrinsic motivation)

It should be noted that the above aims will be attained at varying

stages for different participants. The above plus a number of new aims

will be covered again in Organisational Thinking II and III which uses

Organisation of Dots with increasing complexity.

Mediation, Facilitation and Teaching Methods

The mediation will attempt to influence the participants awareness of the

various cognitive functions mentioned above. The whole interrelated aspects

of input-elaboration-output cum affective-motivational processes are involved

albeit for different dimensions.

The role of the mediator includes:

helping participants gain awareness of their cognitive functions involved

helping participants identify their cognitive deficiencies

helping participants modify their patterns of thought processes (cognitive structure) through self-reflective and insightful processing from working on the exercises

bridging these congitive awareness to academic and life-situations

The teaching methods involves

students working on Organisation of Dots

diagnostic approach

mutual questioning (teacher-student, student-student)

dialogue and interaction

self-reflection. insightful processes

peer learning and buzz groups

Examples of Lesson Structure

Linkage to previous lesson:

Focus on the question of what we can do to improve our thinking? Help students recall and share on points such as "know our patterns of thoughts", "being aware of weak habits of thinking", "changing and modifying one's tendencies or structures of mental acts that results in ineffective thinking", "practicing positive patterns of thinking" and "using thinking tools".

Introduction to activity:

Use of a visual to provide a talking point to introduce idea of

organisational thinking. Introduce idea that “we needing to take time to think”.

Activity 1 (OD1-1, see Appendix 1)

Participants work on boxes in row 1 and row 2.

Beginning activities emphasize points related to “rules”, “constraints”, “assumptions”, “clarifying instructions”.

Participants proceed to work on boxes in row 3 to the end of the page.

Observe individual performances to take diagnostic approach whilst helping participants to learn important cognitive functioning such as the need to restraint from impulsiveness in making assumptions.

Highlight on tendencies related to accuracy of thought. Get participants to identify strategies needed to be successful in the activity. Use the difficult ones to highlight strategies needed.

What can be done to solve these more effectively?

Activity 2 (OD1-2, see Appendix 1)

Participants work on OD1-2. Continue to highlight key ideas related to using cues, noting goals, planning, accuracy and systematic thinking.

Bridging

Draw participants responses to areas in academic and student life where cognitive functions emphasized though the activities are important.

CONCLUSION AND SOME PRELIMINARY FINDINGS

It is not the purpose of this paper to look into the details of the intervention and the analysis of the findings. It would be interesting however to consider a sampling of feedback from the participants of the programme.

The following are samples of what students comment about the CMI:

Helps to visualise problems more clearly and how to solve them.. to work quickly and systematically with accuracy. And also helps to build a strong character..

It made me more commited to correct my problems and not to give up so easily…

- TL, M110

The programme gives me another window to my mind that I didn't knew exists. I am able to think things thoroughly and not jump into rash reaction when solving a problem. I am able to set priorities so as to when I should start my project and materials needed and ending it correctly.

- FW, M112

I've changed my ways of thinking towards study and I planned everything well ahead.

- AR, M112

I learn to solve things in the lab where you learned to do things step by step and also the problem..

- KW, M112

It thought me that many time problem can't be solved within itself but also from other aspects. I also learn that metal block could be solved and thus helped me a lot.

- KM, M112

I think it has helped me to think gradually .. to think of an object beyond its purpose.

- JN, M110

It has made me less impulsive and less likely to jump to the first conclusion that I arrive on.

- DC, M110

I must admit it really help me to "see" things from a clear and better angle …I use to think in one track mind.

- CBS, M112

It has helped me to link very thing we learn and help me to see problems in a different way for faster solution finding… It has changed the way I tackle a problem.

- SG, M112

I recommend that polytechnic student should go through the programme because it will allow them to understand themselves better and allow them to overcome problems.

- KK, M110

The researcher's experience is that of most of not all of the engineering students in the experimental groups have been much helped as indicated by the above testimonies.

It appears that the potential effectiveness of this Cognitive Modifiability Intervention for polytechnic students is promising and selected modules of the intervention could be incorporated into the various curricula where the cognitive functions are most directly applicable. The intervention also appears to have possible impact on students overall attitudes and study skills and further research in these areas would be recommended.

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