AN EVALUATION OF THE EFFECTIVENESS OF INTERACTIVE MULTIMEDIA TO ENHANCE DIVERGENT ANALYTICAL THINKING SKILLS

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ABSTRACT

The purpose of this research is to develop and evaluate the effectiveness of an interactive multimedia package, based on students' design preferences in non-academic domain content with an aim of enhancing students' divergent analytical thinking skills in a collaborative learning environment. This study defines divergent analytical thinking as consisting of identifying and analyzing statements by considering different viewpoints. The modus operandi of the package is the sharing of text files in an asynchronous mode in which students' responses can be publicly accessed and judged by their peers. It utilized the IT infrastructure already set up in smart schools. A quasi-experimental research design of nonrandomized control group, pre-test-post-test design was used. The research samples consisted of 233 students in experimental and 81 students in control groups consisting of Form Four students in three fully residential smart schools in Johore. The students were divided into three groups, each working on one specific module only. Data were gathered using pre-test and post-test responses, observations and group interviews. ANOVA testing indicated that the package significantly enhanced the experimental groups' performance compared to the control group for all the three modules (significant level $\alpha = 0.05$). No correlation with gender was found for all the three modules. The study indicated a positive correlation between levels of personal satisfactions on features of the package design to the extent of initial enhancements in performance score after first exposure to the package with respect to pre-test score. After a second exposure to the package, the disparity began to disappear for some students. The study also uncovered positive attitudinal transformation amongst the students in the experimental group.

ABSTRAK

Kajian ini bertujuan untuk membina dan menilai keberkesanan satu pakej multimedia interaktif, berasaskan reka bentuk yang dicadangkan pelajar yang merangkumi bidang di luar domain akademik dalam mempertingkatkan keupayaan pelajar dalam pemikiran analitikal secara divergen di dalam suasana pembelajaran kolaboratif. Pemikiran analitikal secara divergen didefinisikan sebagai mengenalpasti dan menganalisis pernyataan dengan mengambil kira pelbagai perspektif. Modus operandi pakej ini adalah perkongsian bebas fail teks di dalam mod *asynchronous* di mana segala respon pelajar boleh diakses dan dipertimbangkan oleh rakan mereka dengan memanfaatkan infrastruktur IT yang sedia ada di sekolah-sekolah bestari di Johor. Kajian bercorak kuasi-eksperimental jenis *non randomized control group, pre-test-post-test design* digunakan. Sampel pelajar adalah terdiri daripada 233 orang dalam kumpulan rawatan dan 81 orang dalam kumpulan kawalan daripada pelajar Tingkatan Empat daripada sekolah bestari berasrama penuh di negeri Johor. Pelajar-pelajar tersebut dibahagikan kepada tiga kumpulan mengikut tiga modul yang disediakan. Data kajian dikumpulkan menerusi ujian pencapaian pra dan pos, pemerhatian dan temu bual berkumpulan. Analisis ujian ANOVA menunjukkan wujudnya perbezaan yang signifikan dalam peningkatan skor pencapaian di dalam kumpulan rawatan berbanding dengan kumpulan kawalan bagi ketiga-tiga modul yang digunakan (aras keertian α = 0.05). Tiada korelasi dengan jantina dapat dikesan, juga terdapatnya korelasi positif di antara tahap kepuasan pelajar terhadap aspek reka bentuk perisian dengan tahap peningkatan awal skor pencapaian selepas pendedahan pertama terhadap perisian. Tahap peningkatan awal skor pencapaian tidak mempengaruhi pencapaian pelajar secara

keseluruhan selepas pendedahan kali kedua. Kajian ini juga mendedahkan perubahan sikap yang positif di kalangan pelajar yang didedahkan kepada perisian.

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LIST OF ABBREVIATIONS

CADATS	-	Collaborative Approach Divergent Analytical Thinking Simulator
CoRT1	-	Cognitive Research Trust tools for divergent thinking
PMI	-	Plus, Minus, Interesting (One of the thinking tools in CoRT1)
CAF	-	Consider All Factors (One of the thinking tools in CoRT1)
C&S	-	Consequence and Sequel (One of the thinking tools in CoRT1)
OPV	-	Other Peoples' Views (One of the thinking tools in CoRT1)
LAN	-	Local Area Network
p	-	Significance level for statistical analyses purposes

CHAPTER 1

INTRODUCTION TO THE RESEARCH PROJECT

1.1 Introductory Remarks

This chapter introduces the reader to the research project. It attempts to explain the background of the research, the statement of the problem, the research questions and the significance of the study. It then gives a description of the structure of the research, outlining the research and theoretical framework and finally, it defines some of the main terms used in the thesis.

In Malaysia, relatively little has been done to investigate divergent analytical thinking capabilities of its students in a collaborative, multimedia environment. In view of the objectives of the present educational system to develop the quality of manpower for it to enter the new knowledge era, a better understanding of the resourcefulness of Malaysian students and factors which could affect or enhance it becomes more crucial. The influence of personal variables such as gender, extent of enhancement in performance as well as students' level of contentment on the design of the package provide useful information on the practicability of integrating multimedia technology into the teaching of thinking skills which would be of concern to the educator and the policy-makers. The development of the interactive multimedia package was based on the premise that computer supported systems can support and facilitate group process

and group dynamics in ways that are not achievable by face-to-face, although not designed to replace face-to-face communication. It was typically tailored for use by multiple learners working at the same workstation or across networked machines in asynchronous mode to support communicating ideas and information and providing access to peer group's responses to a specific problem. Since the package developed utilized the concept of file sharing in a group brainstorming session, the study would contribute significantly in the area of direct teaching of thinking skills in a computer-supported collaborative environment.

1.2 The Background to the Research Project

As, for several reasons, divergent analytical thinking is not successfully integrated within traditional classroom instruction; it is an interesting question, whether it can be trained with computer-based instruction. In the era of the Internet and of information society, "divergent analytical thinking" represents a major qualification. Gilster (1997) regarded analytical thinking as the most important skill when using the Internet, because the Internet is full of information gathered from multiple points of views. Reinmann-Rothmeier (1998) and Mandl (1998), as quoted by Astleiner (2002), found in a Delphi-study, that experts from economy and education nominated critical and analytical thinking as the most important skill in knowledge management. Enis (2002) saw critical and analytical thinking as "an important, perhaps the most important of all present time educational tasks". For achieving this complex goal, schools and teachers have to be assisted from educational theory and research.

Educational research activities showed that analytical thinking is significantly anchored within curricula and related teaching goal taxonomies, but that it is not supported and taught systematically in daily instruction. The main reasons for this shortcoming are that teachers are not educated in analytical thinking, that there are no textbooks on analytical thinking available and that teachers have no time and other

instructional resources to integrate analytical thinking into their daily instruction (Astleitner, 2002). This shortcoming counts a lot, because analytical thinking is highly correlated with students' achievements. Frisby (1992) reported correlation coefficients of about 0.40 with the US-school achievement test (SAT). Also, Yeh and Wu (1992) found similar correlation coefficients with other standardized school achievement tests and grades. Very high correlation coefficients ranging from 0.45 to 0.47, or effect sizes larger than 1 were reported for mathematics and science instruction. These correlations have to be considered in educational research, even though they can be explained to some degree with the moderating effect of student's intelligence.

In the field of education and instruction, this kind of research and related approaches were used to develop programs for promoting thinking skills in students. But, only very few of these programs realized a comprehensive “analytical thinking program” in a way that is actually suggested by educational researchers and instructional designers. According to Halpern (1998), such programs for promoting analytical thinking should have the following features: 1) they should consider a disposition or an attitude against analytical thinking; 2) they should regard analytical thinking as a general skill that must be deepened within different subject matters or contexts; 3) they should offer a segmented and instructionally fully developed training in specific skills; 4) they should focus on all (or many) relevant subskills of analytical thinking and integrate them; 5) they should include parts for stimulating the transfer of knowledge; 6) they should support meta-cognitive skills for assisting self-regulation activities; 7) they should not include formal, mathematical, etc. algorithms, but everyday language problems; 8) they should train students for a several week's or month's period; and 9) they should consider the organizational context of classroom instruction.

When traditional classroom instruction do not work, then it is obvious to ask for alternative classroom scenarios. In such scenarios, the teacher should be assisted by some additional help or the students should be able to work for their own and therefore release the teacher from some duties. Such assisting and releasing functions can be realized by computer-based instruction, especially CDROM and networked-based

instruction for collaborative learning. CDROM and Internet-based instruction showed to be successful for learning in general and for lower order thinking skills in a literature review compiled by Dillon and Gabbard (1998). But, such reviews were not yet made for higher order thinking skills, like analytical thinking. It is an open question, whether CDROM and Internet-based instruction can successfully promote analytical thinking in daily instruction.

Jonassen (1996) postulated that mulimedia can be used as content and as tool (for problem solving) in order to stimulate and support analytical thinking. Duffelmeyer (2000) pointed out that relevant everyday problems infused into daily instruction could be used to teach analytical thinking and to use multimedia to deliver analytical thinking skills. Reimann and Bosnjak (1998), however, delivered some empirical data about the efficiency of computer tools for analytical thinking. They used hypertexts as a tool to stimulate and guide analytical thinking. In their study, students had to criticize and to expand an argument structure and had free access to a content-rich hypertext. But, using the hypertext did unexpectedly not improve analytical thinking. The authors of this study concluded that it is not sufficient to offer content information, but that analytical thinking has to be supported by carefully designed instructional activities. This assumption is also confirmed by a study from Glebas (1997), in which another computer tool, a spreadsheet, was found to be ineffective for analytical thinking when it is not integrated within an instructional context. Scarce (1997) found that the use of email — as communication tool without any further instructional function — did not improve analytical thinking in comparison with traditional classroom instruction. Santos and DeOliveira (1999) found similar non-significant results when using the Internet as tool for content presentation.

Within traditional learning environments, in contrast to many other findings, positive effects of collaborative learning on analytical thinking were reported (e.g., Gokhale, 1995). These results are mainly due to the fact that carefully designed collaborative learning generally delivers many different point-of-views, and therefore many different learning experiences and multi-faceted learning support. Newman,

Johnson, Cochrane, and Webb (1996) compared a traditional course with a course in which an Internet-based discussion forum for assisting collaborative learning was used. They found that using the discussion forum resulted in better analytical thinking, because students had more learning materials available and related more often their arguments to each other. Overall, students in the discussion forum condition experienced more learning opportunities than students in the traditional course. Despite this remarkable result, this study tells nothing about the design of learning environments for promoting analytical thinking. Bullen (1998) delivered more background knowledge about the design of learning environments based on students' surveys about using an Internet-based discussion forum. A content analysis of students' messages showed, however, that students did not acquire analytical thinking. The author gave several reasons for this finding, but without testing them in a controlled setting. Also, students missed specific instructional activities which were related to a certain teaching goal. Sloffer, Dueber, and Duffy (1999) as quoted by Astleiner (2002) implemented a synchronous and an asynchronous conferencing tool for promoting analytical thinking which considered the suggestions given by Bullen (1998). In addition, they stimulated analytical thinking by visualizing elements of the analytical thinking process. For example, students had to assign to their messages symbols indicating important elements of analytical thinking, like “hypotheses” or “evidence”. The authors also implemented a mechanism that only those students could read other messages which accomplished their own duties. Finally, a human tutor had to motivate students. Results showed that many students delivered contributions with high-quality analytical thinking content and that almost all students read the messages of the other students. However, this positive result was not confirmed by comparable research studies.

To sum up, it can be stated that the effect of collaborative learning with multimedia on analytical thinking, cannot be evaluated properly. The given results show some instructional elements that can help to improve the situation, but these elements have not yet been tested within controlled research. When using this type of new media for promoting analytical thinking, then everyone has to be aware of the fact that collaborative learning has to be enhanced by specific analytical thinking tasks and that

learning in such environments has to be managed comprehensively in respect to time, group meetings, etc. Overall, the state-of-the-art of research on collaborative learning, multimedia, and analytical thinking shows no consistent fmdings, but it shows that preparing and managing this form of learning require significant additional time resources and advanced technical skills. When having a closer look at the present situation in daily school, then it is not realistic that analytical thinking can be promoted by collaborative learning and related media, because the necessary effort in time, preparation, etc. for teachers significantly exceeds the expectable learning effects for students.

According to Chan *et.al.*(2001), divergent analytical thinking is vital in producing ideational fluency (capability of producing many ideas), resistant to closure (the ability to keep an 'open mind'), flexibility (the ability to produce a large variety of ideas), originality (the ability to produce ideas that are unusual), elaboration (the ability to develop ideas) and abstractness of titles (the ability to transfer the essence of a figural into another modality). Preliminary study done by the researcher revealed that students did not give much importance to this aspect.

According to Astleiner (2002), analytical thinking consists of identifying and analyzing diverse arguments and of logical reasoning. Paul (1997) defined analytical thinking as "to break up a whole into its parts, to examine in detail so as to determine the nature of, to look more deeply into an issue or situation. Students should continually be asked to analyze their ideas, claims, experiences, interpretations, judgments, and theories and those they hear and read." Analytical thinking forms the core of analytical thinking which constitute a higher-order thinking skill mainly consisting of evaluating arguments (Astleiner, 2002).

Overall, it seems very difficult to successfully implement divergent analytical thinking skills into traditional classroom instruction. Ediger (1999) saw that problems faced in engaging students in thinking were that: (1) Students want factual answers rather than thinking things through when analyzing subject matter (2) Students are in a

hurry to discuss alternatives in and during time devoted to thinking (3) Students do not wish to take time to deliberate on ideas presented (4) Students fail to engage in depth thinking when coming up with alternative ideas (5) Students lack background information and mind models to do analytical and analytical thinking. Thus, according to Gifford (2000), a positive attitude as well as competence to be able to think enthusiastically, methodically and successfully need to be inculcated amongst students. The package is an attempt by the researcher to alleviate these problems amongst Malaysian Form Four students, particularly in fully residential smart schools in the state of Johore.

Past researches done in Malaysia seem to point out the lack of success in propagating analytical and analytical thinking in schools. Asmah (1994) conducted a survey of teachers' knowledge, skills and attitudes in secondary schools in Kuching, Sarawak. Results of the study include: (a) teachers have a minimal knowledge of basic skills and tasks emphasized in analytical thinking. (b) a course on analytical thinking had an effects on teachers' skills and attitudes towards analytical thinking. The findings of this study suggested that analytical thinking instruction is best achieved by incorporating it into present subjects but the delivery and effectiveness is wanting. This phenomena was echoed in the research done by Lam (1994) which indicated a general lack of analytical and analytical thinking skills amongst teachers and students.

Sadhna Nair (1998) conducted a case study on the thinking skills in a Malaysian ESL (English as Second Language) context. The findings of this study indicated that although teachers are aware of the importance of integrating thinking skills into the English Language curriculum, they do not seem to have the appropriate knowledge and skills needed to assist them in their attempts at integrating these thinking skills into lessons successfully.

Rajendran (1998) set out to probe the teaching of higher-order thinking skills in language classrooms in Malaysia. The contributions of the study to knowledge about teacher learning include (1) Teachers perceived that they are not prepared to make this

innovation in their own classrooms. Teachers also lack the attributes to construct the pedagogical content knowledge. The number of years teachers have been teaching significantly influenced their perceptions of their knowledge and skills. (2). Many factors such as teachers' own orientations towards teaching, curricular requirements, and myths about teaching thinking inhibit the teaching of higher-order thinking skills. (3). There is a dissonance between what teachers believe and carry out and the kind of teaching recommended by reformers. Their own orientations towards teaching are often not changed by their pre-service and in-service training. (4). All the four language components are underutilized in promoting higher-order thinking skills. There is a serious need for teachers to understand the importance of active student participation and encourage it in their own classrooms. Some strategies, such as the problem solving strategy, have the potential to promote higher-order thinking skills in language classrooms. Teachers are not adequately prepared to use the infusion approach.

Another aim of the research was to examine degree of satisfaction on the design aspects of the package and its correlation with performance gain in divergent analytical thinking exercises. The style of display has a great influence on the learning performance (Levin, 1997). Weiss (1994) divided multimedia interface into several units: (1) the display interface (2) the conversation or interactivity interface (3) the navigation interface and (4) the control interface. This study was based on the premise developed by Crook (1991) that to extract the maximum educational potential of computers in education, the interface design must create a positive emotional reaction or intrinsic satisfaction amongst the users. Passig and Levin (2000) reported the presence of gender differences in the level of contentment to varying designs of multimedia interfaces which affect the user in terms of performance and the desire to use the package. An in-depth study into the influence of these individualistic factors would thus contribute in revealing their correlation with students' performance in a Computer-mediated-Communication (CMC) environment which forms the perimeters of this project.

1.3 The Statement of the Problem

The primary focus of this research was to

1. analyse the difference in levels of proficiency in divergent analytical thinking skills before and after exposure to an interactive multimedia courseware specially developed for that purpose with regards to gender and level of contentment towards the instructional design used in the package
2. examine students' perception towards the instructional techniques adopted by the courseware to upgrade divergent analytical thinking.
3. analyse the features in an interactive multimedia courseware that can contribute to the enhancement of divergent analytical thinking skills of students

1.4 The Objectives of the Research Project

1. To conduct a quasi-experimental study to measure quantitatively any significant improvement in students' performance in divergent analytical thinking after exposure to the developed interactive multimedia package with respect to
   (i) control and experimental groups
   (ii) gender

2. To investigate features of an interactive multimedia courseware package that could contribute to the enhancement of divergent analytical thinking skills amongst its users

3. To investigate possible correlation between students' performance scores on divergent analytical thinking skills and their level of contentment towards the design of the package.

4. To investigate students' perception on the instructional design adopted by the package that would contribute to a positive change to divergent analytical thinking.

In order to achieve the objectives stated above, the researcher has to

a. To conduct a preliminary study of the adeptness of students of Form Four in fully residential smart schools in Johore towards divergent analytical thinking skills using real-life ill-structured problems.

b. To develop an interactive multimedia package prototype using group brainstorming technique in a networked environment based on meta-cognitive model through the usage of graphic and verbal organizer and several CoRT1 tools. Three modules were developed to represent three different facets of analytical thinking namely: Module 1: Compare and Contrast; Module 2: Parts of a Whole and Module 3: Proposal Ponder. This package is entitled 'Collaborative-Approach Divergent Analytical Thinking Simulator' (CADATS).

c. To conduct formative and summative evaluation in order to produce a fully-tested interactive multimedia package.

d. To conduct quantitative and qualitative analyses on students' performance scores and students' perception of instructional methodologies adopted by the package.

1.5 The Specific Questions to be Addressed

(A) To test whether male and female students were equally competent in control and experimental group in the pre-test:

Q1. Were there any statistically significant differences in performance in divergent analytical thinking *before* exposure to the package between the control and experimental group for each of the three modules?

Q2 Were there any statistically significant differences in performance in divergent analytical thinking *before* exposure to the package for each of the three modules in the package between male and female respondents in the *control* group?

Q3. Were there any statistically significant differences in performance in divergent analytical thinking *before* exposure to the package for each of the three modules in the package between male and female respondents in the *experimenta*l group?

(B) To ascertain whether the package did significantly affect performance in analytical thinking skills

Q4. Were there any statistically significant differences in performance in divergent analytical thinking scores for each of the three modules in the package between the pre-test and first post-test scores for the experimental and control groups?

Q5. Were there any statistically significant differences in performance in divergent analytical thinking for each of the three modules in the package between male and female respondents in the first post-test scores for the *control* group?

Q6. Were there any statistically significant differences in performance in divergent analytical thinking *after* exposure to the package (first post-test) for each of the three modules in the package between male and female respondents in the *experimental* group?

(C) To investigate whether any of the gender groups showed significant improvement in first post-test performance scores with pre-test scores as covariate (initial performance score gain) in the experimental and control groups:

Q7. Were there any statistically significant differences in initial performance gain in divergent analytical thinking in first post-test for each of the three modules in the package shown by the *male and female respondents* in the control group?

Q8. Were there any statistically significant differences in initial performance gain in analytical thinking in first post-test for each of the three modules in the package shown by the male and *female respondents* in the experimental group?

(D) To test whether any significant difference was shown by male and female students on the second post-test in the experimental group:

Q9. Were there any statistically significant differences in performance on second post-test scores *(full collaborative mode)* with respect to gender for experimental group?

For the next batch of research questions, students were categorized into 4 groups based on gender and initial level of gain in performance score (first post-test minus pre-test scores)

(1) Male-Low Gain (2) Male-High Gain

(3) Female-Low Gain (4) Female-High Gain

Low and High Gain were determined by the students' rank in initial gain in performance score with respect to the overall mean gain in performance score in the experimental group only.

(E) To depict the level of contentment shown by different categories of students towards different aspects of the design of the package:

Q10. What were the profiles of the level of contentment indicated by the different categories of students in the experimental group after exposure to the package in terms of the factors below:

a. Ease of use
b. Design of thinking activity
c. Design of motivational elements
d. Design of user interface
e. Navigational design of the interactive multimedia package

(F) To test whether any statistically significant difference was indicated by different categories of students on their level of contentment towards different aspects of design of the package:

Q11. For each category of students, was there any statistically significant difference in the level of contentment indicated for each module in terms of the factors below:

a. Ease of use
b. Design of thinking activity
c. Design of motivational elements
d. Design of user interface
e. Navigational design of the interactive multimedia package

(G) To compare efficiency of the three modules in enhancing performance of students in divergent analytical thinking capabilities:

Q12. Which category of students benefited the least and the most from exposure to the interactive multimedia package based on the second post-test performance score for each module?

Q13. Which one of the three modules was the most effective in terms of enhancing students' performance scores in divergent analytical thinking based on the second post-test scores?

(H) Qualitative data to probe performance of different categories of students in using the package:

Q14. How did students with different gender and levels of initial performance gain in divergent analytical thinking scores view the group brainstorming techniques as well as the graphical and verbal organizers employed in the interactive multimedia package?

Q15. What were the features of the package that contributed to the enhancement of divergent analytical thinking skills amongst its users?

1.6 Theoretical Framework of the Study

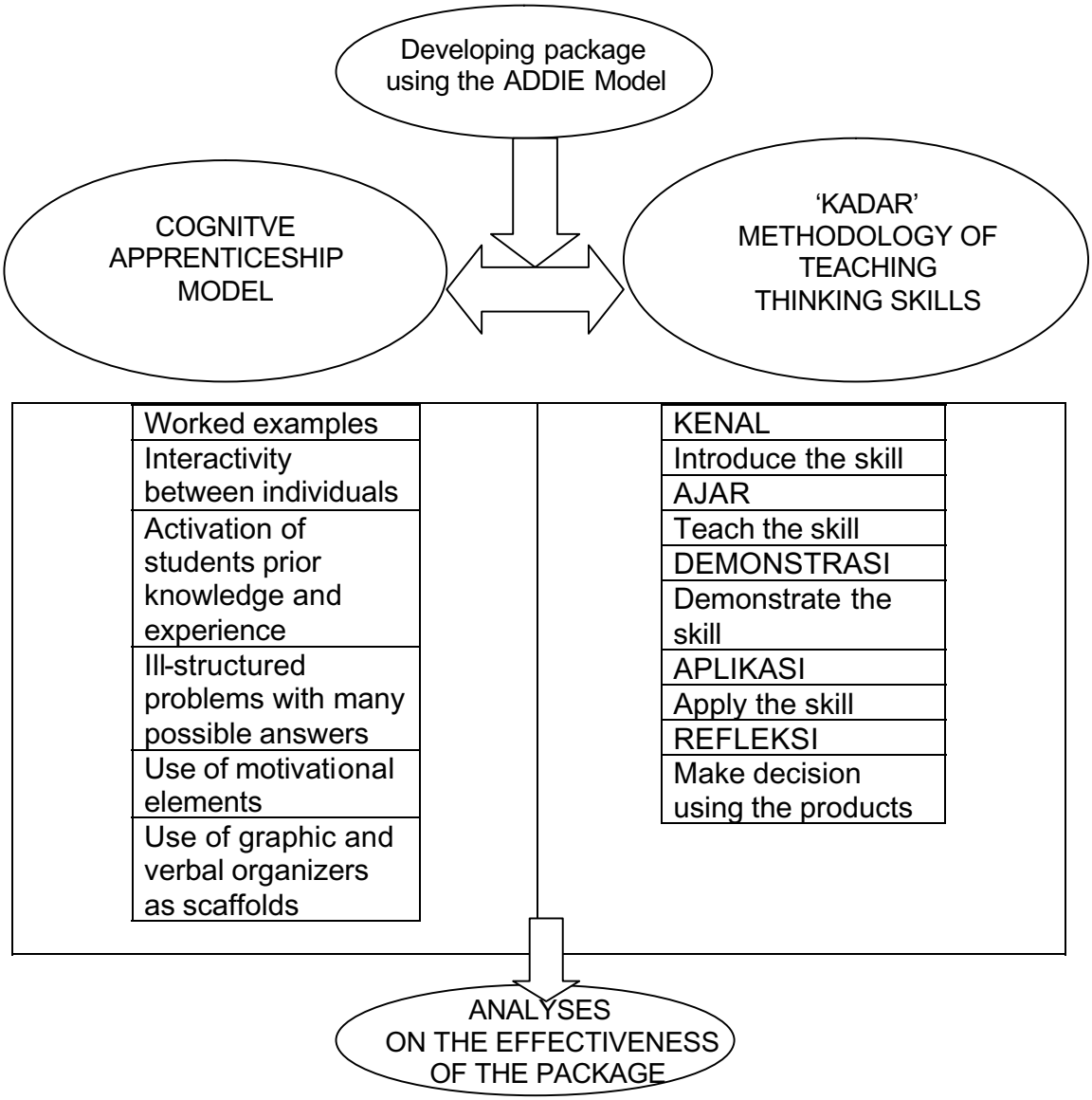


Figure 1.1 The structure of the theoretical framework

The methodology adopted in developing the interactive multimedia package was based on the ADDIE model as shown in Figure 1.2 in the operational framework. The framework for the development of the multimedia prototype consisted of the five developmental stages of the ADDIE model, namely:

- Analysis
- Design

- Development
- Implementation
- Evaluation

The research project involved the preliminary needs analysis, exploring methods for direct teaching of thinking skills, constructing instruments to divulge divergent analytical thinking skills of respondents and checking for validity and reliability, design and development of prototype, content validation by experts, implementation and evaluation of an interactive multimedia package in analytical thinking skills using three techniques; verbal and graphic organisers and several CoRT1 tools. These are strategies adopted by local experts in thinking skills and are found in numerous documents published by the Ministry of Education (Som and Mohd Dahlan, 1998 and Poh, 2000).

The underlying concepts that served as underpinnings for this study are namely:

- Cognitive Apprenticeship Model
- KADAR methodology of direct teaching of thinking skills

a. Cognitive Apprenticeship Model

Cognitive apprenticeship is situated within the social constructivist paradigm. It suggests students to work in teams on projects or problems with close scaffolding of the instructor. The main characteristics of cognitive apprenticeship have been identified and elaborated upon by De Corte (1990) in his analysis of powerful learning environments. De Corte explained how powerful learning environments allow students to move from apprentices to master or expert status. For example, students need to observe an expert performing the task (modeling) and to be given hints and feedback on their own performance (coaching). They need to be given direct support (scaffolding) in the early stages of learning a task and to move gradually from other-regulation to self-regulation (fading). Students also need the opportunity to articulate their own cognitive and meta-cognitive strategies and to make comparisons with other learners; they should explore, identify and define new problems within a domain and be shown how strategies acquired

in one domain can be used to learn and solve problems in another domain (teaching for transfer).

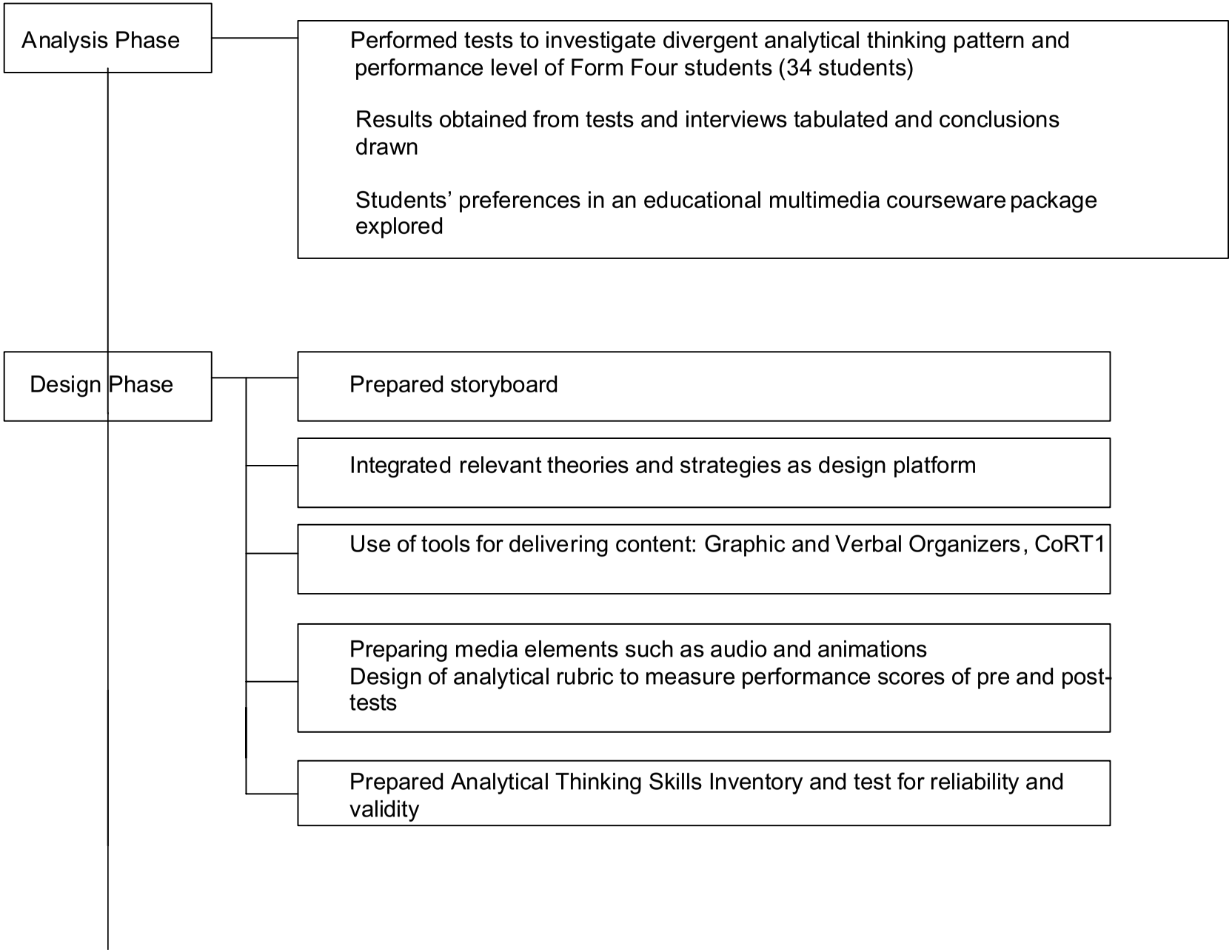
Cognitive apprenticeship model demand that student tasks to be slightly more difficult than students can manage independently, requiring the aid of their peers and instructor to succeed (Collins, Brown and Holum, 1991). Gilliani (2000) outlined the phases that would lead to a student achieving his full potential, which included 'reliance on others', 'collaborate with others', 'self-reliance' and lastly 'internalization' of knowledge and skills. These phases formed the basis of the instructional design of the interactive multimedia package.

Proponents of collaborative learning claim that the active exchange of ideas within small groups not only increases interest among the participants but also promotes thinking. According to Gokhale (1995), there was evidence that collaborative teams achieve at higher levels of thought and retain information longer than students who work quietly as individuals. The shared learning gives students an opportunity to engage in discussion, take responsibility for their own learning, and thus become analytical and analytical thinkers (Gokhale, 1995).

b. KADAR methodology of direct teaching of thinking skills

This strategy was introduced by Phillips (1997) for teaching thinking skills and is referred to as KADAR. The acronym appropriately stands for KENAL (Introduce), AJAR (Explain), DEMONSTRASI (Demonstrate), APLIKASI (Apply) and REFLEKSI (Reflect). A slight modification was made in the developed interactive multimedia package in that the sequence of instruction was modified to KDAAR based on the researcher's own findings conducted in the formative evaluation stage of the effectiveness in its implementation. The output from the exercise would then be scrutinized by the respondents in the 'decision-making' stage (REFLEKSI). The respondents would then be assessed by the scores they accumulate during the session.

1.7 Operational Framework



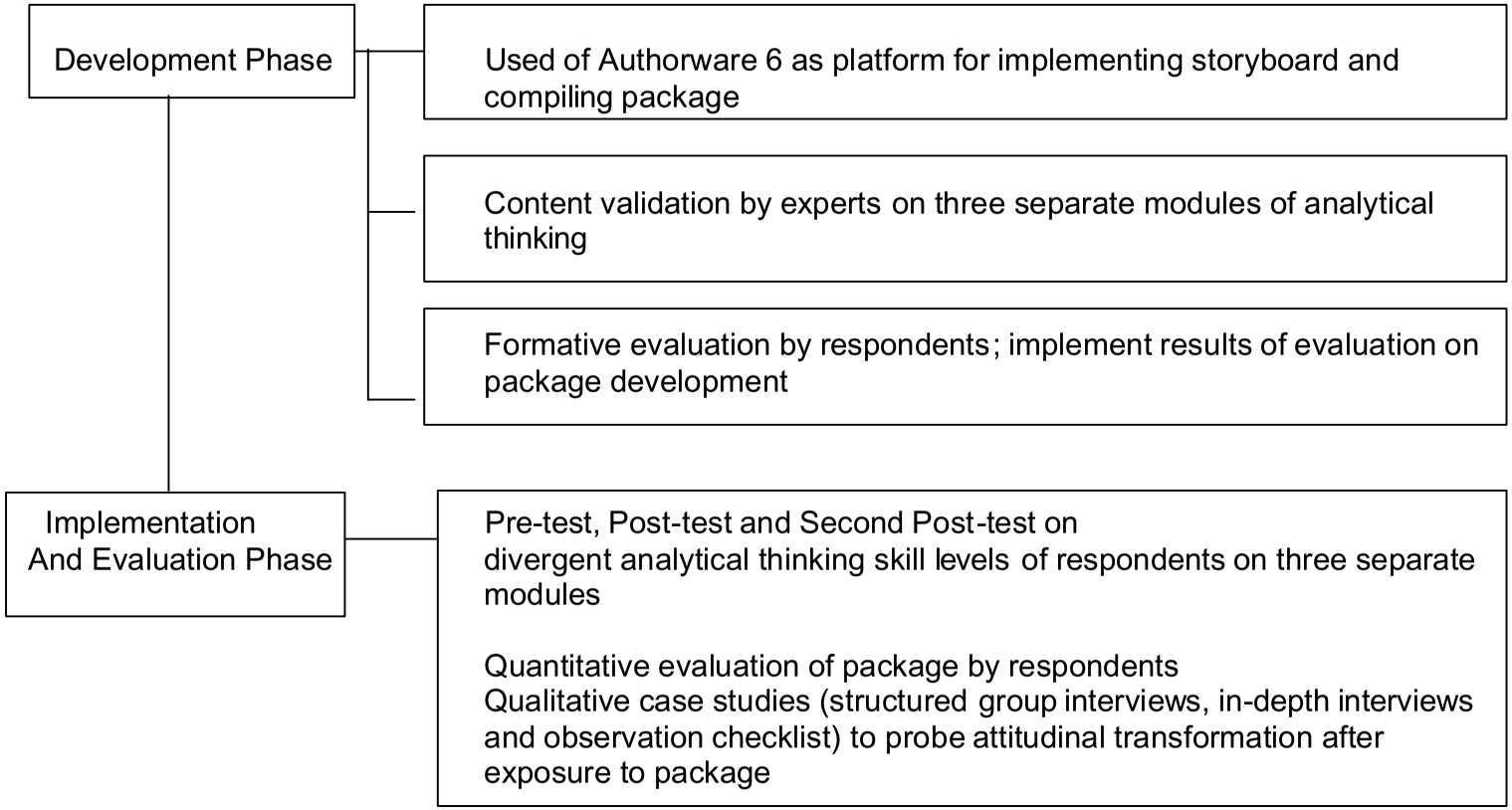


Figure 1.2 The structure of the operational framework

The structural content underlying the development of the package was based on the cognitive apprenticeship model using a modified approach of teaching thinking skills namely KADAR, proposed by Phillips (1997). Three modules representing three different facets of analytical thinking were constructed using graphic and verbal organizers as tools of thinking. The modules were Compare and Contrast (Module 1), Parts of a Whole (Module 2) and Proposal Ponder (Module 3). Graphic and verbal organizers as laid out by Poh (2000) and Som and Mohd Dahlan (1998) formed the backbone for Module 1 and Module 2, whilst the researcher constructed the graphic and verbal organizers for Module 3. Several CoRT1 tools were implanted into the package to facilitate divergent thinking. Elements of multimedia, interactivity and collaborative learning were then installed and undergone formative evaluation. The computer laboratories in three fully residential smart schools in Johore were chosen for the venue of the study to simulate collaborative learning in a intranetworked environment, where sharing of text files within a group of work stations were possible. Results of the formative evaluation by students and expert teachers were used to rectify weaknesses in the design. The interactive multimedia package developed as a vehicle for divergent analytical thinking skills enhancement then underwent summative evaluation to determine its effectiveness. The respondents from the randomly assigned control and experimental groups were administered pre-testing to determine levels of divergent analytical thinking performance using the 'pencil and paper' technique. Each student was tested using only one module. Their performance was evaluated based on ideational fluency and flexibility using an analytical rubric devised by the researcher and validated by expert teachers in the field of 'Analytical and Creative Thinking'. After a time lapse of two to three weeks, the control groups underwent post-tests whilst the experimental groups were then given the opportunity to explore the package based on the same module that they were initially tested in the pre-test. Respondents' behavioural dispositions were documented using an observational checklist. A second post-test were administered the next day where the respondents participated in a fully collaborative session. In this session, respondents create their own problems or scenarios and their peers would then have a go at them. Responses were recoded and scrutinized by the analytical rubric to calculate the performance score. Structured group interviews were

conducted in which the members were picked based on types of modules exposed. The transcripts were then recoded and summarize to include all the respondents' experiences and perceptions towards the package based on their responses from the pre-determined interview questions. Another session of a smaller scale in-depth group interviews was conducted in which the members were picked from different groups of respondents based on gender and level of gain in performance scores after the first post-tests were conducted. The transcripts were then analyzed qualitatively by cross-checking responses from different categories of students with the previous larger-scale group interviews' feedbacks to explore in-depth their personal experiences and any contrasting outlook on the effectiveness of the package.

1.8 The Rationale of the Research Project

Many important aspects of school life and home learning climate were predominantly motivated by the need to do well in examinations which curtailed students' mental process to conforming to ideas presented to them from the textbooks and other main stream resources (Nickerson, 1988). In addition, Kartini (1998) deliberated on the lack of emphasis given by trainee teachers on thinking skills' instructions in teaching colleges in the country. Results from other studies done locally exposed a low command of analytical thinking skills amongst Malaysian students (Safiah, 1996; Ravi, 1999; Razali, 1999).

One of the primary considerations in the Integrated Curriculum for Secondary School (KBSM) is 'to develop and enhance (students') intellectual capacity with respect to rational, analytical and creative thinking' (Ministry of Education, 1989). This is in line with the National Education Philosophy. The need to develop and enhance thinking skills amongst students is important and pressing so as to achieve one of the goals of Vision 2020 which is to produce a thinking society. An integrated or infusion approach of teaching thinking skills is adopted

which involves the inclusion of thinking skills instruction within the subject matter ever since. Thus, the need to inculcate the culture and skills in thinking is ranked highly in the educational achievements of Malaysian students. Roman (2003) deliberated the skills that the 21st century worker will need and amongst them are logical and intuitive analytical skills.

Evidence that is available from the literature on scientific reasoning suggests significant weakness in methodical thinking within school students that have implications on their thinking skills (Beyer, 1987). Cognitive strategies, even though they have been the focus of attention in scientific reasoning research, may sadly be the most analytical element that is lacking in our students' forte. This fact became apparent from the pre-test results administered in this study. The researcher thus raised the possibility that students at the middle school level have a non-existent mental model that underlies weakness in methodical thinking, and that impedes their analytical thinking capability.

Why should we be concerned about students' adeptness in divergent analytical thinking in our classrooms? Obviously we want to educate citizens of Malaysia whose decisions and choices will be based upon a multitude of ideas that span across a wide ranging school of thought. Maintaining a high level of productivity in today's modern society requires one to be analytical and analytical in processing ideas as well as capability in utilizing a number of different strategies of thinking.

1.9 The Significance of the Research Project

Indeed, very few studies have been conducted using newer instructional techniques, such as by means of multimedia package in a networked environment using the collaborative learning approach. From the researcher's literature search, it can be generalized that the teaching of skills, especially in divergent analytical thinking skills,

is still very much an emerging field of study in Malaysia. Since the aim of the current research project was to develop multimedia technology to meet the needs of Malaysian students and teachers, it was felt that the project would contribute to the literature on the teaching of thinking skills using interactive multimedia technology. The correlation between students' degree of contentment towards different aspects of design used in the package and their improvements in performance would also throw some light on issues regarding factors that could influence students' readiness and acceptance to use a new medium of instruction.

1.10 Limitations of the Study

Some of the limitations of the study will now be reviewed.

The first limitation of the study is the lack of generalization. The results could not be generalized outside fully residential smart schools in Johore, since the study only involved students of those schools. Entry requirements and socio-cultural background of these schools are not representative of day schools in the country. Superior academic excellence is a dominant factor of the respondents involved in the study. Limited exposure to social environment might have inhibited diversity in students' responses. Although variance was homogeneous in this study through the method of sample selection, it would be interesting to look into a more heterogeneous population.

Secondly, the number of scenarios posed to the respondents for each module was limited to six. This was due to the time constraint involved in each session. Respondents showed a much more positive eagerness in exploring the package in the second post-test when they tried out scenarios or problems created by their peers which was more diverse in nature, more relevant to their personal interests and much greater in number.

Thirdly, the effects of the package on enhancing students' performance and any attitudinal change that followed would be seen as short term effect. This is due to the short length of exposure time for respondents to explore the package.

1.11 Definition of Some of the Main Terms Used

1. *Divergent Analytical Thinking Skills*

It is regarded as a thinking exercise in which students generate as much verbal ideas as possible on a task based divergent thinking paradigm, universally known as ideational fluency. Since the scope of this project is focussed on analytical thinking based on peer group's views as the knowledge base and involved only verbal tasks, the term divergent analytical thinking was coined. Ainon and Abdullah (1995) pointed out that analytical thinking is an effort to perceive a situation in detail, breaking up entities into its components, to compare and contrast, to find the root cause of a problem and to find correlations between facts and situations. Modules in the package facilitate the generation of ideas either from one's own thought or reproduce ideas generated from his/her peers. The performance score would take into account the number of ideas generated by a student (ideational fluency) and the number of view points taken (ideational flexibility). The quality of ideas generated is not judged.

The elements in the interactive multimedia package are comprised of three modules on analytical thinking skills namely: Comparing and Contrasting, Relationship between Parts to a Whole and Proposal Ponder. It is an endeavor to cover some and not all aspects of analytical thinking skills.

The items posed to the students are designed to generate analytical and creative thinking in considering all possible solutions and view points. The ability to generate

statements through the use of graphic and verbal organizers with the utilization of CoRT1 techniques and peers' responses as knowledge base to proliferate these ideas will be the success indicator of the multimedia package.

The analytical rubric used to measure divergent analytical thinking performance scores are illustrated in Section 3.5.

2. *Graphic organizers*

It is defined as a mapping framework or symbolic guidelines to organize factual data and highlight relationships between them (Poh, 2000). Module 1 (Compare and Contrast) and Module 2 (Relationship between Parts to a Whole) of the developed package made use of graphic organizers taken from Poh Swee Hiang's (2000) "KBKK: Kemahiran Berfikir Secara Kritis dan Kreatif" and Som and Mohd Dahlan's (1998) book of the same name with a slight modification by the researcher of this study. The graphic organizer used in Module 3 (Proposal Ponder) is constructed specially for this study by the researcher. Please refer to Figures 2.3, 2.4 and 4.9 for diagrammatic illustrations.

3. *Verbal organizers*

Som and Mohd Dahlan (1998) viewed the importance of planting probing questions in thinking as "a tool to stimulate a person to procure information, to explore understanding, to generate interest and evaluate one's aptitude on a subject." The use of verbal organizers in this study is not in the usual form of questions posing but statements generated by the package based on respondents input to confirm, substantiate and verify ideas put forward. This constituted a meta-cognitive element in the package to facilitate reflection on individual responses. Please refer to Tables 2.3 and 2.4 and Figure 4.9 for diagrammatic illustration.

4. *Interactive multimedia*

Interactive multimedia refers to an interactive learning material incorporating different, integrated types of media which is interactive in nature. Hofstetter (1995) defined multimedia as "a computer to present and combine text, graphics, audio, and video." Hofstetter also maintained: "If one of these components is missing, you do not have multimedia. For example, if a computer does not provide interactivity, you have mixed media, not multimedia". Vaughan (1999) further strengthened the definition of multimedia, and described it as "woven combinations of text, graphic art, sound, animation, and video elements. When you allow an end user – the viewer of a multimedia project – to control what elements are delivered, and when, it is called interactive multimedia." The use of audio and video materials as well as appropriate Flash animations and helpful navigational buttons will be highlighted in the package.

5. *Analytical thinking skills performance score and initial performance score gain*

The respondents' performance in the pre-test, first post-test and second post-test sessions are based upon the total number of statements produced by the respondents for the module that they worked on. These scores will be further amplified if the responses given are categorically different or from different view points. This is to cater for ideational fluency and flexibility of the responses key-in. This analytical rubric used will be further elaborated in Chapter 4. The initial gain in performance score would constitute the difference between first post-test and pre-test scores to indicate the extent of initial impact of the package and used later to correlate with students' level of contentment on the design of the package.

6. *CoRT1 tools*

CoRT stands for Cognitive Research Trust initiated by Edward de Bono. CoRT1 tools are used in education to train the mind to be more creative, constructive and analytical by widening one's perception or views (Poh, 2000). It is composed of seven

techniques but only PMI (Plus, Minus, Interesting), CAF (Consider All Factors), C&S (Consequence and Sequel) and OPV (Other Peoples' Views) were used in this study. These tools constitute the 'divergent' factor of the package.

7. *Collaborative approach in an intranetworked environment*

Students are individually involved in authentic inquiry such as organizing ideas and resources, questioning and interpreting responses and decision making. Responses and feedbacks by peers are open to free access by all the members of the group through the sharing of text files stored on the network server in asynchronous mode. Thus, each and every member in the Local Area Network would collaboratively contribute ideas towards the problems at hand.

8. *Problem scenarios*

Questions in the pre-test and post-test are posed using everyday situational problems that are seen relevant to the students' past experiences or knowledge base. These ill-structured questions do not have a right or wrong answer attached to it and is entirely dependent on the students' own discretion to provide as many responses as they possibly could. Nevertheless, towards the end of each problem scenario, the students would have to reflect and decide on the best response as they saw fit to represent the outcome to the problem. This was to provide a purpose for the whole exercise as well as to accommodate for analytical thinking and decision making skills but would not affect their performance scores.

1.12 Summary

The study is aimed at investigating the feasibility of providing students with an alternative mode of enhancing divergent analytical thinking skills through multimedia driven, collaborative learning approach. The possible relationships between students' level of analytical thinking skills, gender and their level of contentment towards different aspects of the design of the package were also explored. It is imperative that the design of research is capable of magnifying differences in effectiveness of the package between different profiles of students so as to ensure a profound and multifaceted study can be carried out successfully, thus specific strategies were employed in the data analysis stage to highlight any significant differences that might have existed between them.

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