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3CAM MODEL CONCEPT MAPS, CRITICAL THINKING, COLLABORATION ASSESSMENT (3CAM) TOWARD THE PATH OF MASTERY LEARNING

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**3CAM MODEL
CONCEPT MAPS, CRITICAL THINKING, COLLABORATION AND
ASSESSMENT (3CAM) TOWARD THE PATH OF MASTERY LEARNING**

A Dissertation Presented

by

ELHAM ZANDVAKILI

Submitted to the Graduate School of the
University of Massachusetts Amherst in partial
fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

May 2019

College of Education

Language, Literacy and Culture

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DEDICATION

I dedicate my dissertation work to my family. A deep feeling of admiration and appreciation to my caring and loving parent, Kianoosh Rahimi whose support and persuasion have always helped me to keep my faith in the work. My brother Omid Zandvakili has never left my side, he is the reason of success in my life and he is very special.

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ABSTRACT
3CAM MODEL
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ASSESSMENT (3CAM) TOWARD THE PATH OF MASTERY LEARNING

MAY 2019

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This study reports an exploratory study of the 3CAM model of classroom learning. 3CAM is an acronym for concept maps, critical thinking, collaboration, and mastery. It is a student-centered approach to mastery learning that empowers students to take responsibility for their own learning. The model is a theory and a practice. The theory is the language games of critical thinking and the practice is the activities of visualizing concept maps, applying critical thinking, collaborating, and creating their own assessment. Students play the language games of critical thinking using the WH questions: “what, when, why, where, who and how”. Students apply the model each week to the chapters of a child development text.

The study also compared two groups of students: a group working collaboratively and a group working individually using the 3CAM model. The results of the study support the practices of the activities of the model as well as the theory of the language games of critical thinking. The data reveal that students who work collaboratively use significantly more “why, how and when” questions in creating their concept maps. The most used critical thinking question was “what”, and its use declined in the collaborative group as the use of “why, how and when” increased. The

use of “what” remained the same for the individual group. Student comments about the model were so supportive of both theory and practice.

TABLE OF CONTENTS

	Page
ACKNOWLEDGMENTS	v
ABSTRACT.....	vi
LIST OF TABLES.....	xii
LIST OF FIGURES	xiv
 CHAPTER	
1 INTRODUCTION	1
Statement of the Problem.....	1
Purpose of the Study	2
Definition of Key Terms.....	3
2 LITERATURE REVIEW	5
Introduction.....	5
Theoretical Framework.....	5
Bloom.....	6
Chomsky	8
Wittgenstein	9
Gordon	11
Literature on Each Component of 3CAM Model	13
Mastery Learning, Concept Map, Critical Thinking, Collaboration and Assessment	13
Mastery Learning	13
Concept Maps: The Deconstruction of Text into Personal Knowledge	15
Critical Thinking.....	17
Critical Thinking: Teachable and Learnable.....	20
The Role of Collaboration in Critical Thinking	21
Collaboration.....	22
General Approaches to Teaching Collaboration.....	24
Assessment of Collaboration	25
Assessment.....	26

3CAM Model	31
The Language Game of Critical Thinking (LGCT): A Method to Teach Critical Thinking	31
Syntax	33
Pragmatics	34
Semantics	36
Individuals and Groups	37
Pilot Study	38
Introduction	38
Statement of the Problem	38
Purpose of the Study	39
Questions and/or Hypotheses	40
Methodology	40
Sampling	40
Materials	40
Data Collection	41
Procedures	41
Prioritization	41
Collaborative Phase of the 3CA Model	41
Steps to Generate Hybrid Questions	43
Data Analysis Procedures	46
Significance of the Pilot Study	47
Preliminary Data Analysis of Pilot Study	47
Methods to Define Score's Consistency	47
Split-half reliability	47
KR-reliability	48
T-Test	48
Assessing the Internal Consistency of Questionnaire	50
Cronbach coefficient alpha	50
Conclusions from the Pilot Study	52

3 METHODOLOGY	55
Introduction.....	55
Research Questions	55
Research Question No. 1.....	55
Research Question No. 2.....	56
Research Question No. 3.....	56
Research Question No. 4.....	57
Research Question No. 5.....	57
Research Question No. 6.....	57
Research Question No. 7.....	58
Description of Variables and Research Design	58
Research Design.....	59
Participants.....	60
Instruments.....	60
Data Collection Procedure	61
Description of Data Gathering	61
Experimental Group 1/Collaborative Group: (Conceptual Map, Critical Thinking, Collaboration and Assessment) Using Multiple Reasoning Items	61
Individual Phase of Collaborative Group	61
Collaborative Phase of Collaborative Group	64
Experimental Group 2/Individual Group (Conceptual Map, Critical Thinking) Using Multiple Reasoning Items	66
Individual Phase of the Individual Group.....	66
Individual Group in the Classroom.....	67
Data Analysis Procedures	67
Analysis of the Concept Maps: Critical Thinking Questions	67
Applying Qualitative and Quantitative Analysis	68
4 RESULTS	73
Data Analysis.....	73
Frequency Analysis.....	73
ANOVA with Repeated Measures.....	78
Correlations Between “WH Questions”.....	89
CC-IN.....	90
CC-IC.....	90

IC-I.....	90
Multidimensional Preference Analysis	90
Correlations Between the Scores	92
T-Test	94
The TTEST Procedure	97
Questionnaire Data Analysis.....	98
Quantitative: Means Analysis	98
Qualitative: Thematic Analysis.....	99
5 DISCUSSION	104
Discussion of Findings.....	104
Why.....	107
How	107
When	108
Who.....	108
Where.....	108
Correlations.....	109
Multidimensional	110
T-test	113
Questionnaire Discussion.....	113
Teacher's Role in M3CA Model.....	116
Implications of Findings	117
Limitations of the Study.....	119
Future Research Direction: Moving the Dial.....	120
APPENDICES	
A. 3CAM MANUAL.....	121
B. PRACTICUM STAGES	135
C. QUESTIONNAIRE.....	137
REFERENCES	140

LIST OF TABLES

Table	Page
1. T-Test Result Comparing NO and O	49
2. Equality of Variance (NO-O).....	49
3. T-Test Result Comparing NO and O	50
4. Equality of Variance NO-O	50
5. Reliability of the Ranking Specified Questions.....	50
6. Reliability of the Yes/No questions (Binary Response)	51
7. Variables	58
8. Repeated Measures ANOVA for Generation of “What Questions” Under the Critical Thinking of 3CAM Model.....	78
9. A Comparison of Means Between Conditions Across Time Intervals of “What Question”	78
10: Repeated Measures ANOVA for Generation of “Why Questions” Using the 3CAM Model of Critical Thinking	80
11. A Comparison of Means Between Conditions Across Time Intervals of “Why Question”	80
12. Repeated Measures ANOVA for Generation of “How Questions” Using the 3CAM Model of Critical Thinking	82
13. A Comparison of Means Between Conditions Across Time Intervals of “How Question”	82
14. Repeated Measures ANOVA for Generation of “When Questions” Using the 3CAM Model of Critical Thinking	83
15. A Comparison of Means Between Conditions Across Time Intervals of “When Question”	83
16. Repeated Measures ANOVA for Generation of “Where Questions” Using the 3CAM Model of Critical Thinking	84
17. A Comparison of Means Between Conditions Across Time Intervals of “Where Question”	85
18. Repeated Measures ANOVA for Generation of “Who Questions” Using the 3CAM Model of Critical Thinking	85

19. A Comparison of Means Between Conditions Across Time Intervals of “Who Question”	86
20. Correlational Analysis Between CC-I	89
21. Correlational Analysis Between CC-IC	89
22. Correlational Analysis Between I-IC	89
23. Correlation Analysis Between Score’s Test	93
24. Confidence Limits for Means Between IN-CN	95
25. T-Test Result Comparing (IN) and (CC)	95
26. Equality Variances	96
27. Confidence Limits for Means Between IN-CC	96
28. T-Test Result Comparing on the Old-test (IN) and (CC)	96
29. Equality of Variance IN-CC	97
30. Confidence Limits for Means Between Old-Stm.....	97
31. T-test Result Comparing on the Old-test and Stm Test for All Students.....	98
32. Equality of Variances Old-test-Stm	98

LIST OF FIGURES

Figure	Page
1. Components of 3CAM conceptual framework	13
2. Semantic relations	3
3. Score's distribution of NO and O (The values are based on Y squared transformation on the original data)	48
4. Score's distribution of N and O (The values are based on Y squared transformation of the original data)	49
5. Student's ranking on concept map	51
6. Student's ranking on collaboration	51
7. Student's ranking on assessment	52
8. Student's ranking on generation of multiple-choice items	52
9. Three experimental conditions.....	59
10. Concept map sample	62
11. The frequency distributions of the "WH questions" for the individual group (IN)	74
12. The frequency distributions of the "WH questions" for the individual Collaborative group (IC).....	76
13. The frequency distributions of the "WH questions" for the Collaborative group (CC)	77
14. A trend analysis of "what question" among conditions as affected by time intervals.....	79
15. A trend analysis of "why question" among conditions as affected by time intervals.....	81
16. A trend analysis of "how questions" among conditions as affected by time intervals.....	82
17. A trend analysis of "when question" among conditions as affected by time intervals.....	84
18. A trend analysis of "where question" among conditions as affected by time intervals.....	85

19. A trend analysis of “who question” among conditions as affected by time intervals	86
20. General picture of a trend analysis of “WH questions” generated under critical thinking	88
21. Multidimensional analysis between CC-IN	91
22. Multidimensional preference analysis between IC-CC	91
23. Student’s rating of different components of 3CAM model in IN/CC groups.....	99
24. Future research direction.....	120

CHAPTER 1

INTRODUCTION

Statement of the Problem

The problem this experiment addresses is how to use the 3CAM model of classroom learning to teach critical thinking and improve the achievement of students. Critical thinking is habits of mind and body essential for living and succeeding in the 21st century. This study is designed to examine the efficacy of the 3CAM model in teaching critical thinking by comparing individual and collaborative approaches. The problem of teaching critical thinking skills has proven to be very difficult and as a result there are great disparities in the achievement of students. The difficulty of reaching a consensus about a definition of critical thinking has resulted in many definitions of critical thinking and a continuing lack of progress and agreements among researchers and teachers. Teachers face the daunting task each day of teaching their students critical thinking skills.

Defining critical thinking as the use of the questions: “why, when, how, where, who and what” is a conceptual break through. The use of these critical thinking questions is not new but can be traced back into antiquity. What has been missing has been a set of tools to teach critical thinking. The 3CAM model of mastery learning is a theory and a set of practices to teach the critical thinking skills of asking WH questions. The language games of critical thinking (LGCT) is the theory that guides this project. The practice of the 3CAM model includes the elements of: concepts maps, critical thinking, collaboration and assessment. Each of the activities in the 3CAM model is connected by the application of the critical thinking questions.

Purpose of the Study

The purpose of this study is to compare an individual and a collaborative approach to teaching critical thinking skills using the 3CAM model of classroom learning. 3CAM is an acronym for concept maps, critical thinking, collaboration, assessment and mastery, and is a collaborative approach to critical thinking and mastery learning. 2CAM is an individual approach to mastery learning that includes concept maps, critical thinking, assessment and mastery. Collaboration is the element that separates the 3CAM collaborative approach from the 2CAM individual approach to critical thinking and mastery learning.

This experiment is designed to show the differences between the collaborative and the individual approaches to critical thinking. The different components of the model: concept maps, critical thinking, collaboration and assessment represent different stages of higher order thinking in a concrete and transparent way. As student's master each of the components of the model, there depth of understanding of the knowledge of the text and critical thinking increases.

The 2CAM or individual approach to teaching critical thinking skills emphasizes concept maps, critical thinking and assessment. This approach to teaching and learning is a mix of tradition and innovation. The tradition is the focus upon the individual learner and the innovation is the introduction of concept maps, critical thinking and assessment. Students learn new skills but do not practice collaboration as they construct their own concept maps and apply critical thinking questions to their maps. They now have a clear picture of their critical thinking but they do have the benefit of seeing the thinking of others.

The 3MCA model expands the scope of teaching, learning and assessment to create classrooms in which there is equality of opportunity. The model changes the

dynamic in the classroom by having students construct, visualize and own their critical thinking as they create knowledge structures using concept maps. All students create concept maps and apply critical thinking questions to the links between concepts, and in the process, they reconfigure the knowledge in a text into their unique knowledge structures. They later use the concept-questions they have created with their maps to create the prioritized lists from which they construct the reasoning items that are the basis of the assessment of their achievement in the class. The result is an approach to classroom learning in which students are empowered to take responsibility for their own learning and assessment.

This study is designed to show the differences between individual and collaborative learning of critical thinking skills. The theory of the LGCT makes the obvious point that there are syntactic connections between the different questions. The search for these patterns has been hindered by the assumptions that the questions were independent of each other. This research project shows there are indeed patterns in the relationships between the WH questions. This study is an exploratory study of the patterns of critical thinking used by students who work individually and those who work collaboratively.

Definition of Key Terms

Concept map: A concept map is a graphical representation of concepts connected by arrows and drawn either digitally or on a sheet of paper. Concept maps are tools to organize knowledge help students to notice the important concepts in different materials (Novak,1991; Jonassen Beissner, & Yacoi,1993; Roberston, 1989; Wandersee,1994).

Critical thinking: Critical thinking is defined by Halpern (1998) as the use of skills and strategies that increases the probability of a desired outcome, and can be learned in ways that promote transfer to novel contexts.

Language games of critical thinking (LGCT) is the theory that the critical thinking questions of “what, who, when, where, why, what and how” constitute a language that has a syntax, semantics, and pragmatics. (Zandvakili,2018)

Collaboration: Collaboration is derived from the Latin collaborare and means to work together.

Assessment: Ioannou-Georgiou (4) defines assessment as “a general term which includes all methods used to gather information about student’s knowledge, ability, understanding, attitudes, and motivation.”

Mastery learning: Mastery learning is an instructional strategy and educational philosophy, first formally proposed by Benjamin Bloom in 1968. This cycle continues until the learner accomplishes mastery, and they may then move on to the next stage.

CHAPTER 2

LITERATURE REVIEW

Introduction

This review of the literature starts with the theoretical framework and culminates in a picture of the 3CAM model. The literature review focuses upon the relevant literature for each of the components of the 3CAM model: mastery learning, concept maps, critical thinking, collaboration and assessment. The literature review will come to an end with a review of the 3CAM model.

Theoretical Framework

My theoretical framework is a new perspective on a theory of critical thinking that will enable students to learn and achieve at a level of mastery. In the past mastery learning has been predicated on students having sufficient time and resources to reach high levels of achievement. This approach assumes that students need the appropriate skills to achieve at a high level.

The language games of critical thinking (LGCT) is the theoretical orientation for this research project in understanding thinking. This theory (LGCT) is a skill-based approach to teaching the language games of critical thinking. The theory is derived from Bloom's (1974) theory of mastery learning, Chomsky's (1959) theory of language and syntax, Wittgenstein's (1954) concept of the language game and Gordon's (2018) conception of the role of assessment in education. These theories are blended together to create the language games of critical (LGCT) to create a theory of the language games with syntax.

The language game of critical thinking is the theoretical perspective that is the basis of the 3CAM model. The LGCT proposes that the critical thinking questions of "what, how, when, where, what, and who" are constitute a language. The LGCT is

like all languages, children learn to speak the language in a natural and effortless way during the normal course of everyday life. Like all languages, the LGCT has a syntax, semantics, and pragmatics. The critical thinking questions are not new, and were first described by Aristotle and they are to be found today in the daily work of detectives, scientists, and ordinary citizens.

The work of Chomsky, Wittgenstein, Bloom, and Gordon provide a theory of a language of thinking created to close the achievement gap in classrooms. Every language needs a context for learning and development, and Bloom's concept of mastery learning is the theoretical context for the language of thinking. Bloom's context is a classroom in which all children are capable of achieving mastery through learning the language of thinking. His taxonomy of higher order thinking are the basic elements or components of the language of thinking. Chomsky's key revelation is that a language must have a grammar and a syntax that provides the dynamic process to the language of thinking. The late Wittgenstein's theory of the language game integrates the different components of the language of thinking. His view is that the language of ordinary people is perfectly in order, and the language games of thinking consists of a series of activities called a language game. Gordon (2018) insight that in the past education has directed the science of evaluation but in the future, the science of assessment will give direction to education, triggered a reimagining of the purposes and tools of assessment.

Bloom

Benjamin Bloom's Taxonomy of Higher Order Thinking is an important contribution to the 3CAM model. His Taxonomy is a framework for creating and designing learning objectives and assessment processes. The taxonomy is an observable set of mental processes that are key to success in schools. It is arranged in

a hierarchical fashion of increasingly complex cognitive functions that include: knowing, comprehending, applying, analyzing, synthesizing and evaluating. Over the decades teachers have found the taxonomy to be a useful guide in lesson planning as they set about creating objectives for instruction. Researchers also rely upon the Taxonomy as the standard for ordering and researching the element of higher order thinking. The Taxonomy originated from Bloom's work as University Examiner at the University of Chicago (Bretucio, 2017). The University Examiner was a legacy of the British University system, and tasked with the responsibility of designing, implementing and scoring term examinations. Bloom and colleagues from the American Psychological Association worried about the lack of clarity and consensus in the construction of tests. They created a system of evaluation that would constitute a common language for the field of educational assessment. Their intentions went beyond the cognitive realm to include emotional and psychomotor competencies. Despite their cautions to the field, the taxonomy of higher order thinking became the defacto standard for teachers as they went about the development of lesson plans and curriculum.

Bloom's contribution to the 3CAM model is a vision of mastery learning and a taxonomy for measuring it. Mastery learning is thus defined as the gathering of facts, comprehending, applying, synthesizing, analyzing, and evaluating knowledge. As this explanation of the 3CAM model unfolds it will be clear he has provided a goal worthy of education, mastery learning, and he has provided a metric to gauge progress toward that goal. Missing so far is a vehicle for reaching the goal, a candidate for the missing link is the 3CAM model of mastery learning based the language games of thinking.

Chomsky

Chomsky (1959) review of Skinner's book, *Verbal Behavior* (1957), set in opposition two competing accounts of language acquisition. The first has been characterized as experiential and the second as biological or formalistic. Skinner (1957) was a landmark experiential account of language acquisition using behavioral principles. Chomsky's *Aspects of Syntax*, was a biological and formalistic account of language acquisition. A half century and more later, the dichotomy between the two positions has blurred and it is increasingly recognized that the competing accounts of experience and syntax are not mutually exclusive but are essential aspects of first language acquisition. The same arguments and debates are present in second or bilingual language acquisition. This perennial debate is important because the same issues are present in a consideration of second language learning, and the language of thinking.

The characteristics of a language include: 1) from a finite set of components, an infinite set of possibilities, 2) recursion is defined as in terms of itself and its types. The types fold into themselves in an endless, repetitive and cumulative process, 3) a minimal stimulus elicits maximum possibilities, 4) everyone learns to speak the language by four years of age.

The merge function is the essential element in Chomsky's work that contributes to the model. It accounts for the merging of words while in the 3CAM model, the merge function provides a way of merging and ordering the components of the activities of the language game.

Prior to Chomsky, experiential accounts using behaviorism and reinforcement theory were widely accepted as the standard tools to understand the development of language. After his review, Chomsky's theory of universal grammar became the

major influence upon the study of linguistics and language development. There is still debate among linguists and psychologists as to the origins of syntax. Chomsky still argues that syntax is an evolutionary adaptation of relatively recent origins. Others argue that syntax is simply a function of the massive computational learning by the human brain. The debate continues about the origins of syntax, and interestingly no one debates the centrality of syntax and grammar to the development and learning of languages.

Wittgenstein

Ludwig Wittgenstein (1896-1954) one of the great philosophers of the twentieth century authored two texts: *The Tractatus Philosophicus* and the *Philosophical Investigations*. In the first he offered a picture theory of thinking and in the second he introduced the concept of the language game. These texts are thought by some philosophers to be diametrically opposed to each other. Wittgenstein thought the two views to be complementary. The first presented a picture theory of thinking in which pictures mirrored reality, and truth was defined as the correspondence between the picture and reality. Language in this system was a system of transferring pictures from one mind to another. In the *Philosophical investigations* he changed his mind, and introduced the concept of language as consisting of innumerable language games.

The language game was introduced to break the hold of dualism on the thinking of philosophers. Dualism is the idea there are two distinct worlds, the mental and the physical. His concept of the language game put the concept of dualism to rest because he showed the mental and the physical belonged to the same realm.

Wittgenstein showed that language games have their origins in the activities of daily life, and the shared agreement of community rather than a priori mental conditions.

Language games are created, persist, change, disappear, reappear, interact and

sometimes conflict with each other. Language games range from the simple such as: a greeting, a salute or a child's game such as ring around the rosie to the strings of language games found in theoretical physics. Following rules, using role models and beliefs are important in learning the language games of daily life.

The concept of the language game resembles John Dewey's concept of experience or the everyday tasks or activities in settings in which moral deliberations take place and character is formed. Within these local settings individuals debate and agree about how to live their lives. Experience has its own rhythm, boundaries, beliefs, rules, virtues and goals. Within experience the ego disappears within the whole, and the common good becomes preeminent. Concurrently, with experience a new sense of moral identity emerges.

Every culture sets standards for language games (skills and knowledge) for which its institutions are responsible. Every culture is composed of institutions or forms of life in which its members work in the spirit of the whole. At the foundation of institutions are beliefs and values that provide the criteria by which the language games are played. At each stage of development children must master certain skills and knowledge of the different institutions, and deviation is not acceptable.

There are public and private language games. Public language games are shared activities in public view while private language games go on in our heads as thinking skills. Wittgenstein shows that the language games begin as shared activities in open view, and later these same activities are practiced in silence. As an example, we learn to add with objects in our hands, a public language game before we learn to add in our heads a private language game. We learn to read out loud before we learn to read silently.

Wittgenstein contribution to the 3CAM model are two-fold: the emphasis upon a picture theory of language and the concept of the language game. The picture theory of language translates reality into pictures. A picture language preceded spoken language for millions of years and insured the survival of early men. Within the 3CAM model the correspondence between text and the concept map provides students with the means to create a new reality based upon their backgrounds of knowledge. The framework of the language game incorporates pictures in the language games of daily life. The second fold which is the language game includes both pictures and language. Wittgenstein was clear that the relationships between pictures and language permitted a focus on a particular aspect of a picture. Within the language game it was now possible to focus upon “aspects of the picture”. Within the 3CAM model the combination of pictures and words becomes a powerful tool for understanding the concepts.

Gordon

The 3CAM approach is prompted by Edmund Gordon’s (2017) view that the science of assessment has achieved considerable precision in understanding how to guide, classify hierarchically, predict, select, and certify based on developed abilities. At the same time, he noted that the science of assessment has neglected the use of tests to better enable learning as in diagnosis and possible treatment. 3CAM is a methodology designed to demonstrate that assessment can facilitate the learning of critical thinking and other higher order cognitive skills. Gordon argues that the science of assessment has reached the point where soon, assessment will provide new directions to educational practice. In the past education has given direction to assessment, in the future, this relationship will be turned on its head, and the science of assessment will give new directions to education.

Gordon's contribution to the 3CAM model is methodological in that his conception of dynamic assessment in Thomas and Gordon (2013) , provides a template and broader background against to consider the learning of the language game of thinking. Dynamic assessment is defined by Gordon as dynamic process in which assessment, instruction, curriculum and learning are inseparable. The language game is the theoretical perspective against which will be compared to dynamic assessment. This juxtaposition asks the question, how does assessment, learning, instruction, and learning map on to the language game?

In dynamic assessment instruction, learning, curriculum, and assessment flow into each other. The same dynamic relationship holds for the 3CAM model. If we substitute the language games of thinking for learning, the similarity between the models is clear. The study of learning has given way to the study of thinking. In the language games of thinking hypotheses, the data, and the conclusions flow into and are inseparable from each other. The application of critical thinking on concept maps, the concept-questions, and the reasoning questions flow into each other.

The language games of critical thinking are a combination of Chomsky's theory of syntax and Wittgenstein's concept of the language game. The result is a theory of thinking that transforms the language game into a dynamic language in which the different components of the language game merge, fold into each other, and re-emerge in a continuing process of making sense of the world. Language games range in complexity from the simple to the complex while retaining the merge function. The components of the 3CAM model are components of a language game and they merge and fold into each other. Bloom's contribution of the Taxonomy of Higher Order Thinking is a template to classify the complexity of thinking. Gordon's contribution is to reimagine the assessment and the components of the language game

as an opportunity to cultivate learning while transforming the teaching of critical thinking.

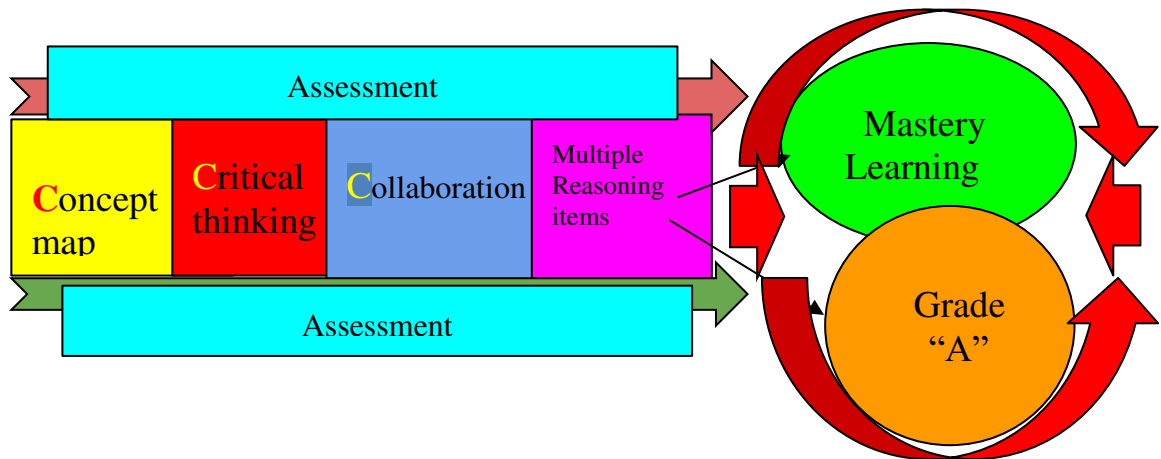


Figure 1. Components of 3CAM conceptual framework

Literature on Each Component of 3CAM Model

Mastery Learning, Concept Map, Critical Thinking, Collaboration and Assessment

Mastery Learning

Bloom's work on mastery learning contextualizes and reimagines a vision of schooling in which all children can be successful. The history of mastery learning begins with Thorndike (1959), Carroll (1963) and Bloom (1974), who proposed the concept of mastery learning as a way of closing the knowledge gap between high and low achieving students. These theorists were in agreement that given sufficient time and appropriate instruction all students could attain mastery of the content of instruction. The idea that all students could achieve mastery was and remains a radical idea. Bloom's model of mastery learning is a template for understanding past and current approaches to mastery learning (Gusky, 2007). Bloom was concerned with eliminating the achievement gaps between students differing in ethnicity, languages,

economic and cultural backgrounds. He observed that many factors outside of school influence the academic achievement of students. He was convinced that teachers could have a significant impact upon classroom. One of his more trenchant observations was that teachers displayed very little variation in their teaching practices, and as a consequence there were large variations in student achievement. Under these circumstances the pattern of student achievement approximates a normal distribution. To achieve better results and improve achievement, he recommended that teachers increase the variation in their teaching.

It was taken for granted in the 1950s, 1960s and 1970s that the gap in achievement between whites and people of color was due to hereditary factors. Anderson and Block (1977) defined mastery learning as a philosophy of school learning, an associated set of instructional practices, and the idea that mastery learning and education are embedded in values about students and learning.

In the 1980s this idea came under severe criticism from many critics. Slavin (1987), for example, argued that classroom data did not support the advocates of mastery. Kulik, Kulik and Banger-Drowns (1990) with wider review of the literature reached the conclusion there was merit and evidence for mastery learning. Interest languished for several decades and was recently brought forward again by Gusky (2007). The concept of mastery still captures the imagination of practitioners and theorists searching for equity in education.

Models of mastery learning have all but disappeared from the educational research literature. Two decades have passed since mastery learning was a topic with currency, and an active topic in the research literature. In contrast mastery learning is a hot topic in the fields of medicine and nursing with hundreds of articles being published over the last two decades. The untimely disappearance of mastery learning

was not alone other child centered, developmental, socially and emotionally oriented programs have also disappeared. Their disappearance coincided with the ascendancy of the cognitive accountability regimes of the No Child Left Behind Law. Testing and multiple-choice testing in particular became the criteria by which educational progress is measured. Educational standards are set to ensure that all children achieve a certain level of proficiency. Models of mastery learning and other child centered programs were not able to meet the new accountability standards. The result is that schools, teachers, and educational policy makers have turned to teacher centered classrooms and highly structured curriculums to reach high levels of accountability and achievement.

Concept Maps: The Deconstruction of Text into Personal Knowledge

Concept maps are a node-link diagram in which each node represents a concept and a link that identifies the relationship between the two concepts (Schroeder, Nesbit, Anguiano and Adesope, 2017). In the process of creating a concept map, students deconstruct the text into their personal knowledge. As students deconstruct the text they make the knowledge within the text their own. Their thinking is now visible, and the concept map is a picture of their knowledge. This picture knowledge is personal because in the student's mind are the background knowledge and skills previously learned. Some of the background knowledge is tacit (Polyani,2009)

Concept maps originated at Cornell University in 1984 in the work of Bill Trochem and a doctoral student, Dorothy Torre (Donnelly, 2017). Concept maps are a form of visual or picture thinking. Picture thinking is fast, automatic, effortless, often unconscious, and brings images to mind, spreading neural activation, enabling the individual or group to respond more easily than before. Concept maps are examples of

visual thinking. When we understand something, we say that we “see” it. We arrive at the solution to a problem through “insight.” To better communicate our ideas, we aim to make them “clear.” Such metaphors likening cognitive processes to visual experiences are so pervasive as to suggest a close correspondence between how we think about and how we see the world (Fan, et al, 2015).

Concept maps are situated in the visual thinking tradition in which signs on maps represent knowledge in space. These maps are what Jonassen (2000) calls mind tools. Mind tools are cognitive amplification and reorganization tools which exceed the limitations of the human mind by doing things more accurately and at a higher speed, and extend the use of other mechanical tools. Mind tools are generalizable from one setting to another engaging and facilitating cognitive processing. They help learners think for themselves and make connections between concepts and create new knowledge. Here-to-fore, the workings of the mind have not been open to public view. The use of mental maps reveals to students, ourselves and others, the workings of the mind.

A meta-analysis of concept maps by Nesbit and Adesope (2017) is a theoretical and practical analysis of the existing experimental research and a guide to future research and inquiry. They succinctly begin with the observation that concept maps or knowledge maps are diagrams that represent ideas as node link-assemblies, and there has been a steady increase in the number of published studies over the past thirty years.

Their review of the literature starts with theoretical orientations that have driven research into concept maps. They begin with Paivio (1986) who outlines a dual processing theory, verbal and visuospatial, that encodes information into distinct verbal and visuospatial memory systems. Links between the two systems are

pathways for the sharing of information. The two systems work together to enhance the processes of learning and the retention of memories. Learning from geographic maps is a useful analogy to the learning of concept maps. Geographic maps are much more efficient ways of remembering lists of places and objects than providing lists of the same places and objects.

Drawing concept maps is one of the most basic of visualization techniques and an invaluable resource for understanding thinking. Drawing is the manual mark-making techniques which produce images that serves some purposes. Maps, graphs, sketches, diagrams, charts, outlines and so on are techniques that facilitate thinking. Drawing is a way of observing the inner and representing the outer world.

Concept maps are considered as a good tool to assist the instructor to organize knowledge and an appropriate tool for students to notice the important concepts in different materials (Novak,1991; Jonassen Beissner, & Yacoi,1993).

The learner's increasing confidence in the creation of concept maps is an important consequence of the use of concept maps. Students are often told it is important to improve their thinking or simply to start to think. The use of concept maps makes it possible to chart the improvement in the thinking of students. Many students have absorbed the criticisms that they do not know how to think. Concept maps make it possible to show students a picture of their thinking and how to improve their thinking.

Critical Thinking

This brief history of the critical thinking questions produced some surprises. The first surprise is that the 5 "Wh questions plus how" began as seven in number, invented by Aristotle, and he called them the Seven Circumstances. In his book, the Nichomachean Ethics, he describes what was required if a person was to live a

virtuous life. He thought of the seven circumstances as a schema to determine if an act was virtuous. During the middle ages Cicero transformed the seven circumstances when they were moved from the ethical realm to the public realm of debate and rhetoric. In modern times the five “Wh plus how questions” have become the favorites of journalists, philosophers, educators, and each embraced the view that the critical thinking questions were cognitive tools to share information.

Like many after him, Aristotle found it easier to list the seven circumstances than define them. He listed them as (1) the who, (2) the what, (3) the around what place or (4) in which time something happens, (5) with what, such an instrument, (6) for the sake of what, such as saving a life, and (7) the how, such as gently or violently. The seven circumstances were a schema critical to Aristotle’s determination to show that an act is virtuous or shameful if it is completed. If one of the seven circumstances is not known, the act is not virtuous. Defining the differences between involuntary and voluntary actions was critical, and acts done in ignorance are not voluntary and bring about regret. He is not concerned with general ignorance but ignorance of particular circumstances.

According to Sloan (2010), Cicero based much of his work on Aristotle who wrote about the seven circumstances from the point of view of a philosopher while Cicero writes about the seven circumstances as a lawyer preparing a defense. The circumstances are a means for confirming an argument or adding authority to a speech. In everyday language, the circumstances are a template to make a narrative plausible. The seven types of circumstances now become a basic set of questions one ought to pursue to supply information and corroborate one’s claims. Sloan quotes Cicero, “All claims are confirmed by argumentation or is attributed to (1) person, (2)

the action, (3) the place, (4) the time, (5) the mode, (6) the occasion, and (7) the means will be investigated.

In modern times journalists have adopted the 5 “wh questions” as a template for storytelling: who was involved? What happened? Where did it happen? When did it take place? and why did it happen? Some writers add how to the list. These questions are a template for getting a complete story. If one of the questions is not answered, the story is not complete. Each question requires a factual answer, and none of the questions can be answered with a simple yes or no.

Lai (2018), a psychologist, in her review of the literature defined critical thinking as actions or thoughts that critical thinkers are able to do. Cognitive psychological focused on how people think in comparison to how they should think under ideal circumstances (Sternberg, 1986). Halpern (1998) defined critical thinking as “the use of those cognitive skills or strategies that increase the probability of a desirable outcome”. This perspective includes a checklist of procedures conducted by critical thinkers (Lewis & Smith, 1993).

According to Willingham critical thinking is “seeing both sides of an issue, being open to new evidence that disconfirms your ideas, reasoning dispassionately, demanding that claims be backed by evidence, deducing and inferring conclusions from available facts, solving problems, and so forth” (Willingham, 2007, p. 8).

Educational researchers have emphasized the cognitive dimensions of critical thinking. Benjamin Bloom and his colleagues focus upon teaching and assessing higher-order thinking skills of analysis, synthesis, and evaluation in classrooms. Other educationally oriented researchers have focused upon a wide range of cognitive skills including hypotheses generating, analyzing, reasoning (Ennis, 1985; Facione, 1990; Halpern, 1998; Paul, 1992); reasoning applying inductive and deductive reasoning

(Ennis, 1985; Facione, 1990; Paul, 1992; Willingham, 2007); assessing or judging (Case, 2005; Ennis, 1985; Facione, 1990; Lipman, 1988; Tindal & Nolet, 1995); and decision making (Ennis, 1985; Halpern, 1998; Willingham, 2007).

Among philosophers questions and answers have taken a decidedly cognitive turn in the twentieth century when the study of language shifted to the study of declarative sentences and propositions. At the same time, it was evident that questions and answers were of equal importance. The linkage between questions and declarative sentences became a subject of great interest though questions did not attain the level of importance afforded propositions and declarative sentences. Recently, a renewed emphasis upon the semantics and pragmatic dimensions of questions and answers marks a return to an emphasis upon the circumstances of human action.

(Sullivan, 2013; Manor, 1982, Hintikka & Halonen, 1995; Korta & Perry, 2006)

Critical Thinking: Teachable and Learnable

There is now widespread agreement by researchers that critical thinking skills are both teachable and learnable. Halpern (1998) presented evidence of two programs to enhance the critical thinking capabilities in students. In one research study, general problem-solving abilities and skills were taught based on Piagetian perspective on theory of cognitive development. In the second research study, the students were taught a particular type of problem-solving skill that provided visual math presentations more like professionals than of beginners. Kennedy et al. (1991) surmised that pedagogical interventions with the purpose of enhancing students' critical thinking abilities have presented more positive outcomes. Abrami et al. (2008) in a meta-analysis of 118 empirical researches concluded that the interventions have positive effects on learners critical thinking skills, with a mean of 0.34. They found that the effect size of the interventions varied as a function of the type of intervention.

One of the persisting problems in the area of critical thinking is the problem of the transfer of training from one domain to another. Abrami and colleagues have documented this problem in their descriptions of the different interventions.

Hummel and Holyoak are sensitive to the problem of transfer and described structure sensitivity as the ability to “code and manipulate relational knowledge” (as cited in Halpern, 1998, p. 453). The aim of training is to make student capable of transferring knowledge from one context to another. In order to accomplish this, they need to be able to identify a specific knowledge or problem structure, to recognize a particular problem so that they apply appropriate skills. Halpern mentions that application of “authentic” activities contribute to the problem of transferring skills to new context. Brown (1990) points out that context-specific background knowledge is essential for young children to appropriately convey skills to a new context. She concluded that “even young children show insightful learning and transfer on the basis of deep structural principles, rather than mere reliance on salient perceptual features, when they have access to the requisite domain-specific knowledge to mediate that learning” (p. 130).

The Role of Collaboration in Critical Thinking

Deductive instruction, modeling, collaborative learning, and constructivist skills are different strategies proposed by different researchers to apply critical thinking. Most of the researchers are advocates of the role of explicit instruction in the improvement of critical thinking (Abrami et al., 2008; Case, 2005; Facione, 1990; Halpern, 1998; Paul, 1992).

Collaborative approach to teach critical thinking is highly recommended by different scholars (Abrami et al., 2008; Bonk & Smith, 1998; Heyman, 2008; Thayer-Bacon, 2000). The collaborative approach is consistent with Vygotsky's theory that

highlights the value of social communication for developing cognitive skills (as summarized in Dillenbourg et al., 1996). Vygotsky proposed ZPD (zone of proximal development) as a gap between what a learner can achieve by herself and what she can achieve with the help of a more knowledgeable person (a peer or an adult).

Advocates of collaborative approach claim that critical thinking is the capacity to reply productively to peers during group work, which suggests interacting in socially constructive fashion. Likewise, Heyman (2008) shows that social skills can frame children's critical skills. Nelson (1994) suggests some hints as to how cooperation can provoke cognitive abilities between college students. He mentions that students' misunderstanding interrupts their skill to learn new information, in spite of having appropriate training. Collaborations generate opportunities to reach agreements, disagreements and to prune errors. Collaboration also is a vehicle to obtain essential assimilation to the college learning condition and supports to change implicit disciplinary structures and expectations to more explicit ones. "Collaboration must be scaffolded: first, students must be prepared for collaboration by providing them with a common background on which to collaborate, such as common assigned readings. Second, student groups should be provided with questions or analytical frameworks that are more sophisticated than they would tend to use on their own. Finally, collaborative activities should be structured by specifying student roles and by creating incentives for all group members to actively participate." (Lai, 2018, P.18)

Collaboration

Collaboration is derived from the Latin *collaborare* and means to work together. Collaboration is sometimes distinguished from cooperation in that cooperation is typically accomplished through the division of labor, with each person responsible for some portion of the problem solving. Collaboration, on the other hand,

involves participants working together on the same task, rather than in parallel on separate portions of the task. However, Dillenbourg et al. (1996) note that some spontaneous division of labor may occur during collaboration. Thus, the distinction between the two is not necessarily clear-cut.

In their review of the psychological and cognitive science literature, Andrews and Rapp (2015) make clear that collaboration has its own unique benefits, costs, and challenges in facilitating learning and memory. The benefits of collaboration include social, emotional and psychological well-being of the participants. Collaborative activities support achievement, problem solving, positive attitudes toward subjects, self-esteem, positive peer relations, when compared to individual and competitive activities. There are also costs associated with collaboration; Group members while collaborating can also provide unrelated or inaccurate information, and this information can be accepted, endorsed, and incorporated into existing cognitive structures.

The benefits of collaborative activities include providing opportunities for the elaboration of knowledge, inquisitive and constructive dialogue, the co-construction of ideas, the resolution of conflicting knowledge and better information recall. Dialogue within groups discounting particular kinds of information. Task complexity is an important variable in understanding collaborative learning in groups. Students in groups solving problems of high complexity are more successful than students working alone. Not surprisingly students working alone on a low complexity task do better than students in groups. Low complexity tasks include activities which can be retrieved while high complexity tasks require retrieval and also involves relating that information to solving a problem. provides articulate explanations, strengthen existing knowledge structures and encourages the reorganization of knowledge, helps acquire

new information and correct misunderstandings. One of the more salient benefits of collaboration in learning is that the process makes gaps in knowledge more salient. The discomfort generated by the collaboration helps reconcile conflicts and facilitate critical thinking.

The benefits to memory of collaboration are as beneficial as learning. Group members are exposed multiple times to more information than a person encounters as an individual. As learners encode more information during an activity, recall increases when compared to independent recall. Collaboration does improve the quality of group members production while providing feedback to each other regarding truthfulness. Andrews and Rapp use the term “error-pruning” to describe the process by which individuals engage in discarding or there are costs and there are benefits to cooperation in group. Andrews and Rapp propose that collaborative groups share the cognitive load among group members as they coordinate, discuss and critique ideas. The coordination of group members sometimes places additional cognitive and social burdens upon the group. It is possible, of course for groups to pass on misinformation, and this suggests that the costs of passing on misinformation can be limited by monitoring, providing opportunities for critique and appropriate feedback.

General Approaches to Teaching Collaboration

Few studies investigate whether students can be successfully trained to collaborate. As Bossert (1988) observes, “specific training in cooperative roles is not offered in most studies of cooperative learning methods: The activity itself constitutes the training” (p. 227). Although, many researchers suggested applying explicit instruction in collaboration skills (Fall et al., Webb, 1995). “Teaching students social and communicative skills. Structuring tasks to support collaboration was highly recommended as well”. (Bossert, Dillenbourg, 1999; Mercer, 1996; Webb, 1995).

Assessment of Collaboration

Measuring a learner's collaborative skills is a challenge. Most educators are interested in the individual's achievement score. They believe that group learning obscures the task and leaves the individual contribution unclear, making it complicated to grade each individual. Sometimes teachers will assign a single grade to a group based on completion of a group product, and this group score is given to each individual in the group; although, the effort from each individual is not equal. The score may not necessarily be a good representation of students' skills. (Race, 2001; Webb, 1995). There are four possible aims of collaborative assessments 1) Assessing each individual skills or knowledge, 2) Assessing an individual's ability to learn from group members, which can be obtained by involving both individual and collaborative assessment elements 3) Assessing group efficiency, as shown by the result of the final project completed cooperatively 4) Teachers assessment of a student's collaboration abilities and skills. (Webb, et al, 1995).

According to Webb, "if the task is well-defined and has one correct answer or solution, attempting to involve low-ability students may actually slow the group down. In this case, it may be more effective for students to work separately instead of together, for one or more group members to do most of the work while others contribute little, for one student to take control of group work if group members cannot agree, and to have minimal helping behavior" (p. 249).

According to Dillenbourg (1999) and Race (2001) increasing teacher monitoring with peer assessments of collaborative abilities and skills is helpful. Race mentions that learners are mostly a better assessor and can judge each other's work better because the learning procedures are clearer to them. Assessing a partner's job can also contribute to learning development. In order to help students to assess their

own knowledge and ability, students can complete a questionnaire and submit it along with assigned group work. (As cited in Lai,2018)

Assessment

The field of assessment is wider than the field of education, it is as deep as the many disciplines within it, and it has a history that stretches back millennium. This brief sketch relies upon Hill's technical history of assessment but also includes the social political context in which changes and advances in tests and measurement take place. Hill's (2012) social political analysis of the history of assessment does not take for granted as many do that assessment is synonymous with testing. He recognizes that testing is and has been at the center of the science of assessment. There is also no denying the field of assessment has made great advances in technical knowledge especially in the area of measurement and classification of developed abilities. Gordon (2012) argues that the field of assessment must move from the assessment of the measurement of developed abilities to an understanding of the processes of development. The social political aspects of assessment were present at its beginnings.

According to Hill this is evident when Emperor Wu in third century China instituted the first systematic use of testing as a way of checking the power of the nobles with the aim of bringing officials from the provinces into the central government. This early experiment in selection and certification began a long tradition of using tests as a means of social control. Passing the test certified that the candidate has mastered the Confucian classics as well as the skills necessary for their positions. The imperial essay exams were rigid in form and content, and applicants would spend years in preparation for the exam. Only 5% of the test takers passed the exam, and this led to the test preparation movement in which applicants were

prepared through the use of successful examinations. Slowly the tests imposed such a rigorous and lengthen regimen upon the applicants that the tests also imposed a model of character.

News of the imperial exam spread to Europe, and coincided with the decline of feudalism, and tests were seen as a way of encouraging the spread of equal opportunity and democracy. By 1788 the Chinese model of testing was imported into Prussia in what is now Germany. The government commissioned the creation of the *Arbitur*, a test for admission to the University. The test was created to eliminate the system of patronage in which universities exacted payment from the privileged for admission to the universities. By 1812 admission tests had spread to the secondary schools in Prussia. In 1808 Napoleon decreed the establishment of the *Baccalaureate* degree for admission to universities. Candidates were expected to have proficiency in physics, chemistry, biology as well as the social and economic sciences. Very rapidly entrance exams spread throughout Europe for admission to universities. Throughout Europe tests were widely accepted as a democratic instrument to ensure a university system based on merit.

According to Ernest Washington (2018), the testing movement gained strength with the enlightenment emphasis upon the individual and merit. This enlightenment tradition continued from the nineteenth and into the twentieth century. In Paris, where in 1905 Alfred Binet invented the Binet Scales, the first practical test of intelligence. He had been charged by the French government with the responsibility of creating a test that identify those children who did not profit from normal instruction. He interviewed teachers and asked them, what were the tasks that successful students could do and unsuccessful students could not? The answers from teachers gave form to the first scales of intelligence. The Binet scales included six items at each age level

from four to sixteen. Binet used the term mental age to describe the age at which children successfully passed the items. Those children whose mental age was below their chronological age were given remedial exercises. Binet coined the term mental orthopedics to describe his philosophy of mental development. The scale was used to identify the mental faculty of the child that needed strengthening, and teaching was the prescription to strengthen the weak faculties.

American social scientists also embraced the myth of a meritocracy that began with Thomas Jefferson who envisioned a public-school system which would educate the citizenry. This citizenry, of course, excluded those men without property as well as women and Black people. World War I brought on the draft and the need to select men for the armed forces. In 1914 Frederick Kelley, Dean College of Education at the University of Kansas introduced multiple reasoning tests as a means of testing. At about the same time Robert Yerkes, President of the American Psychological Association convinced the U.S. Army to use the newly invented Army Alpha Test, to test the intelligence of recruits. The Army Alpha developed by Arthur Otis and Lewis Terman was used to select service members to serve in certain units in the armed forces. The development of machine scoring made tests widely available and reified the objectivity of the tests. In 1926, the College Entrance Examination Board implemented the Scholastic Aptitude Test(SAT). By the 1930s multiple reasoning tests and their offspring, true false tests were widely accepted in schools.

Terman was later involved in the adaptation of the Binet scales into the Stanford-Binet Test of intelligence in which the concept of I.Q. become synonymous with the concept of intelligence. The concept of I.Q. was simply mental age divided by chronological age and multiplied by one hundred. The resulting single number rapidly became synonymous with the development and measurement of intelligence.

Testing and research on race ignited a firestorm in the 1960s and brought about charges of racism and turmoil. Until 1960 America was an apartheid state, and tests and measurements confirmed what most white people knew, Blacks were an inferior race. These latent sentiments came to the surface when Nobel Prize winner, James Shockley, enlisted Arthur Jensen (1968) to accept funds from the Heritage Foundation to conduct research and report his findings on race. Jensen's 128-page review of the literature on I.Q. testing, in which he claimed I.Q. differences were genetic and could not be ameliorated by social policies, set off protests at Harvard and the University of California at Berkeley as well as other universities. The protests had a chilling effect upon research at universities and the testing industry.

A generation later, protests over high stakes testing, began to rock the testing industry. This time the protesters were not blacks and liberals but middle class white parents who were protesting the impact of high stakes testing upon their children. The turn of the twentieth century marked the ascendancy of the testing industry and widespread controversy about high stakes testing. This controversy is reflected in the tension between formative and summative assessment functions, that is, assessment to support learning and assessment for certification and accreditation, although these are not separate or fixed paradigms (Wiliam and Black, 1996).

Currently, formative assessment is the objective and sanitized version of assessment and summative assessment has come to represent all social aspects (Scriven, 1967, p. 42). Differences, claims and counter-claims about the functions of summative and formative assessment has been continuous. Despite the support by Black and Wiliam and the Assessment for Reform group suggesting that the two types of assessment are inseparable (Black and Wiliam, 1998; Wiliam and Black, 1996; Wiliam 2000) notes that the differences may not be reconcilable. Torrance and Pryor

(1998) notice that little actual research has been done on the relationship between summative and formative research while there has been a great deal of theorizing about functions: this comparison however focuses almost exclusively on the functions of assessment.

Formative assessment is more time consuming, expensive and less reliable in scoring. The growing endorsements, approval, and prominence of formative assessment is due in part to the dissatisfaction with summative assessment which does not capture the complexities and individuality of the competence of the individual. (Jacobs & Farrell, 2003, pp. 19-20)

Alternative approaches to assessment became a credible reform movement in the early 1990s and continues into the 21st century by emphasizing formative assessment, procedural knowledge, cognitive, social, emotional relations, relationship between students and teachers, and the development of intellectual competencies. These reformers are concerned with moderating the negative impact of summative evaluation and judgments about the knowledge and potential of students. This movement expanded inquiry beyond declarative knowledge to embrace procedural knowledge to include knowledge of the self, knowledge of the other and knowledge of the social world. Advocates of alternative assessment are quite willing to consider diverse ways of gathering knowledge that go well beyond testing to include portfolios, classroom artifacts, and place emphasis upon student directed learning.

The tensions between formative, summative, and alternative approaches to assessment have given way to mixed method methodologies as the methodology of choice in the educational assessment. Mislevy's model (2012) is a natural extension and mix of methods in the development of methodologies of assessment. He offers, four metaphors we need to understand assessment. He begins by commenting that

everyone agrees the improvement of assessment is critical to making progress in educational practice and policy, and yet conversations about improvement pass each other like ships in the night. Each theory of evaluation is safe in its own ship and cannot see the connections with others going in the same direction. He offers four metaphors that he believes will improve communication between theories: assessment as practice, assessment as Feedback Loop, Assessment as Evidentiary Argument, and Assessment as Measurement. He is not quite finished when he lists these metaphors, he has four other metaphors that will complete his lists of essentials for a science of assessment. His four additional metaphors are: tests as contests, Assessment Design as Engineering, Assessment as the Exercise of Power and Assessment as Inquiry.

It is this desire to suppress the negative and destructive side effect of assessment which devalues personal worth and future prospects, that has prompted many educationalists to see summative assessment in a negative light and promote formative assessment (Torrance, 1993; Sebatane, 1998; Black and Wiliam, 1998; Wiliam, 2000; Torrance and Pryor, 2001: 624; Black et al., 2003). Society at large naturally, and rightly, makes judgements; the misuse of these judgements does not invalidate or minimize their necessity. It seems that the very fear of the possible social misuse of assessment has distorted our view of it (Scriven, 1967,41).

3CAM Model

The Language Game of Critical Thinking (LGCT): A Method to Teach Critical Thinking

This thesis is an exploratory study of the patterns of critical thinking WH questions “who, what, when, where, how and why” students use as they learn the content of the chapters of a child development text. The LGCT is a language with a

syntax of “what, when, where, how and why”. Like most languages the language games of critical thinking has a syntax, semantics, and pragmatics. Each of these aspects of language illuminate different dimensions of the language of critical thinking. The LGCT are the theoretical link between the learning of individuals and learning in groups. As a result, the LGCT are also a link between the individual and the collaborative phases of the M3CA model.

The six “WH questions” collectively provide information for understanding a narrative. Answers to each question is a declarative statement that provides different information. The critical thinking “WH questions” are deceptively simple, singular, and important sources of information. These singular language games merge together into the development of the language games of critical thinking. The games of thinking may start with “who, when, what, where, how, where” and novelists and scientists alike begin inquiry from these different perspectives. The focus upon a single “wh question” misses the point that much of information sharing involves the serial application of the “WH questions” to a problem.

The LGCT is the M3CA approach to understanding the language games of thinking. The idea of a language of thought (LOTH) dates back to Fodor (1975) who introduced the concept of a computational theory of thought. His proposal listed a series of requisites if a theory of the language of thinking was to be viable. His proposal is over forty years old today, and advances in philosophy and cognitive science have strengthened the case for a language of thinking. He proposed that a language of thinking must account for 1) the nature of thought, 2) the nature-nurture issue, 3) account for the empirical evidence for against language of thought, 4) the scope of the language of thought and the role of intentionality. Fodor’s ambition was to account for the entirety of landscape of thinking.

The M3CA makes the more modest claim that the “WH questions” are the basis for the language games of critical thinking. The analysis of the syntax, semantics, and pragmatics of the LGCT is a useful way to answer the questions raised by Fordor and to point toward future research.

The plan for this analysis is to use the theory of the LGCT to examine the M3CA model. The premises of the language games of critical thinking (LGCT) is that the language games of critical thinking have a syntax, pragmatics and semantics. The LGCT begins with Chomsky’s assumption there is a language function or faculty and that all human beings have the ability to learn any of the world’s languages. The first topic to be taken up is the syntax of the LGCT and the nature of thought. Pragmatics includes not only the meaning of a word or question but also an account of the social circumstances. In the case of LGCT the circumstances include the nature of the learner and a developmental approach to meaning. Semantics includes the traditional topic of meaning of the question, answer, word but also the meanings of images, feelings, as well as thoughts.

Syntax

According to Berwick and Chomsky (2016) the basic premise of syntax includes a merge function that builds a discreet infinity of structured expressions that are interpretable in a definite way by the conceptual-intentional system of thought and action, and by a sensory motor system for externalization. Another way of putting it is that from a finite combination of expressions and infinite number of possibilities. Merge occurs when two syntactic components are combined into a new unit (a set). Recursion is one of the properties of syntax and it occurs when it applies to its own output: the components combined by merge form a new unit and throughout which the original component remains.

The critical thinking questions of “what, why, when, where, how, and why” are the basic components of a language of critical thinking. Like all languages the LGCT has a syntax. The syntax of the LGCT is simple and yet powerful. There are two pivot words, “why and how”, and there are four open ended words “what, where, and when”. There is no strong empirical evidence to date as to the answer to the empirical question, is there evidence that the six “WH questions” have a syntactic structure? A strand of evidence is to be found in this dissertation. An examination of the statistical interactions of the frequency (use) of the pivot words and the infrequency of the open words (questions) will give some indication of the presence of a syntactic relationship.

The components of “why, when, where, how, and what, who” are finite in number and generate an infinite number of possibilities. There remains the empirical question of “is there a merge function during the application of the “WH question” to a series of problems over a period of time?”

Pragmatics

The pragmatic dimension of language learning is a reminder that language is a social activity. Collaboration is at the heart of the M3CA model and capitalizes on the necessity of social activity for the development of the language games of critical thinking. The individual and collaborative phases of the model take advantages of individual and collaborative learning. Students create their concept maps-questions, and for the first time they have a picture of their uniqueness as an individual thinker. Later they exchange concept maps and they see the representation of the thinking of a team mate. They exchange concept maps, and a new question arises, is there a synthesis of their knowledge? Notice the concept of synthesis bears a family resemblance to the concept of merge.

There is a small literature on individual children learning to use questions, and that literature will be briefly reviewed. There is no literature on the collaborative uses of the critical thinking questions. Scardamalia and Bereiter (2012) emphasize that in the coming decades team learning and not individual learning will be the focus of attention. They want to go beyond collaboration to cognitive responsibility for team learning. They make their case by beginning with the observation that all learning is group learning. Their emphasis is on what they call cognitive responsibility which can be described under the rubric of team learning while including a shared commitment to achieving a goal or completing a task.

It is important to begin with a brief discussion of the individual use of critical questions by children to provide a baseline for the use of critical thinking questions. Pinker (2003) describes children as intuitive psychologists who recognize the intentions before they copy them. If children recognize that an action was not intentional, they will not pay attention or imitate it. The minds of children are fitted with mechanisms to copy and imitate the intentions of others, and this is so ordinary. The motivation to be like others fuels the need to benefit from the information and knowledge of others and the second is normative, the desire to follow the norms of a community. Learning to ask questions is a normative experience that children learn and imitate.

The desire to acquire knowledge is present in children between two and five years of age as they learn the language games of question asking. According to Chouinard; et al, (2007) children use an average of 107 questions an hour when engaged in conversation with adults. These youngsters are using language and conversation in a purposeful and intentional way to gather information, fill in gaps in their knowledge.

Ruggeri, Sim and Xi (2017) investigated how preschool children used question asking to explain, why is Toma late for school? They compared hypothesis-scanning questions with constraint-seeking questions. Hypothesis-scanning questions target single objects within a given set such as, can this dog be found on Planet Apres? Constraint-seeking questions target a category or a feature shared by multiple objects such as “Can animals be found on Planet Apres”? Constraint-seeking questions are able to rule out alternative hypotheses and therefore are usually considered more effective than hypothesis scanning questions. As a result of their experiments they found that children become more proficient at generating constraint seeking questions because they are more proficient at categorization, verbal knowledge and previous experiences.

Bereiter and Scardamalia (2012), remind us that are continuities and discontinuities when moving from the individual to group analyses of learning. They use the concept of cognitive responsibility to capture a wide range of group phenomena that capture shared knowledge, beliefs, intentions, goals, and understanding. Cognitive responsibility is already shared by research, design and planning teams. Accordingly, they speculate that it is difficult to imagine the assessment of these complex social undertakings without computer technology. Such technologies will provide teachers and students to monitor levels of participation and discourse in knowledge building. In the future, they claim to see the evolution of ideas. In this era leaders will be able to facilitate but not necessarily control and manage the processes of learning.

Semantics

At the individual level semantics is concerned with the meaning of words, images, gestures and/or questions. The figure below captures the traditional view of

the nature of semantics. Asking a question (always occurs in a certain context) and this question requires an appropriate answer. This answer of course, if it is to have meaning, must connect to the reality of the world. The connection between the answer and the world is the correspondent definition of truth. There is much debate about this simple scenario, and it remains after a century of debate.

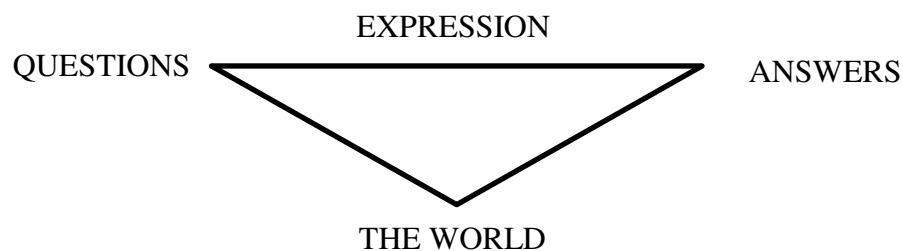


Figure 2. Semantic relations

A useful question is one that elicits an answer in accord with the world. Useful hypotheses in a science lab produces answers that are in accord with the facts about the world. The great detective Sherlock Holmes used questions and answers to solve the great mysteries of the world.

Individuals and Groups

The LGCT acknowledges the reality that in the real world critical thinking goes on individually and in groups. Students study alone and they study in groups, they learn alone and they learn in group. LGCT are the theoretical link between these paths of learning. The LGCT are a theoretical bridge that offers new theoretical insights into the processes of thinking. Critical thinking involves asking not one “WH question” but a series of questions. This series of “WH questions” can be considered a pattern of questions. Surely students over a life time have learned certain strategies or patterns of thinking.

The LGCT is a systematic way of assessing the patterns of questions used by students in solving problems. The trajectory of critical thinking WH questions “what, why, when, who, where, and how” can each be traced over time. The measurement of the critical thinking question over times provides a dynamic view of the processes of thinking. Students come to class with established patterns of using only one “WH question” in their approaches to inquiry. It is possible to use educational strategies, suggestions and directions to alter the established trajectories of critical thinking.

Pilot Study

Introduction

This exploratory study analyzed classroom learning with concept maps, critical thinking, and collaboration (3Cs) using multiple reasoning questions. At the center is a learner who is thinking and exploring patterns of knowledge. The pattern seekers create questions using concept maps, critical thinking and collaborative dialogue empowering them to analyze, create and evaluate their own learning.

Statement of the Problem

The 3CA is a model of classroom learning and assessment is necessary at this time. There is now an impasse in which the science of assessment has reached new levels of precision in the assessment of developed abilities and the classification of students. At the same time this very precision has alienated parents, students and scholars insistent that assessment account for different forms of knowledge, different ways of learning, social emotional learning, resistance to the hierarchical structure of classrooms and the necessity to have classrooms which spark curiosity and learning without the burdens of fear and stress. This exploratory study asks the question, “Does the 3CA model of assessment facilitate the learning of academic content, and empowers students?”

Purpose of the Study

The purpose of this study is to show that the science of assessment has reached the point where testing will guide the achievement of students in education. In the past education has guided developments in the science of assessment.

Going forward the science of assessment will guide advances in education. The proposal by Gordon (2017) turns the relationship between assessment and education on its head. In the future, the science of assessment will guide the future directions of the achievement of students in education.

The 3CA model changes the power dynamics in the assessment process by having students construct and visualize models of their own thinking as they create knowledge structures using concept maps. This process makes transparent the thinking of the students and the structure of knowledge in the classroom. While using critical thinking skills to analyze their concept maps, students are empowered to take control of their thinking and learning.

This study deconstructs the 3CA model using concept maps, critical thinking, collaboration and assessment. Each of these components influence classroom learning. The ultimate aim of this approach is to create a model of classroom learning that empowers students to create concept maps, apply critical thinking skills to collaborate, to share knowledge and create multiple reasoning tests that will be used in the assessment of their achievement.

This study is a first step in the understanding the dynamics of a model of learning in which students are empowered to use a transparent approach to learning that encourages higher order thinking and equity.

Questions and/or Hypotheses

There are two major research questions:

- 1- Does the 3CA model make any differences in the student's academic achievement?
- 2- Are there any difference between achievements test scores of students and the scores of students in the previous years who were in a traditional lecture/discussion classroom?

Methodology

Sampling

There are 75 undergraduate students, 18-22 years old enrolled in a general education course at a large northeastern university who are satisfying their requirements for graduation. Two thirds of the class are female. The class includes 20% students of color. There are no inclusion/exclusion criteria for this study. Accommodations make for students with learning disabilities as well.

Materials

- The students in the child development class use the textbook “ Understanding Human development by Grace J. Craig, Wendy L. Dunn” 2nd Edition, Prentice Hall, publisher.
- The “Critical Thinking and Test Construction Manual” for the 3CA model developed by Elham Zandvakili and Ernest Washington use to guide the practicum part of the class.
- “The Daily Stages of the 3CA model” is a power-point presentation to clarify the steps and procedures that students follow to meet the standards of 3CA model.
- Student`s Feedback Questionnaire: Developed in consultation with the Institute for Social Science Research.
- Student- made test for mid-term and final exam.

- Old-test: Tests based upon test items distributed by publishers.

Data Collection

Procedures

Training: The class is a four-hour class, and the first day of class is devoted to teaching students the procedures for the experiment. The procedures focused on the training with concept maps, critical thinking, and guidelines for the creation of the questions.

Individual phase of 3CA Model: Step 1: Knowledge recall, simple pattern seeking, application of critical thinking strategies, complex pattern seeking, Step 2:

Prioritization

Step1: Students at home generate 3 hard copies of their individual concept maps (The instructor divides the chapter into three parts and students generate one map for each third of the chapter); The result is that each student comes to class with one hand-written concept map of an entire chapter divided into three parts.

Step 2: Students prioritize two elements in their maps: 1-The concepts from the most to least important. 2- The connections between their concepts from the most to least important. The connections between the concepts are made by applying the critical thinking strategies. The students post their maps to Moodle.

*(Moodle is a learning platform designed to provide educators, administrators and learners with a single robust, secure and integrated system to create personalized and collaborative learning environments).

Collaborative Phase of the 3CA Model

Steps 3,4,5: Synthesizing (social and cognitive), Step 6: Prioritizing and step 7: Assessment (multiple reasoning items/hybrid multiple reasoning items generation)

Step 3 (Social synthesis): Students are randomly assigned to a group of 6, and they work together in three pairs. The group selects a leader and for each session there is a different leader. The leader assigns each pair of students to a team which is responsible for one third of the chapter, so each pair is responsible for one third of the chapter and the whole group covers the entire chapter.

Step 4 (Cognitive synthesis(a)): Each pair exchanges a concept map of one third of the chapter. They give feedback to each other, criticize, agree, disagree and identify gaps in their knowledge. While they are discussing and giving feedback to each other they apply critical thinking cues (What, How, Why, When, Where, Who).

Step 5 (Cognitive synthesis(b)): Each pair of students synthesize and combine the individual maps to generate a new collaborative map of one third of the chapter. There are three pairs in each group and each pair generates a new collaborative map from their individual maps. (The group has now covered the whole chapter)

Step 6 Prioritizing is the evaluative stage of the 3CA model and includes prioritizing the concepts identified in the collaborative concept maps and ranking concepts from the most important to the least important. Like the individual maps, students prioritize two elements in their collaborative maps: 1-Ranking the concepts from the most to least important. 2- Ranking the connections between their concepts from the most to the least important. The connections between the concepts are the critical thinking strategies.

Step 7,8 (assessment): Each group of six students create twenty-four multiple reasoning items with each pair of students creating eight questions; Each individual creates four multiple reasoning items and two hybrid (critical thinking) items.; Then the group gets back together and reduces the 24 items to twelve.

So, first the students generate 12 multiple reasoning items and they prioritize concepts on the collaborative maps; The pairs of students share their generated multiple reasoning items and ask each other about the reasons for the response to each question. They assess and give feedback to each other. The whole group comes together and reviews the items created in the group. They answer each other's question, criticize and revise the items as a group. Each pair presents their questions to the larger group, and asks the group to critique their items and discuss their answers. The group members give feedback to each other and revise their items. At this point they decide which 6 multiple reasoning items are better to be submitted. Now, they put aside the multiple reasoning items (Recalling and reviewing the information) and begin the process of generating hybrid questions (Critical thinking).

Then they go through the following steps to generate hybrid questions.

Steps to Generate Hybrid Questions

1- Recalling the information

Students close their eyes and remember content of the book, their individual maps, Professor's lecture, the discussion with their partner, collaborative maps, ordering of the concepts, reasoning questions they have made (They review all of the materials they have exposed, learned and generated).

2- Concept selection:

Students choose two of the concepts that they think are the most important ones to think about.

3- Context and real-life problem imagination (Example: a baby is crying)

Students keep their eyes closed and think about a baby (who question) in a context (where and when questions). They can add different elements to their context, people around the baby (who questions, they), what questions include

the arrangement of the room, sounds around her, etc. Students are the director of their imagination and they are applying the critical questions of “who, where, when, what and how”. The baby is crying is the problem. When there is a problem you search for a cause of the problem (why)?

So far, their thinking has taken them through the first, second and third stage of hybrid questions generation.

4- Solving the question (why the baby is crying and what is the solution?)

Students can imagine each of the following possibilities.

1. The when question: when was the baby fed last?
2. How does the baby usually fall asleep?
3. What question, does the baby need a diaper change?
4. How question, how do you comfort the baby?
5. What question, what did the baby have to eat today?
6. Who question, who is the best at calming the baby?
7.etc.

5- Explanation about the imagination journey

Students open their eyes, get back to group and explain about the context and problem they have created; At this point they decide which 6 problems are good to think about critically, to come up with different solutions and finally to submit.

6- Group Solution Finding

The leader of the group identifies the different problems suggested by the different teams of students. Each team suggests two different problems to be solved. The groups consider each of the problems and each individual suggests a critical thinking strategy to solve the problem. The group after some

discussions considers each of the possible strategies, and chooses the best solution or solutions.

Assessment step 8: Group leaders get into action. They post the group's maps and questions along with their answers, and a report about the discussion of hybrid questions to the Moodle Forum where the maps and questions are available for everyone in the class.

*One of the problems associated with collaboration is that students need a clear picture of their responsibilities. Students are reminded that each group member's performance will be assessed using the group rating form.

*The students test items are weekly reviewed, modified and changed slightly if necessary by the instructor to improve accuracy, ease of understanding and clarity between the stem and the multiple reasoning alternatives.

*There are a midterm and a final exam for the students in this experiment. The semester consists of two blocks of six weeks each. During each block of six weeks, the students produce 308 items. The instructors create tests, a midterm and final exam, of 100 items from a total pool of 308 items for each six-week period.

*Students are informed that the midterm and final exams are mastery examinations.

Grades are determined using the following rubric:

A 90-99

B 80 -89

C 70-79

D 60-69

E 50-59

The grade was based on four factors:

25%: Concepts/Critical thinking

25%: Collaboration/Creation

25%: Mid-term (student-made exam/old exam)

25%: Final (student-made exam/old exam)

The grade for the group in previous year was based on test items provided by textbook publisher (traditional tests).

50% mid-term exam

50% final exam.

Data Analysis Procedures

Quantitative analysis was applied to compare the differences in academic achievement between the student-made tests and old traditional test-test was applied to determine if there are significant differences between the two tests.

Qualitative and quantitative analyses were applied to the Student's Feedback Questionnaire. The qualitative data includes student's comments about each of the stages of the 3CA model. Thematic analyses have been conducted during this pilot study, and these analyses will be used during the dissertation research. The qualitative data include a series of "yes, no" and "why questions". For example, "do you think the concept maps were helpful in your learning? (yes, no). "Why do you think concept maps were helpful?" This same format was used to inquire about student's responses to: each components of the maps, critical thinking, collaboration and the construction of multiple reasoning questions.

Quantitative analyses were applied to the Student's Feedback Questionnaire. Students were asked to rate each of the components of the 3CA model: concept maps, critical thinking, collaboration and multiple reasoning item construction. The reliability of these data is measured using Cronbach's Alpha. Regression analyses was used to analyze the relationship between demographic data and the dependent

variables (ratings of the helpfulness of: concept maps, critical thinking, collaboration, and the construction of multiple reasoning items.

Significance of the Pilot Study

This study provides evidence that is feasible to change multiple reasoning test from a norm-based to a criterion-reference based test. We can show that the combination of concept map, critical thinking and collaboration as effective tool to improve achievement. This study changes the nature of assessment, it creates an approach to assessment that is equitable and fair; This study demonstrates that assessment provides guidance in the improvement of classroom learning and achievement.

So, the significance of this study is that it creates a model of classroom learning in which students 1) improve their knowledge and achievement, 2) teaches students critical thinking skills, 3) teaches students how to use concept maps to learn to collaborate, critique, and discover their shared knowledge, and 4) to empower students to control their learning and the assessment of their learning through the construction of hybrid and multiple reasoning items.

Preliminary Data Analysis of Pilot Study

The items from the midterm were analyzed for reliability and validity. Preliminary data indicate the split-half reliability of the tests is .50. This modest level of statistical reliability is due to the fact that the distribution of test scores was a one-tailed distribution. One expects reduced reliability when there is a one tailed distribution of scores.

Methods to Define Score's Consistency

Split-half reliability. To estimate the reliability of the student made test, the following formula, known as the Spearman Brown prophecy formula was used. The

correlation between the two half corresponds to the reliability of one half of the test and not the total test.

$$r(\text{total}) = 2(r \text{ half}) = 0.50$$

KR-reliability. We also used Kuder and Richardson to estimate the reliability of test score. $(KR-21)r = \frac{K-1}{K} \left[1 - \frac{\sum k^2}{K \sum V} \right] = 0.78$

T-Test.

1- Comparing scores of students in 2017 who took a standardized old exam from 2015/new old (NO) ?

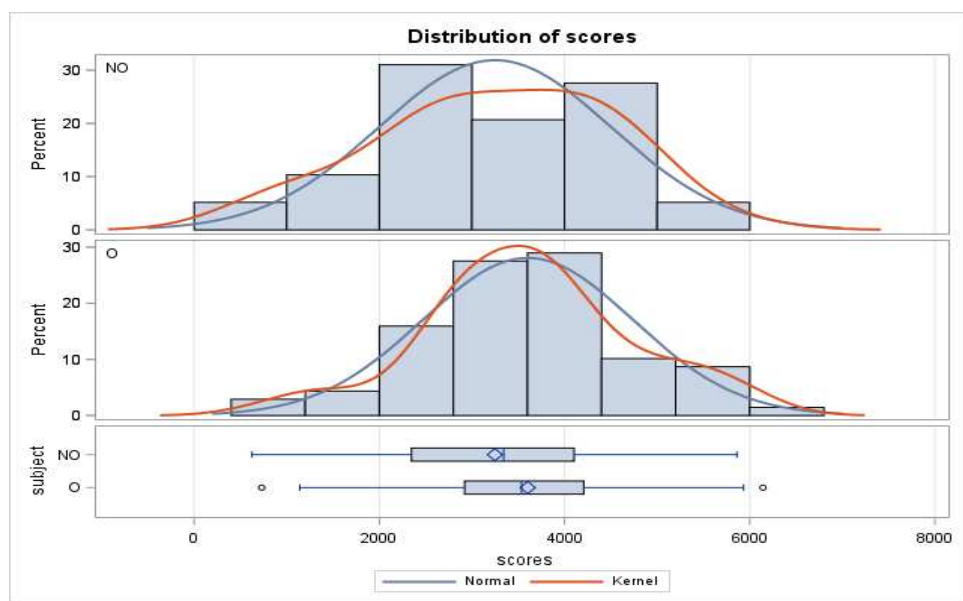


Figure 3. Score's distribution of NO and O (The values are based on Y squared transformation on the original data)

Table 1

T-Test Result Comparing NO and O

Method	Variances	DF	t Value	Pr > t
Pooled	Equal	125	-1.67	0.09

Table 2

Equality of Variance (NO-O)

Method	F Value	Pr > F
Folded F	1.21	0.44

The conclusion is that we don't reject the null hypothesis and that the scores of measures of interest are not significantly different.

- 1- Comparing scores of students who took the student-made tests in 2017 (N) with scores of students in 2015(O)

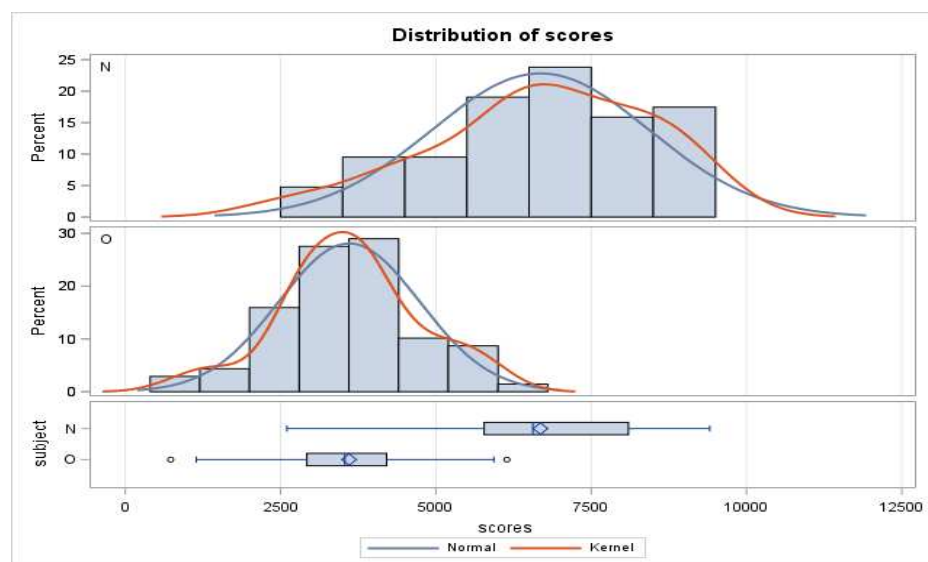


Figure 4. Score's distribution of N and O (The values are based on Y squared transformation of the original data)

Table 3

T-Test Result Comparing NO and O

Method	Variances	DF	t Value	Pr > t
Satterthwaite	Unequal	104.84	11.88	<.0001

Table 4

Equality of Variance NO-O

Method	F Value	Pr > F
Folded F	2.37	0.0006

The conclusion is to reject the null hypothesis and that the scores of measures of interest are significantly different.

Assessing the Internal Consistency of Questionnaire

Cronbach coefficient alpha. We used Cronbach alpha as a measure of internal consistency. Because Cronbach alpha can be used for both binary type and large-scale data. It is in fact a Coefficient of reliability.

$$\bar{C}/\tilde{V} + (N-1) * \bar{C}$$

N=Number of items

$\bar{C}$ = Average inter item Covariance

$\tilde{V}$ = Average Variance

Table 5

Reliability of the Ranking Specified Questions

Cronbach Coefficient Alpha	
Variables	Alpha
Standardized	0.633

Table 6

Reliability of the Yes/No Questions (Binary Response)

Cronbach Coefficient Alpha	
Variables	Alpha
Standardized	0.643

Distribution of the Components of 3CA model based on the questionnaire

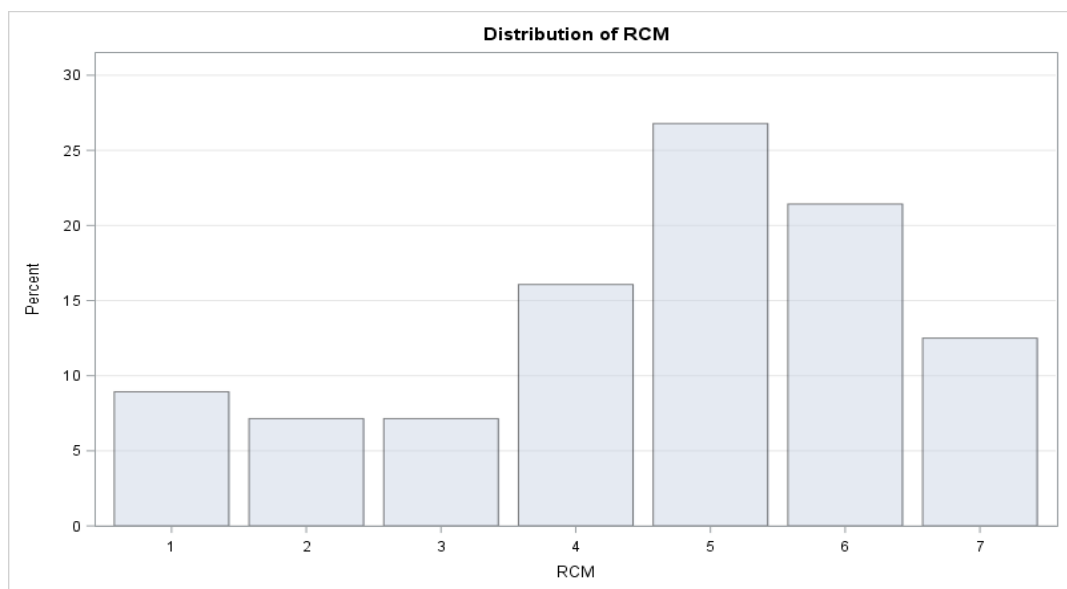


Figure 5. Student's ranking on concept map

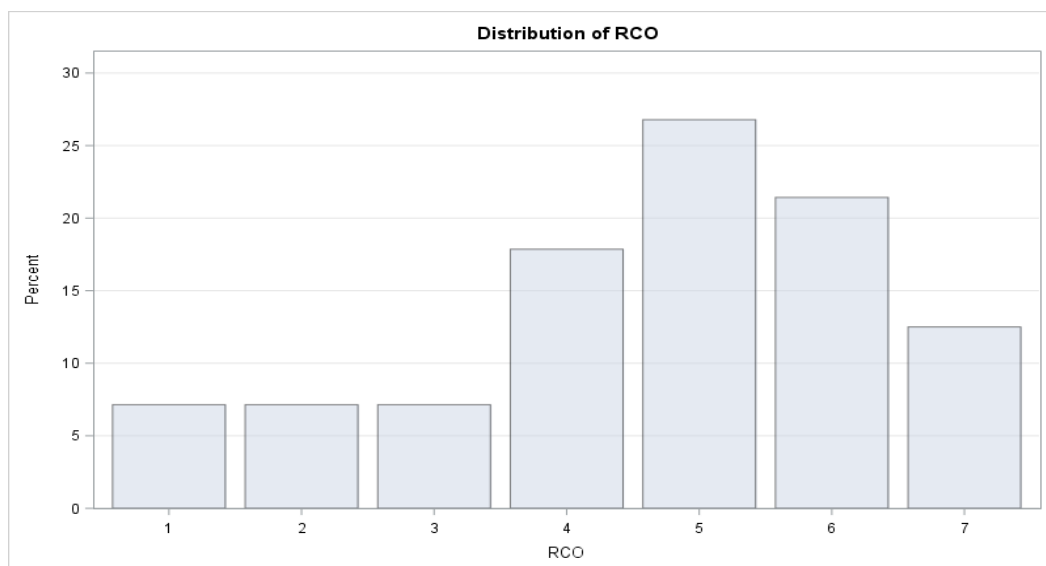


Figure 6. Student's ranking on collaboration

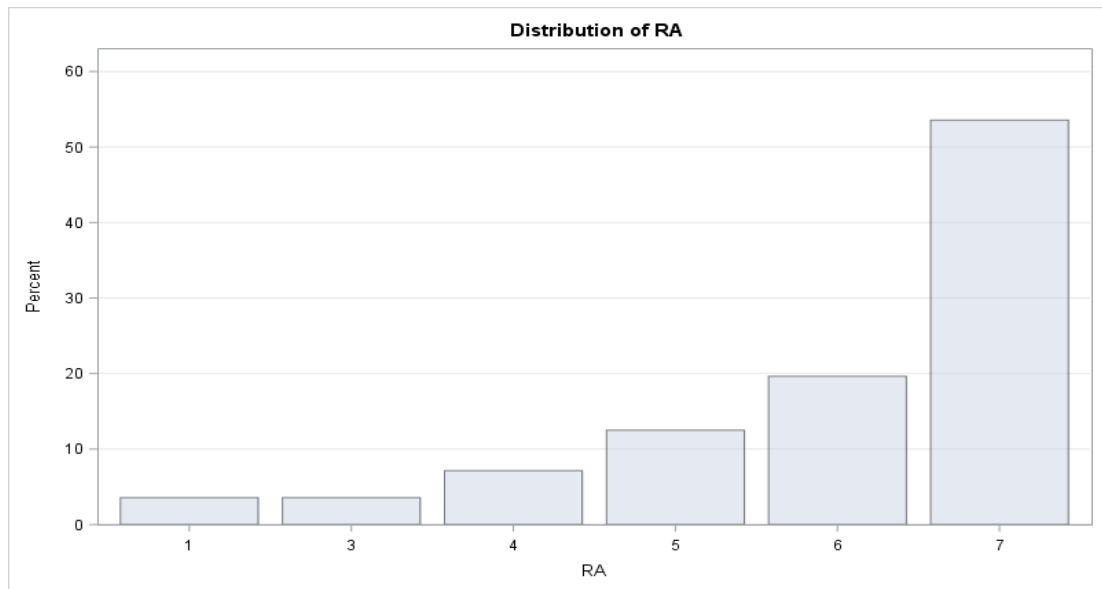


Figure 7. Student's ranking on assessment

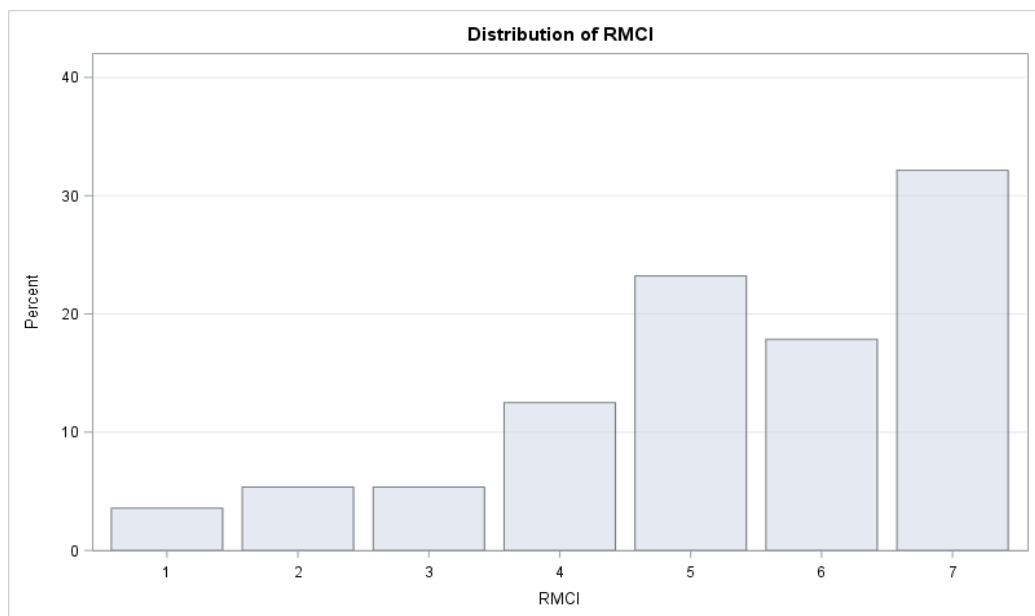


Figure 8. Student's ranking on generation of multiple-choice items

Conclusions from the Pilot Study

This pilot study encouraged the researcher to go forward with an experiment to investigate the potential of the 3CA model. The encouragement to go forward was based on several factors: the modification of the Manual for the 3CA model, student feedback, researcher's observations of collaboration, and statistical analysis.

The modification of the Manual for the model was a major step because it provided a systematic way of preparing students to use the model. The critical step of having a written model was a morale booster because the Manual made it clear that it was possible to articulate to the students the procedures for the conducting a study. The students were also impressed that there was a model and reference for them when they needed to understand classroom procedures.

Student feedback from the student survey of their participation in the study was very encouraging. They were enthusiastic about the different components of the model. They all enjoyed their participation and were very supportive.

The observation of the students by the researcher was a critical element in going forward with a study. The classroom came alive when the students were engaged in collaboration and the sharing of the concept maps. Students were helpful in making the decision to switch from handwritten concept maps to digital maps. This decision was critical because it was now possible to have an objective picture and data about student learning. Digital maps also made it possible to include critical thinking questions as links between concepts. Suddenly, the study was transformed because the researcher now had a reliable way of recording the thinking of students.

The statistical analyses of the data for the pilot study was a challenge because of the nature of the data. When using student constructed reasoning items, the distribution of scores when using was skewed. The skewed data made it difficult to use standard statistical methods that are based on the assumption of normality of distributions. My statistical consultant found that using a Y squared transformation and Tukey's ladder to transform the distributions. It was almost a miracle to see that a one tailed distribution could be transformed a distribution that appeared normal.

Students in the class took two final examinations. One final examination was based on a traditional standardized test and the other was a test constructed using the reasoning items developed by students. The student made tests were transformed and compared with the students' performance on a standardized test. The interesting result was that the distribution of scores was almost exactly the same. A T-test revealed that there were no significant differences between the two distributions. This finding of no differences between the two distributions encouraged the researcher to believe that student learning with multiple reasoning items resulted in performance that was similar to the performance of students in the past.

CHAPTER 3

METHODOLOGY

Introduction

This chapter begins with research questions and it is followed by a description of the data gathering methods used in the dissertation research.

Research Questions

The methodology begins with a series of six broad guiding research questions:

- 1) Are there significant differences in the overall pattern of the “WH questions” (what, when, where, how, who, why) for the individual (IN) collaborative and individual(IC)-collaborative(CC) groups for times: one, two and three?
- 2) Are there significant differences between the three different groups for each of the critical thinking questions and interactions between groups and time”?
- 3) Are there significant correlations between the “WH questions”?
- 4) Are there differences in the multi-dimensional preferences of “WH questions” for the individual, collaborative and individual-collaborative groups?
- 5) Are there significant correlations between the collaborative and individual groups in their scores on student made tests and standardized old tests?
- 6) Are there significant differences between the scores of the collaborative, and individual groups on the standardized and student made tests?
- 7) Does the data from the student’s questionnaire support the continued use and development of the model?

Research Question No. 1

1. Are there significant differences in the overall pattern of the “WH questions” for the individual (IN) collaborative and individual (IC)-collaborative(CC) groups for times: one, two and three?

1a. Are there significant differences in the overall patterns in the collective use of the critical thinking questions at times one, two, and three for the individual group(IN)?

1b. Are there significant differences in the overall patterns of the “WH questions” for the individual collaborative(IC) group at times one, two, and three?

1c. Are there significant differences in the overall pattern of “WH questions” for the collaborative-collaborative group(CC) at times one, two and three?

A pie chart showing the frequency of the uses of the WH questions at times one, two and three is used to compare the different experimental conditions.

Research Question No. 2

Are there significant differences in the frequency of use of the individual “WH critical thinking questions: what, why, how, when, where, who. Each research question will have three sub questions?

2a. Is there a significant difference due to groups (CC, IC and IN)?

2b. Is there a significant effect due to time (Time1, Time2 and Time 3)?

2c. Is there a significant difference due to interaction between group and time? These procedures will be followed for all the “WH questions”?

These data will be analyzed using analysis of variance procedures to reveal differences between groups, time and the interactions between time and groups.

Research Question No. 3

Are there significant correlations between the six critical thinking questions?

3a. Are there significant correlations between the six critical thinking questions between CC vs IC?

3b. Are there significant correlations between the six critical thinking questions between CC vs IN?

3c. Are there significant correlations between the six critical thinking questions

between IC vs IN?

A correlational analysis was chosen to show the relationships and overlap between the “WH questions” in the different experimental conditions.

Research Question No. 4

Are there differences in the patterns of the uses of the critical thinking questions using multidimensional preference scaling?

This analysis does not lend itself to decision making using significance levels rather the emphasis is upon the qualitative search for patterns of critical thinking.

4a. Are there differences in the patterns of the uses of the critical thinking questions using multidimensional preference scaling between CC vs IC?

4b. Are there differences in the patterns of the uses of the critical thinking questions using multidimensional preference scaling between CC-IN?

Research Question No. 5

Are there significant correlations between the scores of students on student made tests and standardized tests for the collaborative and individual groups?

An analysis of the correlations between performance on the individual and collaborative groups will reveal if there are similarities in performance on standardized and student made tests.

Research Question No. 6

Are there significant differences between the collaborative and the individual groups with regard to achievement on the student made tests and the standardized measures?

6a. Are there significant differences between groups on the student made tests?

6b. Are there significant differences between the two groups with regard to performance on standardized tests?

6c. Are there significant differences between all the students in both groups with regard to their performance on the student made tests and old standardized tests?

T Tests for independent groups will be used to show the differences between groups.

Research Question No. 7

Does the data from the questionnaire support the continued use and development of the model?

7a. Does the qualitative data from the questionnaire support the continued use of the different components of 3CAM model?

7b. Does the quantitative data from the questionnaire support the continued use of the different components of 3CAM model?

Description of Variables and Research Design

There are three independent variables: 3 groups (individual collaborative (IC), collaborative (CC) and individuals (IN), and 6 dependent variables (WH questions under critical thinking) over 3 time points:

Table 7

Variables

Format Level	Time 1 (beginner period)	Time 2 (Intermediate period)	Time 3 (advanced period)
Individual Collaborative (IC)	WH 1.....WH6	WH 1.....WH6	WH 1.....WH6
Collaborative (CC)	WH 1.....WH6	WH 1.....WH6	WH 1.....WH6
Individuals (IN)	WH 1.....WH6	WH 1.....WH6	WH 1.....WH6

Research Design

The *design* of this study is both exploratory and experimental. It is exploratory because 3CAM is a new model and each one of the components changed and improved as a consequence of trial and error. The design is a comparative study with two groups and the random assignment of students to groups. Formative assessments were made weekly using concept maps, critical thinking and prioritization. Summative data consisting of standardized tests and student created tests were gathered at the end of the experiment. Data are gathered from each group each week with regard to concept maps, critical thinking, and collaboration.

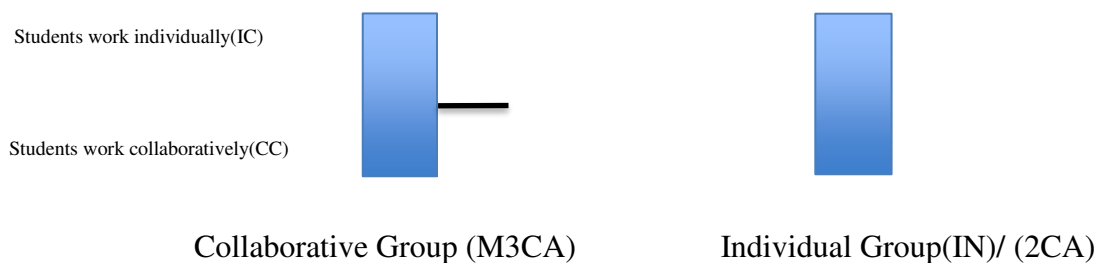


Figure 9. Three experimental conditions

Students are divided into two experimental groups: Collaborative group (concept map, critical thinking, collaboration, assessment) and Individual group (concept map, critical thinking, assessment). In the collaborative group students, independently prepared concept map with critical thinking before they come to class; Individual collaborative (IC), while in class they generate a new collaborative concept map with critical thinking; Collaborative-Collaborative(CC). In the individual group students also prepare a concept map with critical thinking before they come to class; Individual (IN).

The experiment was conducted over a period of 9 weeks and each week all students prepare a concept map with critical thinking prior to coming to class, so over a 9-week period, each student produces 9 concept maps with critical thinking. The data were collapsed into three time periods. Time1(beginner period), Time2 (Intermediate period) and Time3 (Advanced period).

Participants

There were 64 students randomly assigned to two different groups. There were 22 in the collaborative group and 42 students in the individual group. Students were initially assigned in equal numbers to each group. When the class began students chose not to be in the collaborative group, and chose to be in the individual group. Because of the Institutional Review Board regulations, students were given an opt out option and could opt out of the experiment. The experimenter chose to allow students to participate in the individual group if that was their preference. For this reason, we had 22 students in the collaborative group and 37 in the individual group. The sample included 64 undergraduate students, ranging in ages from 18-22 years with an average of 19 years old, enrolled in a general education course at a major university in north east who are satisfying their requirements for graduation. Eighty-two percent of the students were female, and 12% male, and 6% did not self-identify. Sixty percent of the class was White, fourteen percent Asian, and twenty-six percent other.

Instruments

- The students in the child development class used the textbook “ Understanding Human development by Grace J. Craig, Wendy L. Dunn” 2nd Edition, Prentice Hall, publisher.

- The “Critical Thinking and Test Construction Manual” for the 3CAM model by Elham Zandvakili and Ernest Washington was used to guide the practicum part of the class. (Appendix A)
- “The Daily Procedures of the 3CAM model” is a PowerPoint presentation to clarify the steps and procedures that students follow to meet the standards of collaborative and individual group. (Appendix B)
- Student’s Feedback Questionnaire: Developed in consultation with the Institute for Social Science Research, University of Massachusetts, Amherst. (Appendix C)
- Student- made test for final exam
- Old standardized test: Tests based upon test items distributed by publishers.

Data Collection Procedure

There is evidence for the usefulness of applying 3CAM from the pilot study. Preliminary data from the pilot study shows there is improvements in student’s scores. Students are more confident and less anxious, they “love” the whole procedure, they feel they are “in control” and it is “fair, creative and unique.”

Description of Data Gathering

Training: The class is a four-hour class, and the first day of class is devoted to teaching students the procedures for the experiment. The procedures focused on the training for concept maps, critical thinking, and guidelines for the creation of the reasoning questions.

Experimental Group 1/Collaborative Group: (Conceptual Map, Critical Thinking, Collaboration and Assessment) Using Multiple Reasoning Items

Individual Phase of Collaborative Group

Step1: Students at home generate 1 digital map and they apply critical thinking strategies “What, when, where, how, who, why”. students come to class with a digital concept map of an entire chapter. See the sample of the concept map below:

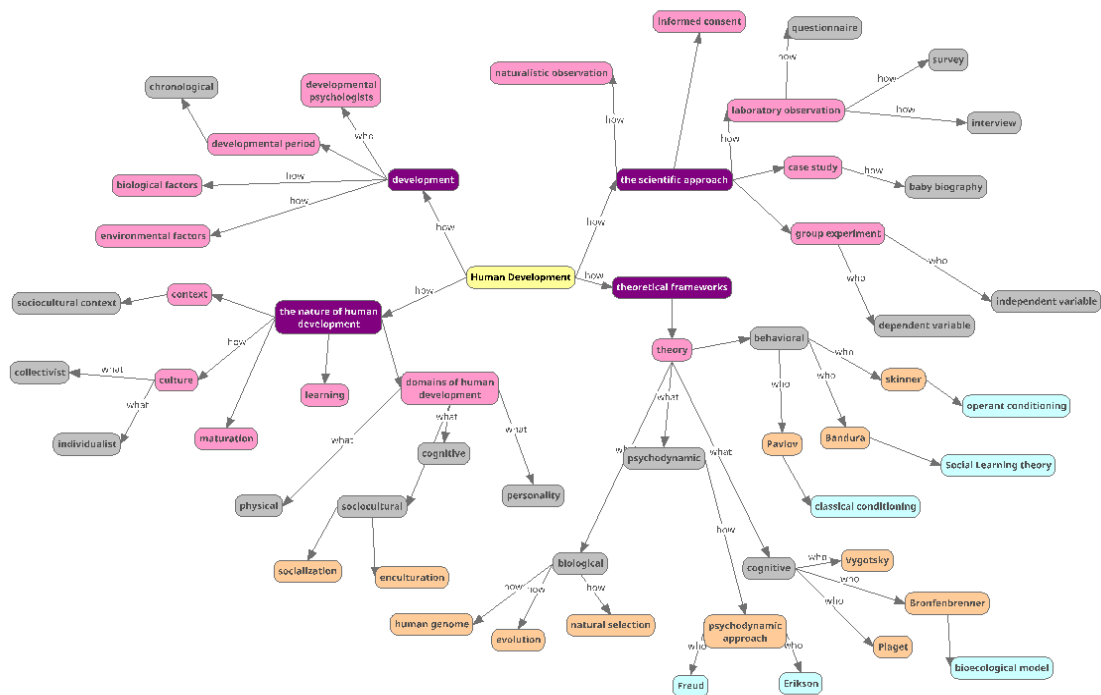


Figure 10. Concept map sample

Step 2: Students prioritize key concepts in their map: The concepts are ranked from the most to least important. The connections between the concepts are made by applying the critical thinking strategies. see the sample below:

Key Concepts:

- | | |
|--------------------------------|------------------------------|
| 1. Human development | 11. Theoretical frameworks |
| 2. Development | 12. Theory |
| 3. Biological factors | 13. Psychodynamic |
| 4. Environmental factors | 14. Biological |
| 5. Developmental psychologists | 15. Human genome |
| 6. Nature of human development | 16. Cognitive |
| 7. Culture | 17. Behavioral |
| 8. Collectivist | 18. Scientific approach |
| 9. Individualist | 19. Laboratory observation |
| 10. Human development domains | 20. Naturalistic observation |

Step 3: Students generate five simple critical thinking questions. see the sample below:

5 Questions:

- 1- Where did the idea that childhood “a time of innocence, during which children should have few responsibilities or chores,”
- in ancient Greece
 - in ancient Rome
 - in modern, industrialized societies like the United States today
 - throughout history in Western societies since about 3,000 B. C.

Answer: c

- 2- How would describe the principle central to Darwin’s idea of natural selection?
- Individuals within a species vary, and those with the best adapted characteristics survive to reproduce, thereby passing their genes to future generations.
 - Nature selects the particular individuals that have the best characteristics and these individuals are allowed to interbreed with each other, thereby creating the strongest offspring.
 - People prefer to mate with the most attractive members of the opposite sex, selecting their mates according to natural factors related to physical attractiveness.
 - Humans evolved from the apes.

Answer: a

- 3- When does Freud’s genital stage occur:
- birth to age 18 months

- b. age 3 to 6 years
- c. age 6 years to adolescence
- d. adolescence through adulthood

answer: b

4-What refers to changes over time in a person's body, thought, and behavior due to biological and environmental influences?

- a. Development
- b. Culture
- c. Maturation
- d. Context

Answer: a

5-Who is responsible for the five psychosexual stages?

- e. Piaget
- f. Vygotsky
- g. Freud
- h. Bandura

Answer: C

Step 4: Students post three documents on Moodle: Concept map, Prioritized list and five critical thinking multiple reasoning questions.

*(Moodle is a learning platform designed to provide educators, administrators and learners with a single robust, secure and integrated system to create personalized and collaborative learning environments).

Collaborative Phase of Collaborative Group

Step 1 (Social synthesis): Students are randomly assigned to a group of 6, and they work together in three pairs. The leader assigns each pair of students to a team.

Step 2 (Cognitive synthesis): Each pair exchanges a concept map of the chapter.

They give feedback to each other, criticize, agree, disagree and identify gaps in their knowledge. While they are discussing and giving feedback to each other they apply critical thinking strategies (What, How, Why, When, Where, Who).

Each pair of students synthesize and combine the individual maps to generate a new collaborative map of the chapter. There are three pairs in each group and each pair generates a new collaborative map from their individual maps.

Step 3: Prioritizing is the evaluative stage of the collaborative phase (3CAM model) and includes prioritizing the concepts identified in the collaborative concept maps and ranking concepts from the most important to the least important. The connections between the concepts are the critical thinking strategies.

Step 4,5 (assessment): Each group of six students create twelve critical thinking multiple reasoning items. Each student is responsible for two questions. Each student has already generated 5 critical thinking multiple reasoning question.

The team members give feedback to each other. Next, the whole group of six comes together and reviews the items created in the group. They answer each other's question, criticize and revise the items as a group. Each pair presents their questions to the larger group, and asks the group to critique their items and discuss their answers. The group members give feedback to each other and revise their items.

Step 6: The group leader posts the questions on Moodle. All the questions from all the students are open to public view and posted on Moodle.

Step 7: There a final exam for the students in this experiment. The semester consists of three blocks of three weeks each. During each block of three weeks, the students produce approximately 150 items Students are informed that the midterm and final exams are mastery examinations. Grades are determined using the following rubric:

The grade will be based on four factors:

35%: Concepts/Critical thinking

35%: Collaboration/Creation

30%: Final (student-made exam/old exam)

Note 1: The students test items are reviewed weekly, modified and changed slightly if necessary by the instructor to improve accuracy, ease of understanding and clarity between the stem and the multiple-reasoning alternatives.

Note 2: One of the problems associated with collaboration is that students need a clear picture of their responsibilities. Students are reminded that each group member's performance will be assessed using the group rating form.

Note 3: The students are reminded of the steps in the collaborative process through the explanation of Figure 1.

Experimental Group 2/ Individual Group (Conceptual Map, Critical Thinking) Using Multiple Reasoning Items

Steps 1 and 2 of the individual phase of experimental group 2 is exactly the same as experimental group 1, Collaborative group(3CAM). Step 3 is different because there is no collaborative phase in the individual group. Students come to the practicum and go through the process individually. This is the step in the process where the collaborative group and individual experimental groups go in different directions. Students in the individual group will be shown a related video about the chapter.

Individual Phase of the Individual Group

* The steps in the individual groups are exactly the same as the first phase of the collaborative group. In both cases students prepare a concept map with critical thinking, they prioritize these concepts and generate five reasoning questions and post these documents on Moodle.

Step1: Students at home generate 1 digital map and they apply critical thinking strategies “What, when, where, how, who, why”. student comes to class with a digital concept map of an entire chapter.

Step 2: Students prioritize key concepts in their map: The concepts from the most to least important. The connections between the concepts are made by applying the critical thinking strategies.

Step 3: Students generate five critical thinking questions.

Step 4: Students post three documents on Moodle: concept map, prioritized list and five critical thinking multiple reasoning questions.

Individual Group in the Classroom

Step 5: Applying critical thinking strategies to Video. During the practicum part of the course, students in the individual group will watch a related video to the chapter and apply the critical thinking strategies to it. The purpose of this exercise is to help students generalize and think visually and more critically about the issues and problems of the day.

Step 6: After watching the video and listening to a short lecture by the instructor each student produces two critical thinking items and post them to Moodle.

The grade for the Individual group(2CAM) will be based on four factors:

50%: Concepts/Critical thinking

20%: Participation & Attention in class

30%: Final (student-made exam/old exam)

Data Analysis Procedures

Analysis of the Concept Maps: Critical Thinking Questions

A breakthrough moment occurred when the researcher found a way to analyze the concept maps. Concept maps without critical thinking are widely used in business, medicine, engineering and planning environments but the systematic analysis of the maps has remained an intuitive process in which experienced researchers and novices alike search for themes within the concept maps.

The insight of joining digital concept maps with critical thinking resulted in a new tool to analyze critical thinking. The use of digital maps provides a data base that lends itself to statistical analysis. This new innovative methodology has the potential to provide a reliable and valid approach to measuring the processual events in

learning and achievement. This dissertation is a demonstration of the efficacy of this new methodology. The new dependent variables of concepts-critical thinking question.

The actual procedures for the analysis of the concept map-critical thinking methodology takes the following steps: The frequency data from the concept maps was obtained by counting each of the WH questions and enter the data into an excel sheet. Next the data are entered into SAS (SAS,9.1.3, The SAS Inst., Cary, NC) for further statistical analysis. Once the data are entered into SAS it is possible to apply any number of statistical techniques. The digitalization of the concept maps-critical thinking creates the possibility of completing digitizing the complete process from data entry to analysis of the data.

Applying Qualitative and Quantitative Analysis

Seven separate analyses were applied to the data from this experiment: Pie-Charts were applied to the collective data of critical questions: “what, when, where, who, why and how” across the three different time periods. Second, the analysis of variance with repeated measures procedures were applied to the individual “WH questions”. Thirdly, Correlational analysis was applied to the six critical thinking questions to determine if there are significant relationships between the six different variables. Fourthly, the multidimensional preference analysis was used to compare the individual collaborative (IC) with collaborative conditions(CC) and the individual(IN) with the collaborative groups(CC). The fifth, correlational analysis was applied to the summative test data of scores on the standardized and the student made tests. The sixth analysis was the application of the T test to the summative test data to make comparisons between the collaborative and individual groups and for the last and

seventh analysis, descriptive statistics and thematic analyses were used to analyze the questionnaire.

To answer the research questions, we used repeated measures ANOVA.

Repeated measures ANOVA is appropriate because we evaluated the same subjects under study over three specific time points (Beginner, Intermediate and Advanced) on the same dependent variables (WH questions). These measurements were made under different conditions. The conditions are the levels of the independent variable grouping (CC-IC-I). The PROC GLM in SAS (SAS,9.1.3, The SAS Inst., Cary, NC) . Was used for repeated measure analysis.

```
PROC GLM DATA=a;
```

```
Class Person Group;
```

```
Model Time_1- Time_3 = Group;
```

```
Repeated time 3/ printe;
```

```
Run;
```

The Sphericity test was used to know if the MANOVA or the Univariate test is appropriate to report the P-Values in the output of repeated measures ANOVA. When the Sphericity test was significant we rejected the hypothesis that the variance/covariance structure has a type H structure and therefore we used the correction for the univariate test rather than MANOVA test. Our preference to use univariate test than MANOVA test is due to Sphericity test being overly sensitive and likely to be deceiving. The result for the corrections obtained by including (Printe) option in PROC GLM in SAS (SAS,9.1.3, The SAS Inst., Cary, NC). An independent sample t-test comparison was performed to compare the means of the final exam's scores between student made tests at the end of the experimental semester called Student-Made Test (STM) and one previous final exam from 2015 created by the

publisher that we called old test.

In order to control family wise error rate, Fisher LSD at $\alpha = 0.05$ was used. Considering having three groups (levels of conditions) and three time points, Fisher LSD can be the most appropriate method for controlling the family wise error rate.

Orthogonal polynomial contrasts were performed to partition the responses (dependent variable) to applying 3CAM model into linear or quadratic trends when the effect of time period was significant. PROC IML was used to generate coefficients for Orthogonal polynomial as follows:

```
PROC IML;
```

```
X= {3 6 9};
```

```
XP= orpol (x,2);
```

```
Print xp;
```

```
Run; Quit;
```

The procedure PROC CORR was used to find the correlation coefficients between pairs of variables in the data set. The basic syntax was as follow:

```
PROC CORR data = a;
```

```
VAR variables;
```

```
Run;
```

The strength of the relationship was assessed by the general guidelines as follows:

$0.1 < r < 0.3$ small / weak correlation

$0.3 < r < 0.5$ medium/ moderate correlation

$0.5 < r$ large/ strong correlation

Multidimensional Preference Analysis of dependent variables (WH questions) was performed in order to discover changes and patterns in “WH questions” and to

look for the possible clusters of the groupings under critical thinking in 3CAM model so that we could see what attributes the “WH questions” have in common. Where points were tightly clustered in a region of a plot, it would represent the groupings that have the same preference patterns. Vectors that point in the same direction (or roughly the same direction) represent the “WH questions” with similar preference patterns. The procedure for Multidimensional Preference Analysis was performed as follow:

```
PROC PRINQUAL data =a plots=all;
```

```
Transform spline (WH questions);
```

```
id group;
```

```
Run;
```

All the graphs were created using spreadsheet programs such as Microsoft Exceltm 2017 and/or Analytical software such as SAS (SAS,9.1.3, The SAS Inst., Cary, NC).

The distributions of the data were tested using the Kolmogorov Smirnov Test and a transformation was done when necessary to obtain homogeneous variance. The distribution of the data was obtained by PROC UNIVARIATE in SAS (SAS,9.1.3, The SAS Inst., Cary, NC). The transformations were done based on the Tukey Ladder of Powers, so that we changed the shape of the skewed distributions into normal or nearly normal.

PROC T TEST was used to compare the two population averages by comparing the independent samples. Scores were considered continuous dependent variables and type of exams were considered as categorical independent variables. Type of exams included: 1-Student-made individual test(smtin), 2-Student-made collaborative test(smtcol), 3- Old-test individual(oldind), 4- Old-test

collaborative(oldcol),5-Student-made test (individual+ collaborative)/(smt), 6- Old-test (individual + collaborative)/(old). If conditions were not met (student-made test was left-skewed) transformation was applied to get normally distributed data.

Both qualitative and quantitative analysis were applied to the questionnaire which was constructed and developed in consultation with a statistician and the Institute for Social Science Research. The qualitative data includes student's comments about each of the stages of the 3CAM model. The qualitative data include a series of "yes, no" and "why questions". For example, "Do you think the concept maps were helpful in your learning? (yes, no). Why do you think concept maps were helpful?" This same format was used to inquire about student's responses to: each components of the maps, critical thinking, collaboration and the construction of multiple reasoning. (Questioner appendix C)

Quantitative analyses were applied to the Student's Feedback Questionnaire. Students were asked to rate each of the components of the 3CAM model: concept maps, critical thinking, collaboration and multiple reasoning test construction.

CHAPTER 4

RESULTS

Data Analysis

Frequency Analysis

Questions: 1) Are there significant differences in the overall pattern of the WH questions for the individual (IN) group for times: one, two and three.

The time periods 1, 2 3 are labeled beginner, intermediate and advanced. Pie charts were used to show the patterns of frequency of use of the “WH questions”. The pie charts provide an overall visual representation of the frequency of uses of the WH questions. Additional quantitative data from the analysis of variance with repeated measures, multidimensional preference scaling, and correlations in the succeeding research questions will complete the quantitative analysis of the differences between groups over time.

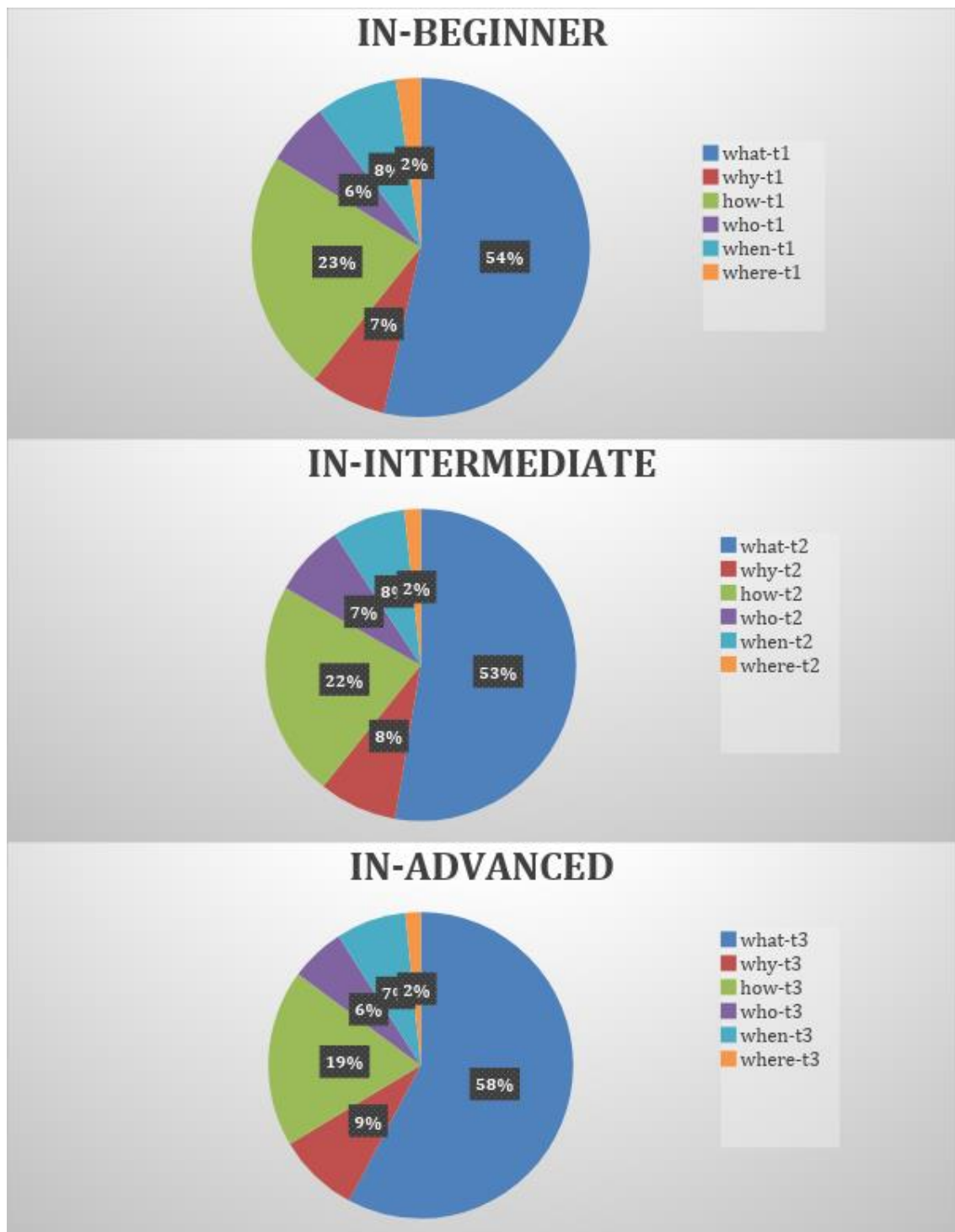
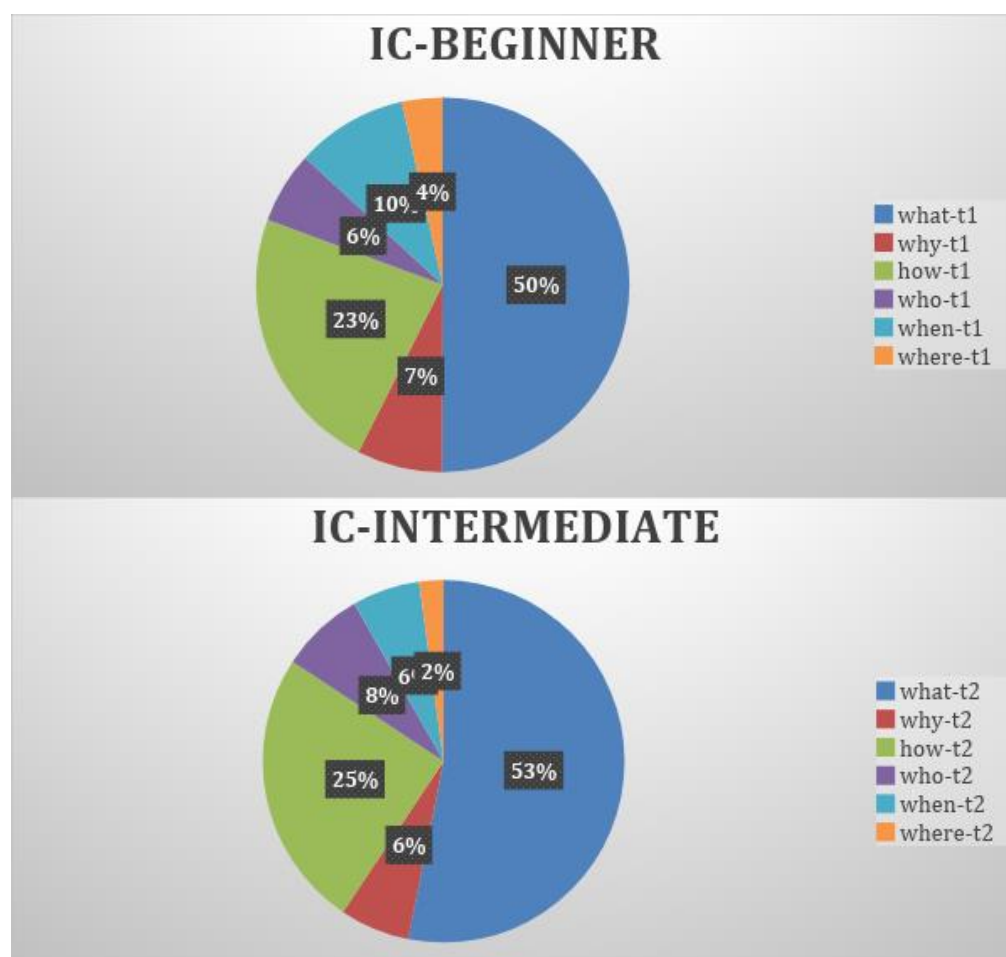


Figure 11. The frequency distributions of the “WH questions” for the individual group (IN)

Figure 11 shows the frequency of the use of “WH questions” for times 1, 2 and 3 for the individual group (IN). The frequency data for the “what questions” remained the same throughout the three periods. The percentage for the “what questions” at time 1 is 54%, at time 2 is 53% and at time 3 is 58%. These data show little change in “what questions”. The percentage for the “how questions” at time 1 is 23%, at time 2 is 22% and at time 3 is 19%. The percentage for the “why questions” is the same throughout three time periods. For time 1 is 7%, at time 2 and 3 is 8%. The percentage for the “who questions” is the same throughout three time periods. For time 1 is 6%, at time 2 is 7% and at time 3 is 6%. The percentage for the “where questions” at all time intervals is 2%.

1b. Are there significant differences in the overall patterns of the “WH questions” for the individual phase of the collaborative (IC) group at times one, two, and three?



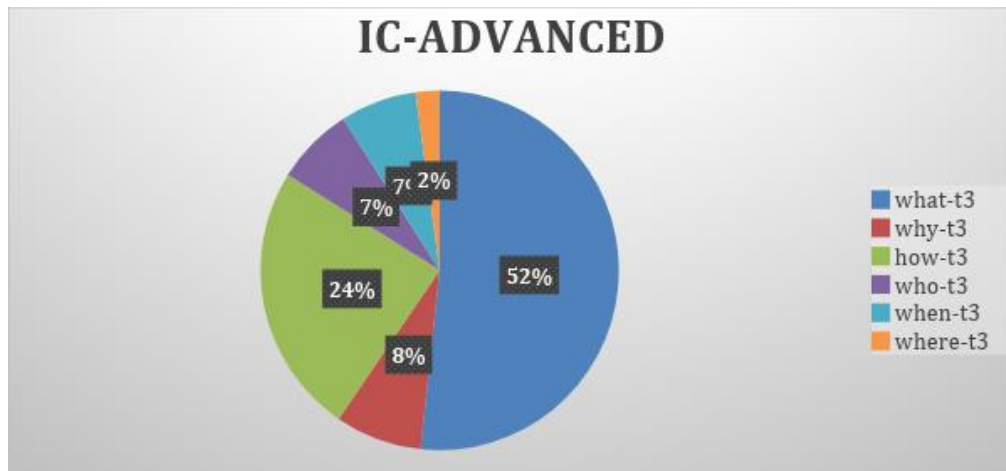


Figure 12. The frequency distributions of the “WH questions” for the individual collaborative group (IC)

Figure 12 shows the frequency of the use of “WH questions” for times 1, 2 and 3 for the Individual phase of collaborative group (IC). The Frequency data for the “what questions” remained the same throughout the three periods. The percentage for the “what questions” at time 1 is 50%, at time 2 is 53% and at time 3 is 52%. These data show little change in “what questions”. The percentage for the “how questions” at time 1 is 23%, at time 2 is 25% and at time 3 is 24%. The percentage for the “why questions” at time 1 is 7%, at time 2 is 6% and at time 3 is 8%. The percentage for the “when questions” at time 1 is 10%, at time 2 is 6% and at time 3 is 7%. The percentage for the “who questions” at time 1 is 6%, at time 2 is 8% and at time 3 is 7%. The percentage for the “where questions” is 2% at all three times.

1c. Are there differences in the overall pattern of “WH questions” for the collaborative-collaborative group (CC) at times one, two and three?

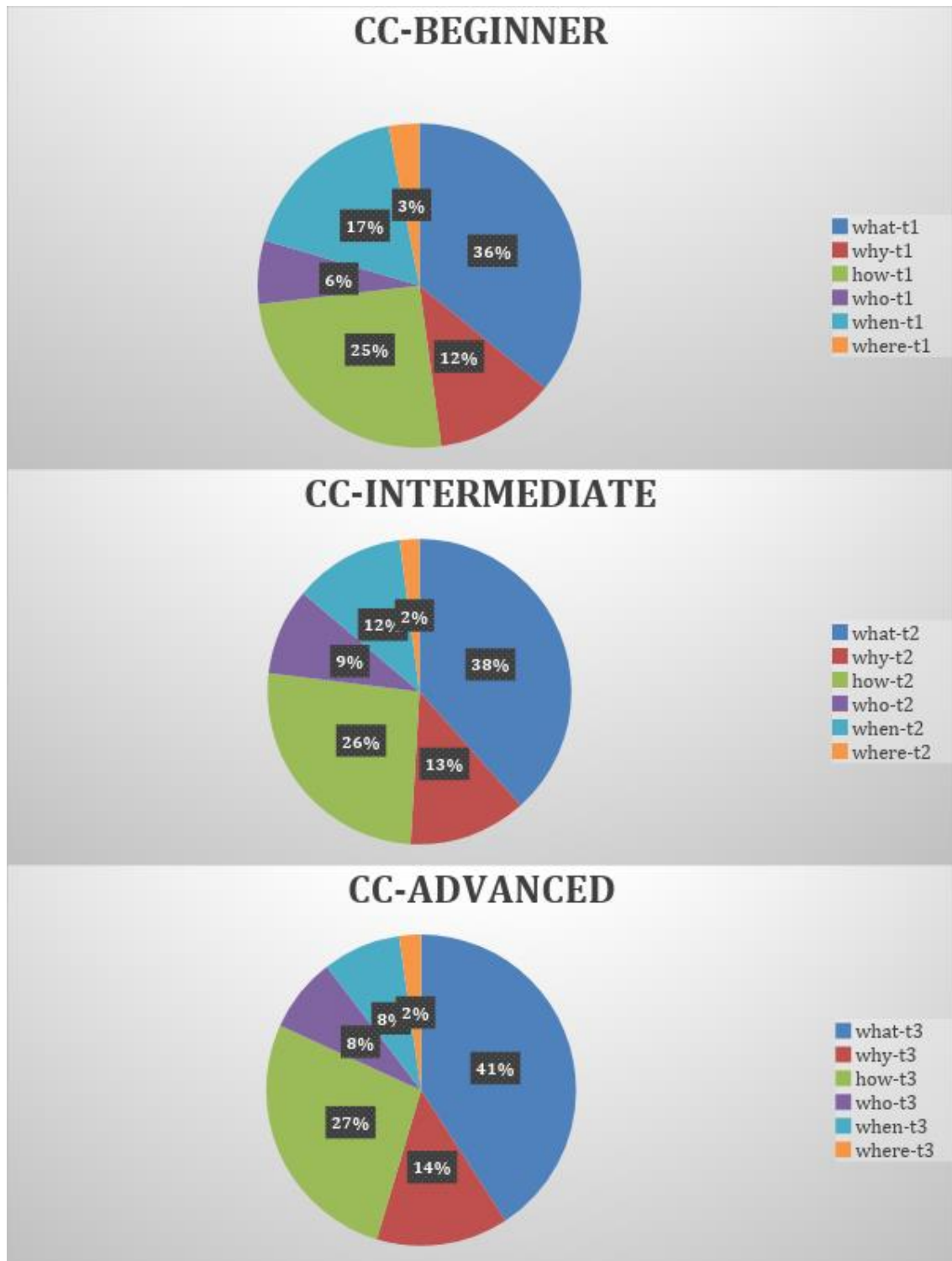


Figure 13. The frequency distributions of the “WH questions” for the Collaborative group (CC)

Figure 13 shows the frequency of the use of “WH questions” for times 1, 2 and 3 for the collaborative phase of collaborative group(CC). As you can see the frequency data for the “what questions” is changed and it is different from the patterns

reported above. The percentage for the “what questions” at time 1 is 36%, at time 2 is 38% and at time 3 is 41%. The percentage for the “how questions” at time 1 is 25%, at time 2 is 26% and at time 3 is 27%. The percentages for the “why questions” at time 1 is 12%, at time 2 is 13% and at time 3 is 14%. The percentages for the “when questions” at time 1 is 18%, at time 2 is 12% and at time 3 is 8%. The percentages for the “who questions” at time 1 is 6%, at time 2 is 9% and at time 3 is 8%. The percentages for the “where questions” at time 1 is 3%, at times 2 and 3 is 2%.

ANOVA with Repeated Measures

Research question No. 2 Are there significant differences in the frequency of use of the individual “WH critical thinking questions: what, why, how, when, where, who. Each research question will have three sub questions. 2a. Is there a significant difference due to groups (CC, IC and IN)? 2b. Is there a significant effect due to time (Time1, Time2 and Time 3)? 2c. Is there a significant difference due to interaction between group and time? These procedures will be followed for all the “WH questions”

These data were analyzed using analysis of variance procedures with repeated measures to reveal differences between groups, time and the interactions between time and groups.

Table 8

Repeated Measures ANOVA for Generation of “What Questions” Using the 3CAM Model of Critical Thinking

	DF	SS	MS	F
Group	2	11265.48	5632.74	5.60**
Error	64	64403.65	1006.30	
Time	2	2628.95	1314.47	11.57**
Time*group	4	299.28	74.82	0.66 ^{ns}
Error(time)	128	14546.59	113.64	

Table 9

A Comparison of Means Between Conditions Across Time Intervals of “What Question”

	CC	IC	IN	Mean
Time_1	22.00	34.23	43.81	37.73 b
Time_2	29.22	47.95	51.72	47.46 a
Time_3	29.00	43.45	52.11	46.16 a
Mean	26.74 b	41.87 a	49.21 a	

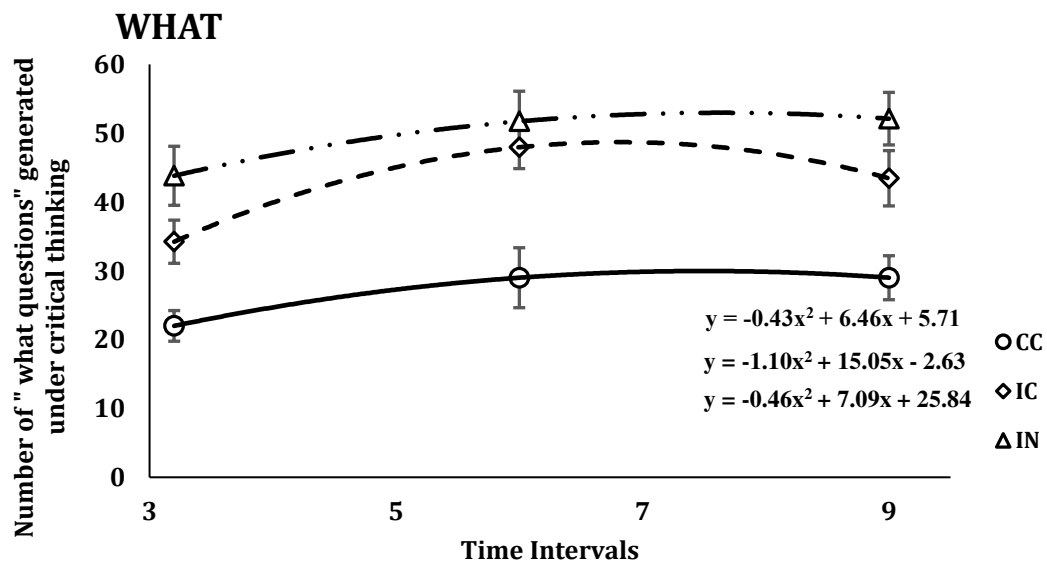


Figure 14. A trend analysis of “what question” among conditions as affected by time intervals

*Explanation about equations for groups: The order of equations corresponds to the order of groups on the right-hand legend.

The repeated measures ANOVA table shows that there are significant differences between times and groups. With 99% confidence, there is a significant difference between student groupings (conditions)/ (Table 8) on the generation of “What questions”. A comparison of means using FISHER LSD shows that individual (IN) and Individual collaborative group (IC) had a significantly higher mean than the collaborative group and that they generated more “What questions”. As well with 99% confidence there is significant difference among the time intervals based on the repeated measures ANOVA report (Table 8). A comparison of means s for time

interval using FISHER LSD revealed that student generated more “What questions” in the intermediate and advanced time intervals as compared with beginner period (Table 9). There was no significant interaction between time intervals and student groupings however. A trend analysis revealed that the generation of “What questions” across time follow the quadratic trend as students within all the grouping conditions had the tendency to generate more “What questions” in the intermediate period as compared with the beginner period. There was no significant difference between advanced and intermediate period.

Table 10

Repeated Measures ANOVA for Generation of “Why Questions” Using the 3CAM Model of Critical Thinking

	DF	SS	MS	F
Group	2	4300.977	215.48	5.59**
Error	64	2465.90	38.52	
Time	2	226.96	113.48	11.38**
Time*group	4	72.04	18.01	1.81 ^{ns}
Error(time)	128	1276.23	9.97	

Table 11

A Comparison of Means Between Conditions Across Time Intervals of “Why Question”

	CC	IC	IN	Mean
Time_1	7.33	5.04	5.94	5.83 b
Time_2	11.33	5.63	7.97	7.65 a
Time_3	12.77	6.54	7.77	8.04 a
Mean	10.48 a	5.74 b	7.23 b	

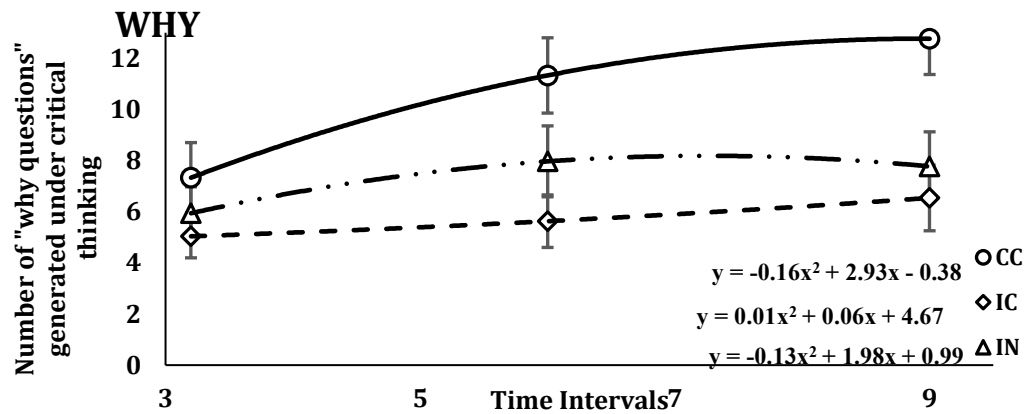


Figure 15. A trend analysis of “why question” among conditions as affected by time intervals

The repeated measures ANOVA table shows significant differences for both times and groups. With 99% confidence, there is a significant difference between student grouping conditions (Table 10) on the generation of “Why questions”. A comparison using FISHER LSD shows that collaborative groups had a significantly higher mean than individual (IN) and Individual collaborative group (IC) and that they generated more “Why questions”. With 99% confidence, there is a significant difference among the time intervals based on the repeated measures ANOVA report (Table 10). A comparison of means for time interval using FISHER LSD revealed that student generated more “Why questions” in advanced and intermediate time intervals as compared with the beginner period (Table 11). There was no significant interaction between time intervals and student grouping however. A trend analysis revealed that the generation of “Why questions” across time follows the quadratic trend as students within all the groups had a tendency to generate more “Why questions” in the advanced period in the collaborative group as compared with the intermediate and the beginner period. (Figure 15)

Table 12

Repeated Measures ANOVA for Generation of “How Questions” Using the 3CAM Model of Critical Thinking

	DF	SS	MS	F
Group	2	105.06	52.53	0.61 ^{ns}
Error	64	5523.02	86.29	
Time	2	911.48	455.74	17.75**
Time*group	4	655.18	163.79	6.38**
Error(time)	128	3287.11	25.68	

Table 13

A Comparison of Means Between Conditions Across Time Intervals of “How Question”

	CC	IC	IN	Mean
Time_1	15.46	15.86	18.83	16.72 b
Time_2	23.56	22.45	22.03	22.68 a
Time_3	25.22	20.91	16.86	21.00 a
Mean	21.41 a	19.74 a	19.24 a	LSD=?

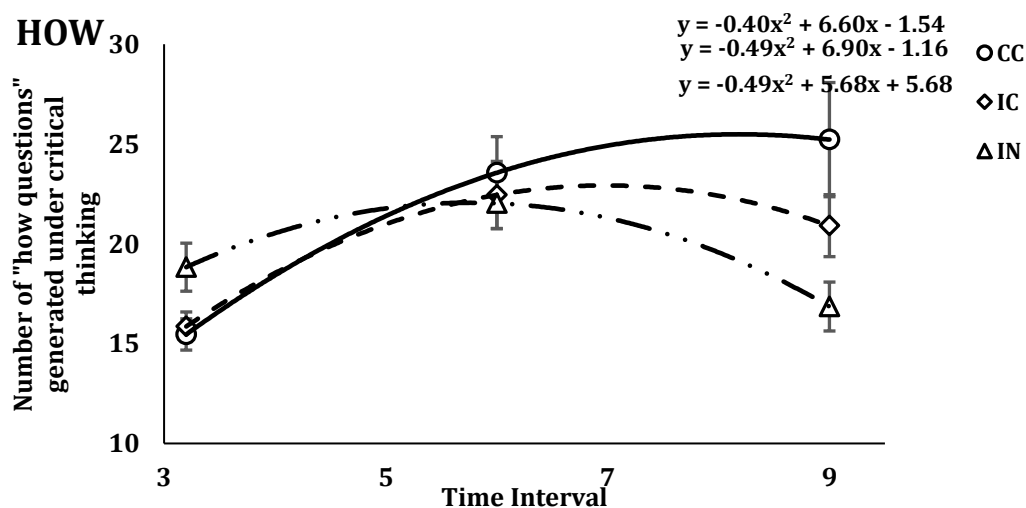


Figure 16. A trend analysis of “how questions” among conditions as affected by time intervals

The repeated measures ANOVA table shows that there was no significant difference between student groups (Table 12) for the generation of “How questions”. With 99% confidence, there is significant difference among the time intervals based on the repeated measures ANOVA analysis (Table 12). A comparison of means for

time interval using FISHER LSD revealed that student generated more “How questions” in the advanced and intermediate time intervals as compared with the beginner period (Table 13). There was a significant interaction between time intervals and groups. A trend analysis revealed that the generation of “How questions” across time follows the quadratic trend. Collaborative group generated less “How questions” in the beginner’s time period as compared with individual (IN) and individual collaborative (IC). However, the tendency to generate “How questions” shifted in favor of the collaborative group from intermediate period and increased over time. (Figure 16)

Table 14

Repeated Measures ANOVA for Generation of “When Questions” Using the 3CAM Model of Critical Thinking

	DF	SS	MS	F
Group	2	256.20	128.10	4.35*
Error	64	1886.19	29.47	
Time	2	43.68	21.84	2.19 ^{ns}
Time*group	4	77.23	19.30	1.94 ^{ns}
Error(time)	128	1275.97	9.96	

Table 15

A Comparison of Means Between Conditions Across Time Intervals of “When Question”

	CC	IC	IN	Mean
Time_1	10.67	6.59	6.42	7.89 a
Time_2	10.67	5.54	7.47	7.89 a
Time_3	7.56	5.91	6.69	6.72 a
Mean	9.63 a	6.01 b	6.86 b	

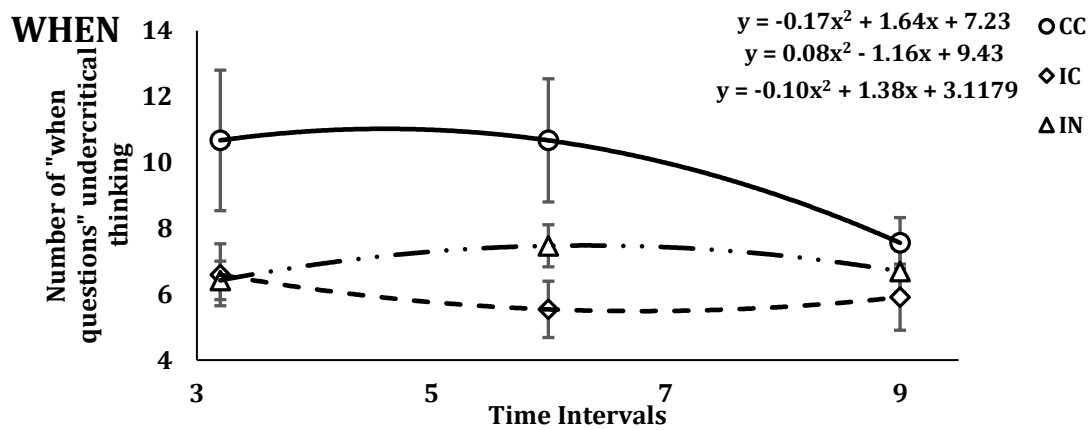


Figure 17. A trend analysis of “when question” among conditions as affected by time intervals

The repeated measures ANOVA table shows that with 95% confidence there is a significant difference between groups (Table 14) on the generation of “When questions”. A comparison of means using FISHER LSD shows that the collaborative (CC) group generated more “When questions” as compared with the individual (I) and Individual collaborative group (IC)/ (Table 15). There was no significant difference among time periods and there was no significant interaction between time periods and groups for the generation of “When questions” (Table 15). A trend analysis revealed that the generation of “When questions” across time follows the quadratic trend. The Collaborative group had the tendency to generate more “When questions” in the beginning period however it decreased toward the advanced period. (Figure 17)

Table 16

Repeated Measures ANOVA for Generation of “Where Questions” Using the 3CAM Model of Critical Thinking

	DF	SS	MS	F
Group	2	6.20	3.10	1.46 ^{ns}
Error	64	136.01	2.12	
Time	2	2.11	1.05	0.88 ^{ns}
Time*group	4	2.34	0.58	0.49 ^{ns}
Error(time)	128	153.91	1.20	

Table 17

A Comparison of Means Between Conditions Across Time Intervals of “Where Question”

	CC	IC	IN	Mean
Time_1	1.89	2.41	1.92	2.07
Time_2	1.89	1.95	1.67	1.84
Time_3	2.11	1.82	1.47	1.80
Mean	1.96	2.06	1.69	

WHERE

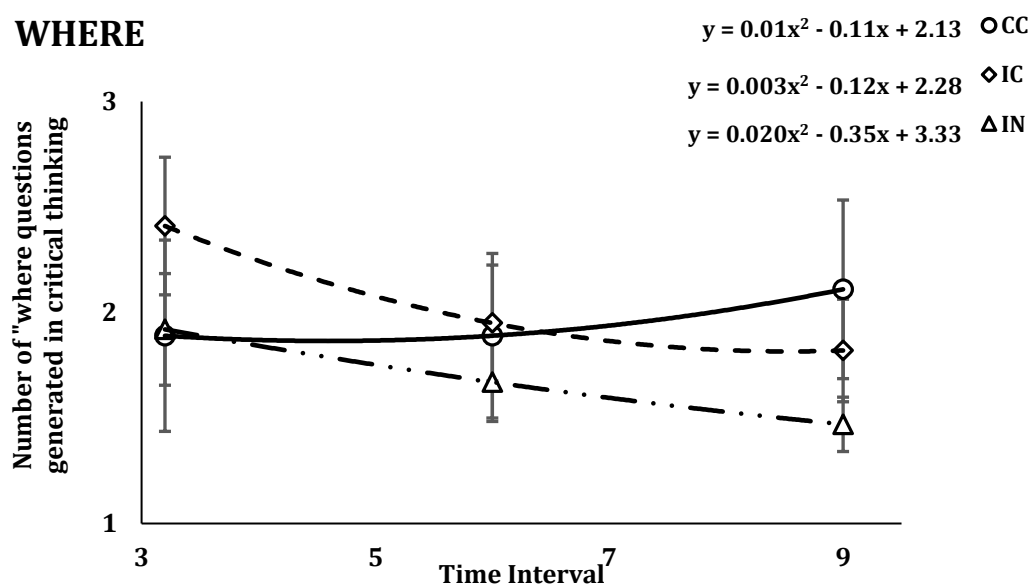


Figure 18. A trend analysis of “where question” among conditions as affected by time intervals

The repeated measures ANOVA for generation of “Where questions” showed that there were no significant differences between groups, time intervals and the interaction between time and groups. (Table 16,17 and Figure 18)

Table 18

Repeated Measures ANOVA for Generation of “Who Questions” Using the 3CAM Model of Critical Thinking

	DF	SS	MS	F
Group	2	11.86	5.93	0.33 ^{ns}
Error	64	1159.93	18.12	
Time	2	242.74	121.37	17.42**
Time*group	4	46.53	11.63	1.68 ^{ns}
Error(time)	128	888.32	6.94	

Table 19

A Comparison of Means Between Conditions Across Time Intervals of “Who Question”

	CC	IC	IN	Mean
Time_1	3.89	4.23	4.92	4.35 b
Time_2	8.33	6.77	7.33	7.48 a
Time_3	7.22	6.14	5.25	6.20 a
Mean	6.48 a	5.71 a	5.83 a	

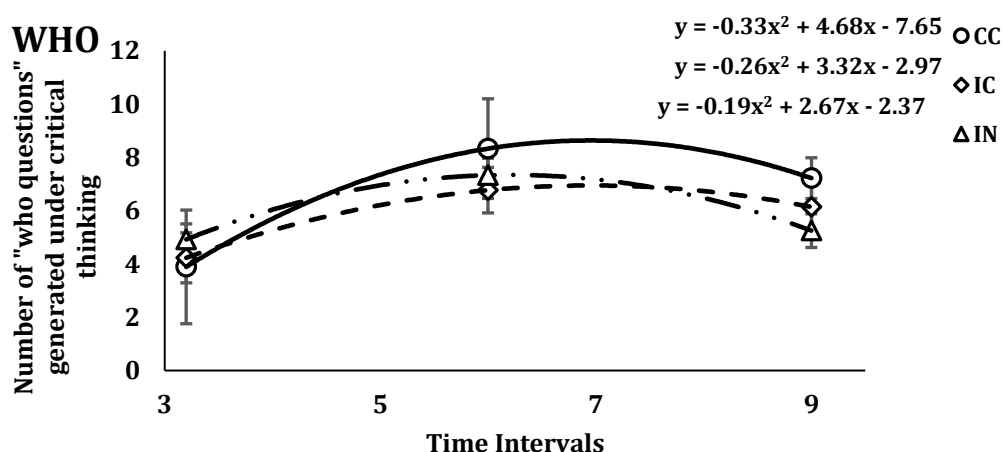


Figure 19. A trend analysis of “who question” among conditions as affected by time intervals

The repeated measures ANOVA table shows that there was no significant difference between student groups (Table 18) for the generation of “Who questions”. With 99% confidence, there is a significant difference among the time intervals based on the repeated measures ANOVA report (Table 18). A comparison of means for time interval using FISHER LSD revealed that student generated more “Who questions” in the intermediate level as compared with the beginner period (Table 19). There was no significant difference between the intermediate and advanced level despite the student tendency to use less “Who questions” in the advanced period. There was a significant interaction between time intervals and groups. A trend analysis revealed that the generation of “Who questions” across time follow the quadratic trend. All the groups had the tendency to generate more “Who questions” across time however the

generation of “Who questions” from the intermediate period leveled off and then decreased toward the advanced period (Figure 20).

Please see Figure 20 that shows a general picture of all the trend analyses for repeated measures for each of critical thinking questions. Please pay attention to the collaborative group (CC) because this group used a wider range of critical thinking questions.

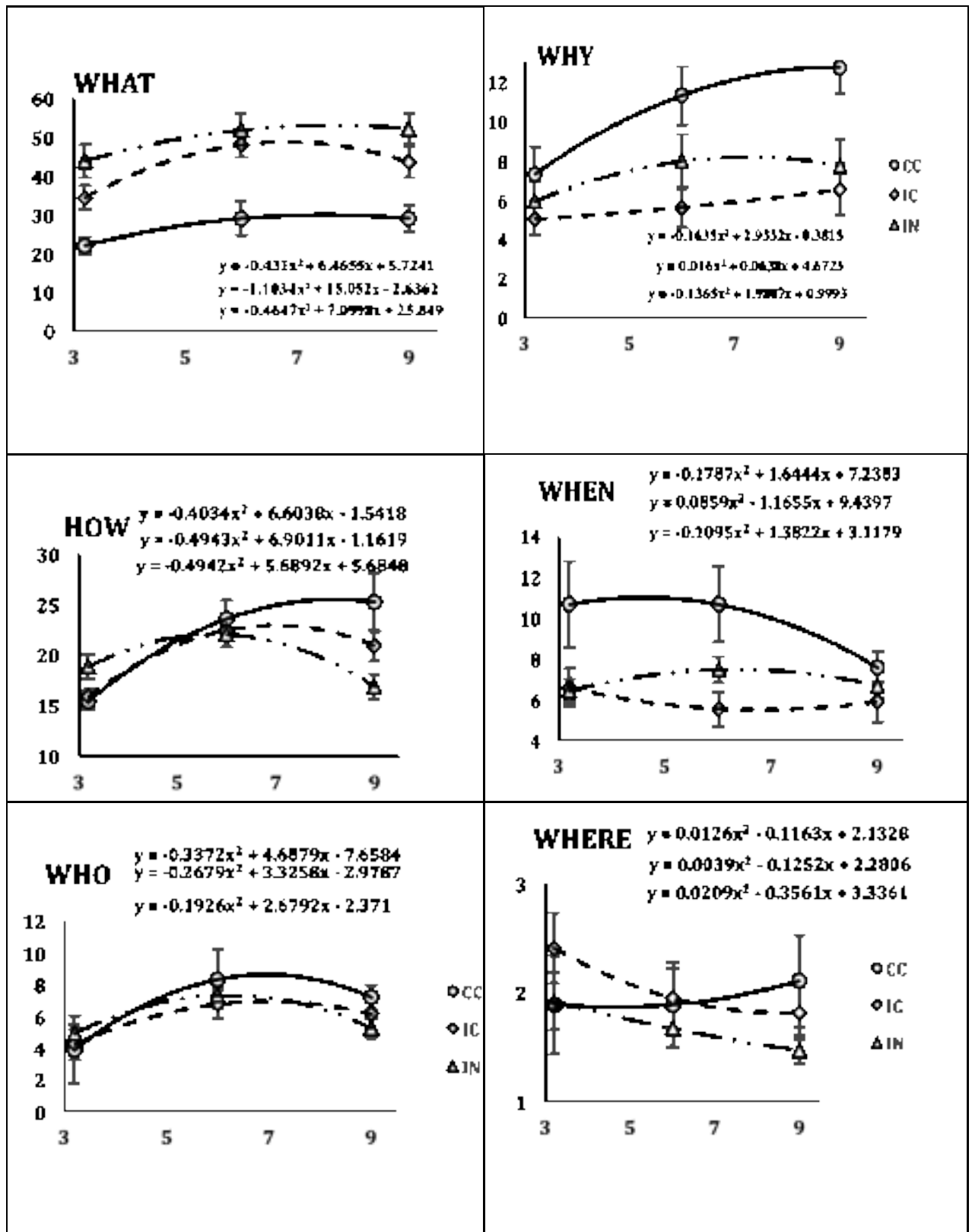


Figure 20. General picture of a trend analysis of “WH questions” generated under critical thinking

Correlations Between “WH Questions”

Research Question 3. Are there significant correlations between the six critical thinking questions?

Table 20

Correlational Analysis Between CC-I

	what	why	when	where	who	how
what						
why	- 0.11 ^{ns}					
when	-0.05 ^{ns}	0.51 ^{**}				
where	0.06 ^{ns}	0.37*	0.36*			
who	-0.10 ^{ns}	0.09 ^{ns}	0.21 ^{ns}	0.32 ^{ns}		
how	0.20 ^{ns}	0.20 ^{ns}	0.09 ^{ns}	0.10 ^{ns}	0.05 ^{ns}	

Table 21

Correlational Analysis Between CC-IC

	what	why	When	where	Who	how
What						
Why	-0.35*					
When	-0.03 ^{ns}	0.50 ^{**}				
Where	-0.17 ^{ns}	0.31*	0.11 ^{ns}			
Who	-0.17 ^{ns}	0.30*	0.48 ^{**}	0.52 ^{**}		
How	0.04 ^{ns}	0.02 ^{ns}	0.26 ^{ns}	-0.10 ^{ns}	0.10 ^{ns}	

Table 22

Correlational Analysis Between I-IC

	what	Why	when	Where	who	How
what						
why	-0.008 ^{ns}					
when	0.07 ^{ns}	0.53 ^{**}				
where	-0.03 ^{ns}	0.39*	0.20 ^{ns}			
who	-0.10 ^{ns}	0.19 ^{ns}	0.22 ^{ns}	0.50 ^{**}		
How	0.28*	0.05 ^{ns}	0.13 ^{ns}	0.001 ^{ns}	0.007	

Note: The correlations between Where and the other variables will not be reported because there are too few cases to have a reliable measurement.

CC-IN

Table 20 Shows the correlational analysis between collaborative group (CC) and the individual group (IN). The table shows there is a highly positive correlation of 0.52 between “why and when” that is significant at the 0.0003 level.

CC-IC

Table 21 shows the correlational analysis between the two phases of the collaborative group (CC) and Individual collaborative (IC). There are three significant correlations in the matrix that is reported. There is a highly significant correlation of 0.50 between “why and when” that is significant at the 0.003 level. There is also a highly significant correlation of 0.48 between “when and who” that is significant at the 0.005 level. The third correlation between “why and what” is a negative correlation of 0.03 that is significant at the 0.04 level that indicates as “what” goes down, “why” goes up.

IC-I

Table 22 shows the correlational analysis between the individual phase of the collaborative group (IC) and the individual group(I). There are two significant correlations that is reported. The first one is a highly significant correlation of 0.53 between “why and when” that is significant at the 0.0001 level. The second correlation between “what and how” is 0.02 and it is significant at the 0.03 level.

Multidimensional Preference Analysis

Research Question 4. Are there differences in the patterns of the uses of the critical thinking questions using multidimensional preference scaling. This analysis does not lend itself to decision making using significance levels rather the emphasis is upon the qualitative search for patterns of critical thinking. 4a. Are there differences in the patterns of the uses of the critical thinking questions using multidimensional

preference scaling between CC vs IC, 4 b. Are there differences in the patterns of the uses of the critical thinking questions using multidimensional preference scaling between CC-IN.

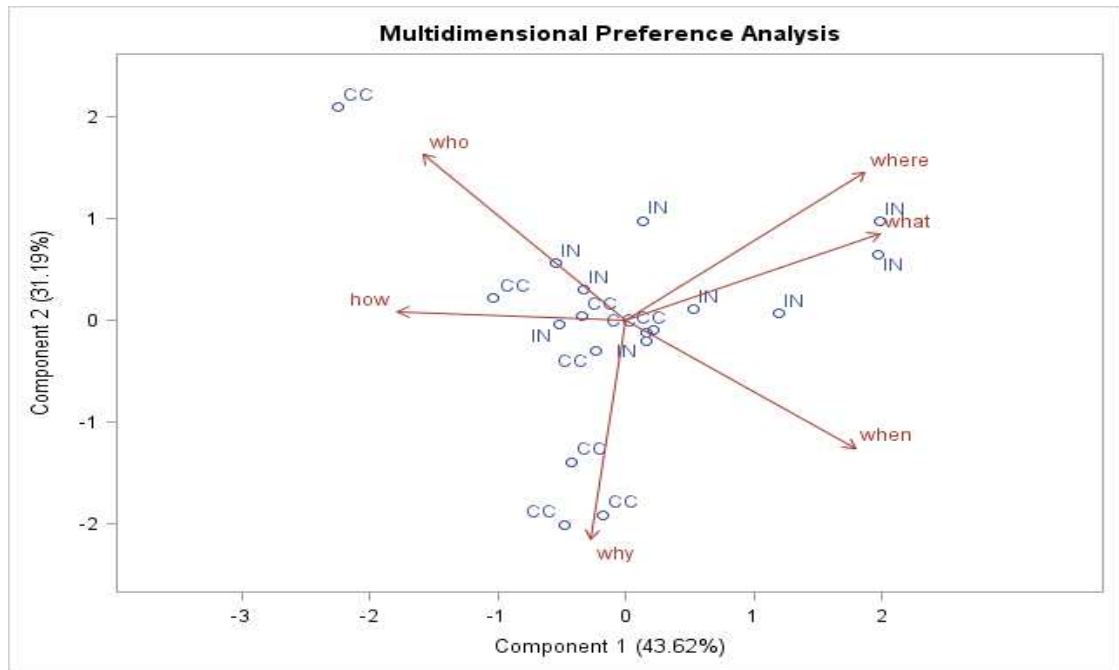


Figure 21. Multidimensional analysis between CC-IN

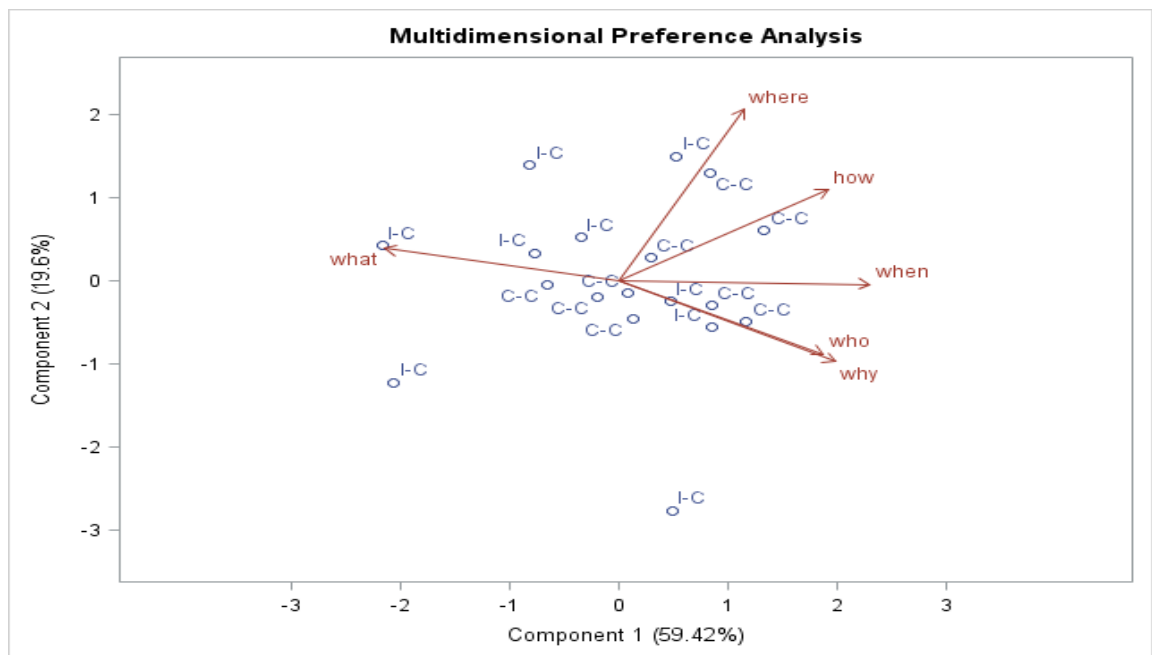


Figure 22. Multidimensional preference analysis between IC-CC

Figure 22 shows the multidimensional preference analysis between collaborative group (CC) and individual group (IN). The biplot, shows the cluster of preferences for the two groups. As can be seen from Figure 22, the preferences of the IN group clustered around the questions of “what and where and who”. On the other hand, the clusters for the CC group clustered mostly around “why, how and when.”

Figure 22 shows the multidimensional preference analysis between collaborative phase of the collaborative group (CC) and individual phase of collaborative group (IC). The biplot, shows the cluster of preferences for the two groups. As can be seen from the Figure 22, the preferences of the IC group clustered around the questions of “what and where”. On the other hand, the clusters for the CC group clustered mostly around “why, how, who and when”.

Correlation Between the Scores

Research Question No 5. Are there significant correlations between the scores of students on student made tests and standardized tests for the collaborative and individual groups? An analysis of the correlations between performance on the individual and collaborative groups will reveal if there are similarities in performance on standardized and student made tests.

The student made test is a test constructed by all the students in both individual and collaborative group. The students in all groups take the same exam.

1-Student-made test in the individual group (smtin): is the scores that students obtained after taking the student made test in the individual group (M2CA)

2-Student-made test in the collaborative group (smtcol): is the scores that students obtained after taking the student made test in the collaborative group (3CAM)

3- Old-test individual(oldind): is the scores that students obtained after taking the standardized test in the individual group (M2CA)

4- Old-test collaborative(oldcol): is the scores that students obtained after taking the standardized test in the collaborative group (3CAM)

5-Student-made test (individual + collaborative)/(smt): is the scores that all the students obtained after taking the student made test in both groups (individual and collaborative) (3CAM + M2CA) = total class

6- Old-test (individual + collaborative)/(old): is the scores that all the students obtained after taking the standardized test in both groups (individual and collaborative) (3CAM + M2CA) = total class

In the Table 23, you will find the results of the correlations between 6 different conditions: 1-Student-made individual test(smtind), 2-Student-made collaborative test(smtcol), 3- Old-test individual(oldind), 4- Old-test collaborative(oldcol),5-Student-made test(individual+collaborative)/(smt), 6- Old-test(individual+collaborative)/(old)

Table 23

Correlation Analysis Between Score's Test

	smtind	smtcol	Oldind	oldcol	smt	Old
smtind						
smtcol	0.05 ^{ns}					
oldind	-0.06 ^{ns}	-0.28 ^{ns}				
oldcol	-0.07 ^{ns}	0.57**	-0.22 ^{ns}			
smt	-0.07 ^{ns}	0.36*	0.31*	0.29 ^{ns}		
Old	0.19 ^{ns}	0.07 ^{ns}	0.13 ^{ns}	0.16 ^{ns}	0.25*	1.0000

In the Table 23, you will find the results of the correlations between 6 different conditions.

Please see the correlational matrix in Table 23. As you can see, there are four significant correlations. The first significant correlation is between student-made collaborative test (smtcol) with the Old-test collaborative (oldcol); This correlation is a result of the collaborative group taking the student made test and the old standardized test. The correlation is 0.58 and it is significant at 0.01 level. This is a moderate uphill(positive) relationship between these two tests. The second and third significant correlation are from the combined groups (individual + collaborative) on the student made tests and the standardized test. The second significant correlation is between the combined student made tests and the old test. The correlation is 0.25 and it is significant at the 0.05 level. The third significant correlation is between student made tests and the old individual test. The correlation is 0.31 and significant at the 0.05 level. The fourth significant correlation is between the student made test collaborative and the student made test. The correlation is 0.36 and it is significant at the 0.05 level. These aforementioned correlations have a weak uphill(positive) relationship.

T-Test

Research question No. 6 Are there significant differences between the collaborative and the individual groups with regard to achievement on the student made tests and the standardized measures?

6a. Are there significant differences between groups on the student made tests?

6b. Are there significant differences between the two groups with regard to performance on standardized tests?

6c. Are there significant differences between all the students in both groups with regard to their performance on the student made tests and old standardized tests?

T Tests for independent groups will be used to show the differences groups

T-test 1:

An independent sample T Test was conducted to determine if there was a statistically significant difference between the scores on the student made tests by the individual group and the collaborative group. There is no statistically significant difference between the two groups. The Mean and standard deviation (SD) for the individual group was 82.67, SD = 21.41, and the Mean and SD for the collaborative group was M=83.93, SD= 17.46. (Table 24,25)

The TTEST Procedure

Variable: scores

Table 24

Confidence Limits for Means Between In-Cn

subject	Method	Mean	95% CL Mean		Std Dev	95% CL Std Dev	
SMT2018I		82.67	76.08	89.26	21.41	17.66	27.22
SMT2018C		83.93	76.19	91.68	17.46	13.43	24.95
Diff (1-2)	Pooled	-1.26	-11.83	9.30	20.18	17.19	24.44
Diff (1-2)	Satterthwaite	-1.26	-11.20	8.67			

Table 25

T-Test Result Comparing (IN) and (CC)

Method	Variances	DF	t Value	Pr > t
Pooled	Equal	63	-0.24	0.81
Satterthwaite	Unequal	50.74	-0.26	0.79

Table 26

Equality of Variances

Equality of Variances				
Method	Num DF	Den DF	F Value	Pr > F
Folded F	42	21	1.50	0.31

T-test 2:

An independent sample T Test was conducted to determine if there was a statistically significant difference between the scores on the old test by the individual group and the collaborative group. There is no statistically significant difference between the two groups. The Mean and SD for the individual group was 49.5, SD = 7.08, and the Mean and SD for the collaborative group was M=51.67, SD= 5.11. (Table 27,28)

Table 27

Confidence Limits for Means Between IN-CC

Subject	Method	Mean	95% CL Mean		Std Dev	95% CL Std Dev	
OLD2018I		49.50	47.14	51.86	7.08	5.75	9.19
OLD2018Q		51.66	49.39	53.93	5.11	3.93	7.31
Diff (1-2)	Pooled	-2.16	-5.62	1.30	6.42	5.43	7.86
Diff (1-2)	Satterthwaite	-2.16	-5.35	1.03			

Table 28

T-Test Result Comparing on the Old-Test (IN) and (CC)

Method	Variances	DF	t Value	Pr > t
Pooled	Equal	57	-1.25	0.21
Satterthwaite	Unequal	54.68	-1.36	0.18

Table 29

Equality of Variance IN-CC

Equality of Variances				
Method	Num DF	Den DF	F Value	Pr > F
Folded F	36	21	1.91	0.11

T-test 3:

An independent sample T Test was conducted to determine if there was a statistically significant difference between the student made tests and the old standardized test.

The student made tests were created by the students and the old tests were tests created by the publisher and used previously. There is a statistically significant difference between the two groups. The Mean and SD for student-made test was 83.10, SD = 20.03, and the Mean and SD for the old standardized test was M=50.31, SD= 6.45. (Table 30,31,32)

The TTEST Procedure

Variable: scores

Table 30

Confidence Limits for Means Between Old-Stm

Subject	Method	Mean	95% CL Mean		Std Dev	95% CL Std Dev	
OLD2018		50.31	48.62	51.99	6.45	5.46	7.89
STM2018		83.10	78.13	88.06	20.03	17.08	24.22
Diff (1-2)	Pooled	-32.79	-38.19	-27.38	15.18	13.49	17.35
Diff (1-2)	Satterthwaite	-32.79	-38.01	-27.56			

Table 31

T-Test Result Comparing on the Old-test and Stm Test for All Students

Method	Variances	DF	t Value	Pr > t
Pooled	Equal	122	-12.01	<.0001
Satterthwaite	Unequal	78.35	-12.50	<.0001

Table 32

Equality of Variances Old-test-Stm

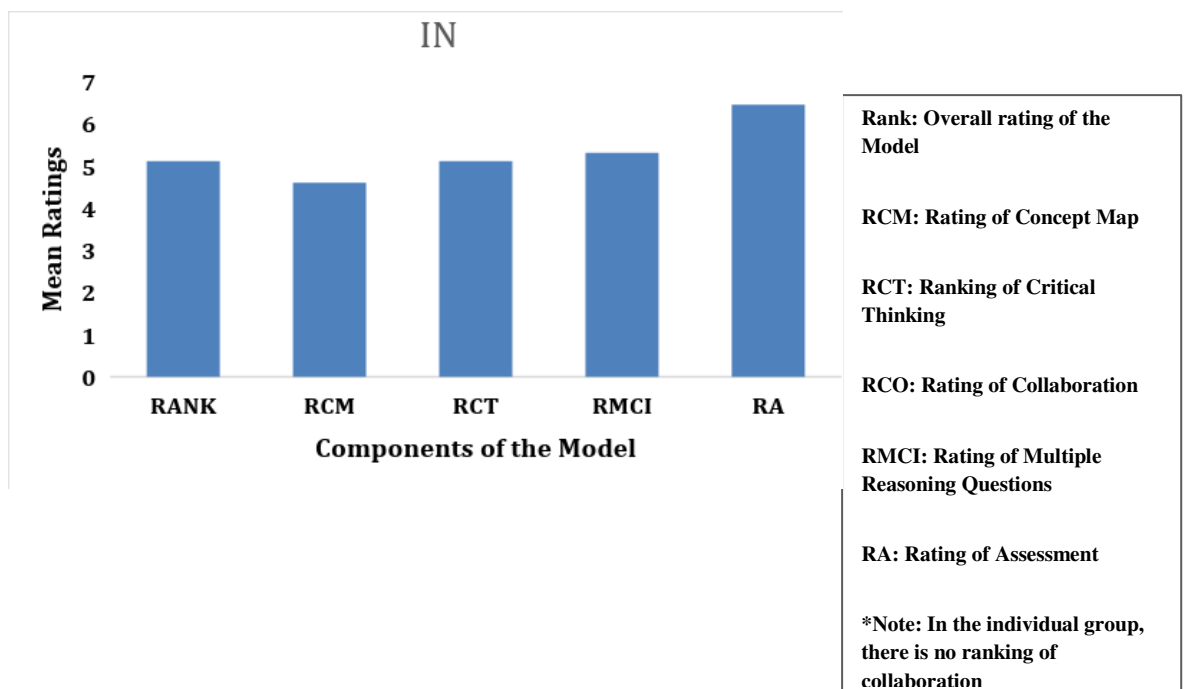
Equality of Variances				
Method	Num DF	Den DF	F Value	Pr > F
Folded F	64	58	9.62	<.0001

Questionnaire Data Analysis

Quantitative: Means Analysis

Research Question No.7. Does the data from the questionnaire support the continued use and development of the model?

Questionnaire



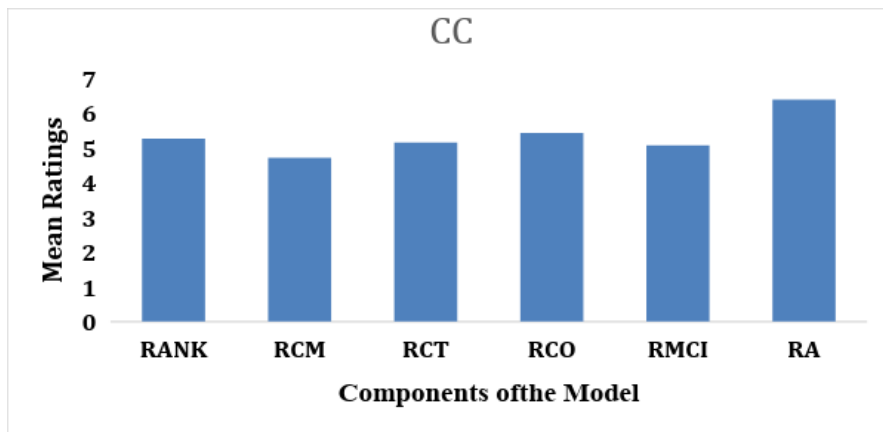


Figure 23. Student’s rating of the different components of the 3CAM model in IN/CC groups.

Students were asked to rate the overall usefulness of the model and its components in their learning. Students rate the different components on a scale from one to seven. One was defined as “least satisfied” and 7 was a ranking of “most satisfied”. Students in the individual and in the collaborative groups rated the components in almost identical ways. The ratings were as follows: How did you rate concept maps 4.7; critical thinking 5.2; collaboration 5.4; creation of the multiple reasoning items 5.1 and using multiple reasoning questions for their own assessment 6.4. Students in the individual group did not rate the collaboration because they did not collaborate.

Qualitative: Thematic Analysis

The student’s comments are listed below along with a number indicating the frequency with which other students agreed with the comment.

Student’s comments on **concept maps**

- Good for note-taking 1
- Organization of info 2
- Organization of thoughts into categories more clearly 2
- Helps me learn info in the process, I am a visual learner1

- Good way of consolidating ideas 1
- They make me look for core concepts 1
- They help visualize concepts for people who are visual learners like myself 3
- They help us think critically and make connections 1
- Memorization is assisted by this type of thought process 1
- You can visualize and draw connections 1
- Made me connect terms, helped me learn more 2
- Forced me to understand the material and how related 1
- They are a good intro to the subject 1
- They helped me understand why we were learning and why 1
- Help visualize important concepts and how they are related 1
- Once we got the hang of it I liked that it helped to visualize the connections between concepts 1
- They make you think 1
- Help map out ideas and big concepts and connect them 2
- They make you apply connections to your thinking which generate meaning 1
- I think they allow students to visualize their own learning as well as their peer's learning, makes it easier to learn 7
- It allows me to see how I think 1
- Not that much helpful, tedious, time-consuming 6
- Organization of thoughts in order 6
- Make it easier to retain info 2
- It furthers my thinking on ideas further than just reading the book 1
- It helps me organize the concepts in the way I understand them 1
- No, it is not in detailed 1
- Makes me think critically about the text 2

- Forced me to read through the book, which taught me a lot 1
- Not really, because I would focus more on the questions than the map, I would worry if there weren't enough things to fill the map 1
-
- Made the info stick to my brain and helped me while studying for the final 1

Student's comments on **digital map and their comparison with hand-written ones**

About two-thirds of the students would agree with the following comments:

- I prefer the digital map, easier and easy to manipulate when making the group map in class, managing is easier, more organized, neat and clean, change it easily, you can decorate it too, less cluttered visually, not limited, easy to turn in, less time consuming, easier to look at, I am not good at designing, at the beginning I would say hand-written but after getting used to it the online ones were definitely easier to manage², more than a person can work on it

About one-third of students made the following comments:

- The digital version was somewhat limited, handwritten is easier to adjust and add on to, it allows me to not think about the text, handwritten helps me to remember things more, better for memory and retaining information⁶, many issues initially, time consuming, more accessible

Student's comments on **Critical thinking**

The commentaries on application of critical thinking strategies were very positive. Over 95% of the students found them helpful.

- They help us to think about info in each chapter, they help to understand why a topic is there and what its connected to, makes me to think deeper about the concept, help you to think critically about what you are learning, it helps connect theories and concepts together, it helps to store info more strongly in the brain, I feel like this is more important once you start making questions not for map, allows to really understand content, it helps us to rethink the concepts in a different way, helps you understand fully, it helps to apply the material to the real world³, helps categorize and deeper thinking, makes me think about each concept, basis of learning and processing new information, helps me to generate questions easier, makes you think forwards and backwards, helps you to think beyond the book, shows us what we actually know and don't know, helps retrieval, got me to think more rather than just asking what is this or how does that work, makes me organize new info, it rationalizes my thinking, helps to think about questions in a different way⁵³
- "No, they were extra on my map" ²

- “Not sure, partly, I didn’t pay much attention, they forced certain labels to ideas that did not really make sense” 4

Student’s comments on **Multiple Reasoning Questions**:

The responses of the students were overwhelmingly supportive. They made the following comments:

- Yes, because it put us in the perspective of an instructor thinking about important concepts, reinforces concepts, further application of the concepts gave me a better understanding of them, makes me think critically, it allows me to apply my new knowledge to another platform, knowing that they will be on exam ease the tension, makes you renew the chapter in more detail , allowed me to explore other answers and think about the questions, helps me connect the dots, point a with point b, better studying habits, It really helped with understanding the topics, I had to go over my book and notes multiple times to create a question, it was like another study tool, it gave me a chance to expand my critical thinking by taking on the professor’s role a bit, it was a fun way to review concepts, I like being a part of my own test taking process, it made me think in depth on what questions I want to generate, makes you think about what’s important from chapter, I liked that you would be creative in terms of the items and create scenarios, helps store them into memory , helps to think in a different way, making your own questions and hearing other people’s questions emphasizes concepts in details, cover main ideas, makes me more actively engaged, I could prepare easily for test, broader understanding about a topic, think outside the box, I had to understand the concept first and then I was able to make questions, I was forced to think 59
- “No, didn’t take much time, tedious” 5

Student’s comments on the **creation of the items that used for their own assessment**

All of the students were enthusiastic about the role they played in their own assessment

“Like it a lot”

Student’s comments on the **fairness** of the model were all strongly supportive as well.

Student’s ideas about **what could be added to the whole process** to make them more involved in their learning were as follows:

- Nothing, this is great, keep as it is, unique, I enjoyed the class, I am excited to learn more 18
- More time to generate the maps 1
- More critical thinking 1
- All questions being student-generated 1
- The professor is doing a good job 1
- No more power point presentation, we know it now ☺ 1
- MCIs generation is difficult 1
- Not using the items in exam, more discussion about them 1
- Discussion in large group after discussion in small group, more interactive class 3
- Better study guide 1
- Less maps, notes instead of maps 2
- More negative feedback for those who do not work hard 1
- Moodle uploading is difficult but I understand there is no other way 1
- Better organization and make sure group is working 2
- More clarity in generating the maps1
- Online, extra, review quizzes 4
- Variety in assignment and not doing the same thing each session 3
- Proof reading or reviewing the questions with the class3
- No comments 6

CHAPTER 5

DISCUSSION

Discussion of Findings

This experimental study compared individual and collaborative groups of students applying the patterns of critical thinking as they used the 3CAM model for mastery learning. The overall aim of the study was to identify the patterns of critical thinking in the two groups. The first step in the analyses of the results was to use pie charts to visually show the overall patterns of differences between the groups. Subsequent analyses using ANOVA with repeated measures, multidimensional preference scaling, and correlations were used to further clarify the findings of the study.

The pie charts of the frequency of use of the critical thinking questions provided a visual picture that illuminated the differences between the groups. Three different sets of pie charts showed interesting and stable differences between the groups in patterns of the frequency of critical thinking. Importantly two sets of pie charts for the individual conditions showed very similar results over times one, two and three. The pattern of uses for the “what, how and why” groups were consistent. The “what question” was favored by the majority of the students in the individual group. “What” was used half of the time in asking critical thinking questions. “How” was used approximately twenty percent of the time by the students. “Who, why, and when” each accounted for slightly less than ten percent of the uses of critical thinking questions. These results were surprisingly stable across the three different periods of beginner, intermediate and advanced learning. The students apparently use the critical thinking of “what” to begin their approaches to inquiry. They did not change this approach to critical thinking over the course of the study.

The second analysis of the Individual group using a pie chart to show frequency of use provides an interesting examination of the strategies of critical thinking. The students in this group were involved in two phases: an individual phase and a collaborative phase. In other words, these students experienced an individual phase and a group phase. This raises the question of whether these students having worked in a collaboration with other students would change their behavior as individuals as a result of having participated in the collaborative group. The data from the individual-collaborative group is strikingly similar to the data obtained from the individual group. These data suggest that students have strategies for critical thinking that is consistent when they are alone and working as individuals.

The third analysis of patterns of frequency of critical thinking in the collaborative group is very different from the two patterns in the individual groups. The collaborative group consistently used about 40% “what questions”, one-quarter “how questions”, 13% for “why and when”, and finally about 8% used “who questions”. This pattern is very different from the patterns of the individual conditions. The most striking difference is the much lower percentage of “what questions”, the difference is between an average of fifty percent for the individual group and forty percent for the collaborative groups. The other significant change is the increasing frequency of use of “when and why” questions. It appears there is an increase in “when and why” and a decrease in “what questions”. These changes are attributable to the processes of collaboration. Working with other students prompts students to widen their use of critical thinking questions. The similarities between the two individual groups affirms the importance of the dialogue between students. Those students in the IC had the experience of working with other students but when they are alone, they return to their habits of thinking as individuals.

“What” is the most frequently used question by students, and reflects the fact that students begin their critical thinking with the question, “what is this”, “what happened?”. This question is simply translated into a declarative statement. The preference for “what question” is a reflection of the style of teaching in many college courses. “What question” are asked at significant level across all groups and time intervals. Bereiter and Sardamalia (2012) remind us that declarative knowledge is becoming less and less important in the age of computers and the internet. Students can simply “google it” and the problem is solved.

It is interesting that the two individual groups (individual(IN) and individual-collaborative(IC)) were significantly different from the collaborative group which used the fewest “what questions” across all three time periods. The low frequency of use of the “what questions” is due to the collaboration process in which team mates challenged each other to go beyond “what questions” and ask, “why and how”. The two individual groups (individual and individual-collaborative) significantly increased their use of “what questions” from times one vs two and three. There were no comparable increases in the frequency of the “what questions” across times one, two and three.

Figure 21 shows a three by three analysis of variance with three groups and three time intervals. There were significant differences due to groups and intervals, and there were no significant interactions between groups and time intervals. As can be seen in Figure 21, the means for Individual and Individual-collaborative were not significantly different from each other. Both individual groups were significantly different from the collaborative group across all three time periods.

The analysis of variance with repeated measures was applied to “what questions”. The analysis shows significance effects in both group and time. This result shows that at

each period of time there is a significant difference between groups.

Why

“Why” is the most prominent of “WH questions”. “Why” is most famously used by scientists and detectives. In both cases, “why” is only one of the interrogatives applied to the situation. “Why” is most often used when there is a mixture of knowledge and ignorance. “Why” is the most used to request an explanation of an event. “Why questions” are also used most often to explain a causal relationship between two events.

“Why” is used significantly more often by the collaborative group than the two individual groups in this context. “Why” is also used more often in the second and third time periods. This suggests as the students become more critical thinkers they tend to use more “why questions”.

How

“How” is the third most frequently used interrogative in this study. The interrogative “how” is used in teleological explanations when the speaker is explaining how some event came about. “How” usually refers to a process while “why” emphasizes a cause. “How” is usually an interrogative about a series of events.

As you can see in Figure 21, the trend for “how” is an increasing function for the students in the collaborative group, in other words they use more “Hows” over the three time intervals. There is a significant interaction between time and group. The use of “How” increases in the collaborative groups but decreases in the individual groups.

As it is clear, the usage of “Hows” and “Whys” increases over the three time intervals in the collaborative group. We can conclude when the students collaborate they use the critical thinking questions of “how and why” significantly more often,

while at the same time using fewer “what questions”, therefore, we can say they move beyond factual information and begin to ask, “why and how” something happens. This suggests that while they collaborate they become better critical thinkers.

When

When an event occurs is an important issue in child development. The collaborative group is significantly different from the individual groups in the use of “When questions”. There are no significant differences in regard to time or in the time/group interaction in the usage of “when”. This suggests that the collaborative group simply uses the concept of “When” more often in comparison with the individual groups. This is understandable, because the collaborative group goes beyond asking the questions of “what happen” to asking the questions “when does it happen”, so they are more focused on context. This finding is in consistent with the higher frequency of the use of “why and how”.

Who

Students use the questions “Who” significantly more often in the last two-time intervals.

The three groups are not significantly different from each other in terms of frequency of use. The increasing use of “Who” is attributable to the students’ understanding of the major figures in child development. Throughout the child development text, there is an emphasis on the major figures in developmental psychology such as: Erikson, Freud, Vygotsky.

Where

The “where questions” was used infrequently in all groups and there were no significant differences between the groups. This is reasonable, because the child

development text that was used in the class did not emphasize the where aspect of the context, the emphasis was upon the theory and decontextualizing the events.

Correlations

The five “WH questions + How” are the essential elements in the construction of narratives in child development. The most significant and frequent variables are “why, when, what and who”. The correlations between why and when were significant across the three comparisons groups. This suggests that the questions about “why something happened” and “when” are important questions no matter what the group. The correlation matrix between the work of the collaborative group in the class and the individual group at home(CC-I) shows there is significant correlation between “why and when” question. It is important to notice that 17 other correlations were not significant. There are also significant correlations between the work of the collaborative group in the individual phase and collaborative phase (CC-IC). As you can see in the result part, there are significant correlations between 1) “why and what question” 2) “why and when question” 3) “when and who question”. There is also correlation between the work of the Individual in collaborative group and individual group working independently (IC-I). There are significant correlations between 1) “when and why question” 2) “how and what question”.

“Why questions” are used more frequently and significantly across among all comparisons with a collaborative group. One of the results of collaboration is an increase in the number of “why questions”. “Why” appears to be the preferred mode of interrogation for students engaged in collaboration. The significant of the correlations shows that this result is no accident. It is also the case that there is no effort to intentionally encourage the students in collaborative group to ask the

questions “why”. Collaboration appears to be a process that encourages inquiry and the use of the question “why”.

“When questions” appears in 3 of the 6 significant correlations. This too is understandable because the content of a child development course centers around the questions of when an event occurs. Collaboration appears to be a process that encourages inquiry and the use of the question “when” as well.

There was also a significant negative correlation between the use of “what and how questions”. The data show that as the use of what questions go up the use of how questions go down.

Multidimensional

We also performed a multidimensional preference analysis to show the clustering of group preferences along the dimensions of the “WH questions”. This analysis provided an overall visual picture of the pattern of group preferences around the dimensions of the “WH questions”. The analysis showed the collaborative groups (IC and CC) clustering around the vectors of the six questions. This analysis accounted for 59.42% of the variance. This suggests that there is a very close fit between the data and the hypothesis questions. Our purpose is to identify the clusters and groupings of the variables along the vectors. The first analysis compares collaborate group with themselves. The comparison is between work completed independently at home and the work completed in class collaboratively. The analysis shows that the groupings for “who and why” overlap. This suggests that there is an underlying commonality between the two questions. The most obvious take away from the CC-IC analysis is that the “what question” is a preferred question for the individual phase. This is consistent with the previous analysis that showed that the “what question” is the most frequent question overall and preferred most often by the

individual groups. As you can see the questions of “who, how, when and why” are clustered together, while “what” is completely independent of the other “WH questions”. It is also the case that students at individual phase (IC) preferred the “what questions” overwhelmingly. This suggests that while students are working alone they are not likely to engage in using the other critical thinking questions. They settled for a simple declarative explanation rather than being engaged in critical thinking. It appears that the use of “what questions” are a barrier to the pursuit of a deeper understanding using the other “wh questions”.

The second multidimensional preference analysis of the dependent variables was applied to obtain an overall visual picture of the pattern of the “WH questions” between two groups: The collaborative group working in group in class and the other group working independently of each other (CC and IN). Our purpose is to identify the clusters and groupings of the variables along the vectors. This analysis accounted for 43.62% of the variance. This suggests that there is a considerable amount of variations that is not accounted for, however, the data fall along the different vectors in a close and systematic fashion. It shows that “who, how, why and when” are independent of each other, nevertheless, it is also evident that the collaborative group clusters around these vectors. Again, the “what” vector is independent of the other variables and in addition the independent group shows a strong preference for the “what question”. This is not surprising because we learned about this relationship from the previous analysis of the trend data. The most obvious take away from the CC-IN analysis is that the “what questions” is a preferred question by the individual group. So, this is consistent with the previous analysis that showed the “what question” is the most frequent question overall and preferred most often by the individual groups. As you can see the question of “who, how, when and why”

questions are clustered together, while what is completely independent of the other “WH questions”. It is also the case that students at individual phase preferred the “what questions” overwhelmingly. This suggest that while students working alone are not likely to engage in using the other critical thinking questions. They settled for a simple declarative explanation rather than being engaged in critical thinking. It appears that the use of “what questions” are a barrier to the pursuit of a deeper understanding using the other “WH question”.

This experiment also compared a collaborative and individual approach to mastery learning. In this study students are assessed using two kinds of achievement tests. These six groups were used to create a correlational matrix. This analysis is focused on the relation between student made tests and an old standardized test generated by text book publisher. The collaborative group was compared to the individual group on the student generated tests and the standardized tests. There was an obvious concern that a student generated test did not provide a rigorous assessment of student achievement. A significant positive correlation between the student made tests and the old standardized tests indicates that the two tests are measuring the same thing.

There was a strong correlation, .57, between the student made test and the old standardized test for the collaborative group. This finding suggests that the students in the collaborative group performed in a similar fashion on the student made tests and the standardized tests. When two experimental groups are collapsed and compared on the student made tests and the standardized test, there is a significant correlation of .25. This finding suggests there is a significant relationship between the student made tests and the standardized tests. In other words, there is an overlap or correlation between the old and the new tests. The third significant correlation, .36, was between

the performance of all students on the student made tests and the student made test for the collaborative group. The correlation of .36 falls between the correlation of .56 and .25 reported earlier. Together these data suggest there is strong relationship between performance on the student made tests and the old standardized tests, and this relationship is strongest in the collaborative group.

T-test

T tests was used to answer the question, are there significant differences between the different groups. The only significant difference was between the student made test and the old standardized test. There was a highly significant difference between the performance of the students on the two tests. Students did remarkably well on the student made test, and performed poorly on the standardized tests. Why was there such a large statistical difference? The finding can be explained by understanding that the students were involved and confident in their preparation for the student made test. In contrast, the students paid little attention to the standardized test because they were told their performance on the student made test would not influence their grades. As a consequence, they paid little attention to the standardized measure.

Questionnaire Discussion

The students in the collaborative and individual groups were asked to rate the components of the 3CAM on a scale from 1 to seven with one indicating not helpful to 7 indicating very useful. The ratings of the two groups had almost the same mean values. The surprising finding for this part of the study is that both groups were identical in their ratings across concept maps critical thinking, multiple reasoning items, and self-assessment using their own items.

In a traditional child development class students take notes through a lecture and then attend a discussion session in which they occasionally engage with their fellow students and rarely ask questions of their instructor. The classroom in the 3MCA model is a busy place as student are noisily and busily engaged in talking and debating with each other. Questions are exchanged and information is shared in a hum of conversations. Student comments about the different components of the model confirm that students are engaged and enjoying their experiences.

Students were enthusiastic about the concept maps. Three major themes emerged from the student's comments on concept maps. Most of the students made supportive comments while 6 students were not satisfied with concept maps. The themes were visualization, organization, simplification of learning. The following are some comments that students made:

- "They help visualize concepts for people who are visual learners like myself"
- "They allow students to visualize their own learning as well as their peer's learning and make it easier to learn"
- "Organization of thoughts into categories more clearly"
- "Made me connect terms and learn more"
- "Not helpful, tedious and time consuming"

For most students, this was the first-time students had a visual picture of their own thinking. Several students commented that they were visual thinkers, and concept maps were a welcomed change in their classroom learning. The vast majority of students found the concept maps were helpful in organizing their thinking. The students were asked for their assessment of the use of the digital concept maps. They reported that it took a while to get used to constructing the digital maps but "once they

got the hang of it, they found the digital maps to be a helpful in organizing their thinking”.

Students were asked about their reactions to the use of critical thinking questions. Again, they said it took them a while to be comfortable with the process but once, they became comfortable with the process they found the language games of critical thinking to helpful in organizing their thinking about the content of the chapters in the text. The critical thinking questions helped them think beyond the book and rationalize their thinking. One student commented, “it helped them to think backwards and forward”. Another said that “it helped apply the material to the real world”.

When students were asked to assess the creation of reasoning questions, they were particularly enthusiastic. They commented that creating questions put them in the place of the instructor and having to make decisions about what are the important concepts. Another said, it eased tensions, “it helped me to connect point A with point B”. “It gave me a chance to expand my critical thinking by taking on the professor’s role a bit”. “It was a fun way to review the concepts”. “It helped me to understand the concept of the chapters. It makes me more actively engaged and think outside of the box”. “I am forced to think”.

Students were asked, “Do you think using your own items in the exams was helpful?

They responded that creating their own exams was better preparation, it was tailored to their learning, and sixty-one students were in agreement with these sentiments.

Students were asked, “What could be added to the whole process to make them more involved in their learning?”. Their responses included the following:

“Nothing, this is great, keep it as it is, unique, I enjoyed the class; More time to

generate the maps! more critical thinking, all questions being student-generated; The professor is doing a good job! No more PowerPoint presentations, we know it now ☺! MCI generation is difficult! Better Study Guide”.

Teacher’s Role in M3CA Model

The 3CAM model of teaching critical thinking provides teachers with a new set of tools to teach critical thinking. The study shows that students can learn to use the critical thinking questions of “what, when, why, where, who and how”, and in process improve their classroom learning. Students come to class with patterns of critical thinking that focuses upon facts and declarative knowledge. The 3CAM model helps students to move beyond the “what” and the facts of the situation and to apply the critical thinking “WH questions” to their learning. Collaboration is the key experience that helps students move beyond the facts and engage in critical thinking.

The model is a student-centered approach to classroom learning in which students work individually and collaboratively to learn critical thinking skills. At the heart of the model is the shifting of responsibility from a teacher directed classroom to one in which students take responsibility for their own learning. The model is a template of activities which culminate in students creating the means of their own assessment. Students are motivated to engage in activities that lead directly to their creating the means of their assessment and grades for the semester. It is a rare opportunity for students to have an opportunity to prepare and create the means for their own assessment and as a consequence they are motivated to engage in the activities.

Teachers play an important in helping students to collaboratively create concept maps, applying critical thinking questions, prioritizing concepts, and creating multiple reasoning questions. These are new experiences for students. Because the

activities are new to students, teachers have an important set of responsibilities to help students to use the model successfully. The feedback and monitoring is necessary for activities done individually and work done collaboratively in class.

Teachers play an important role in helping students to successfully prepare and engage in the individual phase of the model. Each week students receive feedback about their activities of creating concept maps, applying critical thinking questions, prioritizing concepts, and creating multiple reasoning questions. It is essential for teacher to provide feedback about the homework so that students will be prepared to participate in the collaborative phase of the model.

The collaborative phase of the M3CA model also requires continual Feedback and monitoring for the successful implementation of the model. It is especially important for the teacher to monitor the groups to keep them on task. Feedback from the teacher and students have a role to play in the success of the groups. Student feedback to their peers is a necessary motivation tool all students. It is difficult to have all students mutually engaged in classroom tasks. Teachers must visit and give feedback to the groups as they are engaged in completing the collaborative phase of the model.

Implications of Findings

The major implication of this study is that it is indeed possible to teach critical thinking skills in a college classroom. The data on patterns of critical thinking show the patterns of the uses of critical thinking questions. This study suggests that not only is it possible to teach these skills but that it is possible to replicate this study in a wide range of classroom settings. The insight that the critical thinking questions of “what, when, why, where, who” and how are the elements of critical thinking is a conceptual advance in defining critical thinking.

The use of digital concept maps is a major innovation that is deserving of replication. The use of digital concept maps affords researchers the opportunities to measure the changing frequencies of the different critical questions. It is now possible to identify the patterns of critical thinking in a systematic way. The assessment of the processes of learning has been an elusive goal for researchers. The uses of concept maps and statistical techniques deploying repeated measures creates a new methodology to help researchers more fully understand the processes and patterns of critical thinking.

This experiment showed that collaboration is a powerful influence upon critical thinking and affords students opportunities to learn new patterns of critical thinking. There is a long history and tradition of recognizing the advantages of collaboration over working alone. This study documents the fact that collaborative learning results in students learning new patterns of critical thinking. The fact that collaborative learning results in learning new patterns of critical thinking is an important finding.

The recognition that visualization is an important tool in learning is an important implication of this research. Visualization is a neglected dimension of thinking; the introduction of concept maps reinstates visual thinking into a central place in teaching and learning. Students in education who are visual learners have been neglected, and concept maps are a step toward improving the educational experiences of all the students and specially for visual learners.

The generalizability or the transfer of critical thinking from one situation to another is implication of this study. Once students have learned how to use the 3CAM model, they can apply the model to their other classes. This is a useful and practical way to encourage students to transfer knowledge from one class to another. The

problem of the transfer of knowledge from one situation to another has been a continuing challenge for educators. The transfer of the patterns of critical thinking is a possibility deserving of serious study.

The last but not least of the implication of this study is the use of multiple reasoning questions. The use of these questions is potentially controversial because they share the same structure as found in tests used for summative assessment. As a result, many teachers, researchers and policy makers are skeptical about the structure of these questions. A careful consideration of multiple reasoning questions in the 3CAM model shows it is not norm based but is a criterion based approach to assessment.

Limitations of the Study

An important limitation of this study is that the independent and collaborative groups were confounded in this study. Although the study began with random assignment of students, the Institutional Review Board (IRB) required that students be given the opportunity to opt out of the study and/or choose how they wanted to participate in the study. The students in the two groups shared a common lecture each week and came to know each other. Confounding the two groups resulted in an exploratory study without the full power of a randomized experiment.

This exploratory experiment combined the components of concept maps, critical thinking, collaboration, assessment, and mastery into a single package. There is a need for a factorial study that systematically explored the inclusion of different components of the model.

It is important to explore the use of this model in different settings. The beauty of the model is that it can be conducted within a classroom. This suggests that the

model can be tried out in a variety of settings without having to involve large numbers of educational personnel.

This study was conducted in an undergraduate child development class at a major university in the eastern United States. There is a need to explore the uses of the model in different disciplinary settings, different levels of the educational ladder and with students from a range of racial, social and age levels.

Future Research Direction: Moving the Dial

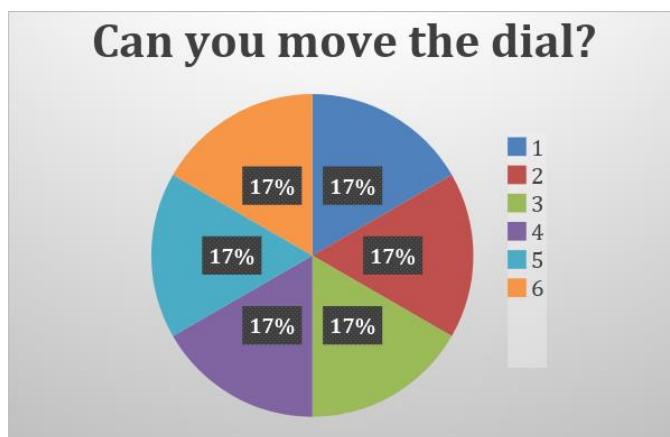


Figure 24. Future research direction

The pie charts used in this study show that students have patterns of critical thinking they have learned over the course of their lives. These patterns are habit of mind and body that have proved useful over time. This research study showed that students come to class with a history of habits of critical thinking. In order to improve critical thinking and achievement, it is necessary to design instructional interventions that include interactions and collaborations with others.

The challenge for you and other researchers is to move the dial. What kinds of interventions will be able to move the dial and significantly improve the critical thinking and the life chances of students. The challenge is to find ways to teach children that encourages them to take responsibility for their critical thinking and achievement.

APPENDIX A

3CAM MANUAL

What is 3CAM?

3CAM is a model of mastery learning in the classroom, and an acronym for Concept Maps, Critical Thinking, Collaboration, Assessment and Mastery. The definition for mastery learning is that everyone in this class can master the content of this class. If you complete all the assignments in this class in a responsible way you will achieve mastery learning and an “A”. This class is different, in most classes there are those who are successful and those who are not. In this class all can be successful and earn an “A” if you put forth the necessary effort.

The 3CAM model is a formative model of skill based mastery learning and assessment that produces high levels of academic achievement and empowers you with a feeling of fulfillment and fairness. The model includes learning the skills of: concept maps, critical thinking, prioritization (evaluation), social and cognitive synthesis, group evaluation (prioritization), and the application of multiple reasoning items to assess the facts, concepts and knowledge of the content of the course. Multiple reasoning items created by and collected from teams of students are posted on Moodle and are available for all to see and used in their assessment. Each step toward mastery is observable, transparent, and open to public view by the students.

*It will take you two sessions to get used to the procedures in this class. After that you will be comfortable and at ease with the processes. Students in previous semesters have found the procedures difficult at the beginning and super easy after a few sessions.

It is necessary to mention that the first two weeks are allocated for training. We will reduce the assignments so that everything can be accomplished in class. For the first two sessions, we only cover one chapter. After the training we will cover one chapter per week.

Purpose of the Manual:

The purpose of the manual is to provide you with a description of the procedures necessary for your learning, success and mastery in this classroom. There are two major phases in the 3CAM model: the individual homework phase and the collaborative classroom phase.

The individual homework phase is necessary to be completed and to prepare you to participate in the collaborative classroom phase. The individual homework phase includes: 1) the creation of digital concept maps, 2) the application of critical thinking questions to the maps, 3) the prioritization of the concepts-critical thinking items, and 4) the creation of multiple reasoning items.

The collaborative classroom phase prepares you for mastery learning in this classroom. It includes: 1) learning how to collaborate (social synthesis skills), 2) to share the concept maps and create a new collaborative concept map (cognitive synthesis), 3) prioritization of concept-questions, 4) creation of multiple reasoning questions, and 5) self and peer assessment.

Now, we will be discussing each and every step in the individual homework phase and in the classroom collaborative phase of the model.

Note: The students test items are reviewed weekly, modified and changed slightly if necessary by the instructor to improve accuracy, ease of understanding and clarity between the stem and the multiple reasoning alternatives.

question

In the first section of this manual, we will provide you with definitions of the Wh, critical thinking questions because you will be using these questions at each step of the model. These definitions will be followed by descriptions of the individual and collaborative phases of the model.

In the second section of the manual, you will see some guidelines for the generation of the questions.

Definition of WH Critical thinking questions/strategies:

“What questions”	have as their target a single event. The focus upon understanding a single event which is the focus of inquiry and the nature of being.
“Why questions”	are of the form what is the relation between two events, E1 and E2...? This is the familiar question of the causal relations between two events. The causal relations is central to much of scientific research and the search for deductive relations between events.
“How questions”	take the form of what is the relation between a series of events, E1, E2, E3 and En. The search for the relations between a series of events is an exercise in inductive reasoning and a hallmark of procedural knowledge and goal directed action. Following a sequence of events: E1, E2, E3, and En, the goal is to understand if the E1, E2, E3 are necessary and/or sufficient to bring about En.
“When questions”	invite a procedural answer. What is the relation between E1, E2, E3 and En when each event is a period in time? When questions have the same logical form as how questions, historians and storytellers are concerned with when an event took place. The simultaneous use of what and when are ways of deepening our understanding of historical events.
“Who questions”	are questions about human beings and human perspectives applied to explanations of events. Who questions can be answered with: I, you, (he, she, or it), we and they. Here the concern is with human actions and explaining the actions that led to an event, En. Consider I, you, he, she, it, we and they as different events that could bring about En.
“Where questions”	is deceptively complex because it is context and includes what, who, why, when and how. A picture of the context is a picture of the whole and is the background for making judgments and taking actions. A picture does not have significance by itself; it has significance in application. We come to understand things by forming pictures and then using them to interpret reality (Ackermann,1988) .

Individual Homework Phase

Individual Homework Phase: You are expected to complete the following homeworks each week prior to coming to class.

Step 1: Creation of concept maps.

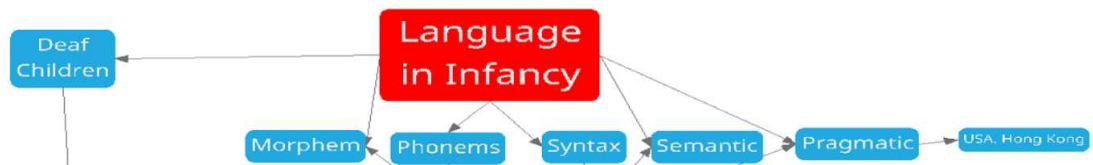
What is a concept? Concepts are the key terms, words, or ideas that are a part of each chapter in our textbook, “Understanding Human Development” . Each week we will complete one chapter in the text and use the concepts in that chapter as the basis of learning for the week. Each week you will identify the key concepts that are essential to understanding the chapter. You will use at least 20 of the key terms at the end of each chapter plus at least five more terms of your choosing.

The creation of concept maps is the first step in the process. You are responsible for learning how to generate the concept maps.

1: Construction of Digital Creation of concept maps, You click on the following address:
<https://www.mindmup.com>:

Click on the third option “tutorials” on the upper left side to learn how to generate a map.

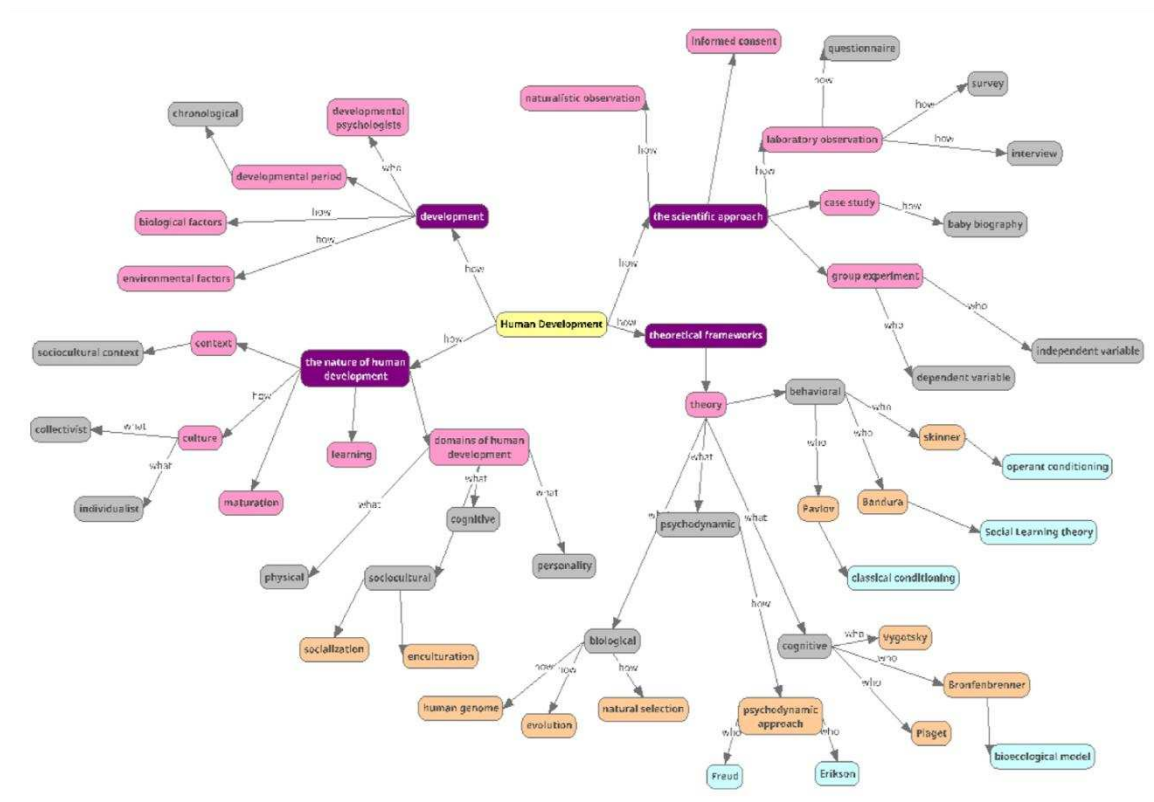
Sample of concept map with one concept (Yours should have 20 concepts at least)



Step 2: Applying critical thinking

Students apply the critical questions of “why, when, what, where, how, and who” to the concept map they have created. You will use the arrows to connect the concepts in your maps. Each of the arrows will be labeled using the critical thinking questions. Choosing which of the six critical thinking questions to apply to the concepts, is a matter of your own thinking and choosing.

The result is that each student comes to class with a digital concept map of the assigned reading. (Please see the sample completed version of the map)



Step 3: Prioritization

Students prioritize the concepts in their maps: The concepts (concept-critical thinking items) are ordered from the most to least important. The reason for the prioritization is to give some ideas about the next step in the process which is the creation of the Multiple Reasoning Items. Sample of prioritized list:

Key Concepts:

1. Human development
2. Development
3. Biological factors
4. Environmental factors
5. Developmental psychologists
6. Nature of human development
7. Culture
8. Collectivist
9. Individualist
10. Human development domains
11. Theoretical frameworks
12. Theory
13. Psychodynamic
14. Biological
15. Human genome
16. Cognitive
17. Behavioral
18. Scientific approach
19. Laboratory observation
20. Naturalistic observation

Step 4: Creation of the Multiple Reasoning items

Students will create the multiple reasoning items that will be the basis of their assessment.

Examples of multiple reasoning items:

- 1- Where did the idea that childhood “a time of innocence, during which children should have few responsibilities or chores,”

- a. in ancient Greece
- b. in ancient Rome
- c. in modern, industrialized societies like the United States today
- d. throughout history in Western societies since about 3,000 B. C.

Answer: c

2- How would describe the principle central to Darwin's idea of natural selection?

- a. Individuals within a species vary, and those with the best adapted characteristics survive to reproduce, thereby passing their genes to future generations.
- b. Nature selects the particular individuals that have the best characteristics and these individuals are allowed to interbreed with each other, thereby creating the strongest offspring.
- c. People prefer to mate with the most attractive members of the opposite sex, selecting their mates according to natural factors related to physical attractiveness.
- d. Humans evolved from the apes.

Answer: a

3- When does Freud's genital stage occur:

- a. birth to age 18 months
- b. age 3 to 6 years
- c. age 6 years to adolescence
- d. adolescence through adulthood

answer: b

4-What refers to changes over time in a person's body, thought, and behavior due to biological and environmental influences?

- a. Development
- b. Culture
- c. Maturation
- d. Context

Answer: a

5-Who is responsible for the five psychosexual stages?

- e. Piaget
- f. Vygotsky
- g. Freud
- h. Bandura

Answer: C

Foot note: Why are we using multiple reasoning items and not essay questions? Multiple reasoning questions provide a systematic way of identifying the concepts, critical thinking strategies, and the inferences used by students in understanding a text. The systematic approach provides a way of comparing the thinking of students across the three different parts of a multiple reasoning item: the question-concept, the problem or puzzle to be solved, and the possible answers. Using the multiple reasoning approach is another way of thinking like a scientist. True-False items are not allowed to use since they are so limited and essay questions will take you off the road in your thinking.

In the next section of this manual there is a description of the procedures for writing a good multiple reasoning item.

Step 5: Post the 1)concept maps with 2)critical thinking questions, 3)the prioritized list of concepts, and 4) the multiple reasoning to Moodle.

Notes for the submissions of your home assignments:

1- On moodle, there is a place for the submission of the individual maps, individual prioritization list and the individual generated questions. Please put all of the 3 homework assignments in one package and post them on Moodle.

PHASE TWO: THE COLLABORATIVE CLASSROOM PHASE OF THE 3CAM MODEL

The steps in this phase are the same as those in the individual phase; the only difference is that you are collaborating and synthesizing your ideas with your partner.

Step 1: Learning to collaborate: The concepts of social synthesis and collaboration are used interchangeably. Students come together in teams and exchange concept maps. Students are randomly assigned to a group of 6, and they work together in three pairs. The group selects a leader and for each session there is a different leader. The leader assigns each pair of students to a team.

Step 2 (Cognitive Synthesis):

Cognitive synthesis includes the exchange process that involves the following steps: identifying the differences, identifying the commonalities.

- a. Each pair exchanges their concept maps. They give feedback to each other, criticize, agree, disagree and identify gaps in their knowledge. While they are discussing and giving feedback to each other they apply critical thinking cues (What, How, Why, When, Where, Who).
- b. Each pair of students synthesize and combine the individual maps to generate a new collaborative map of the chapter. The result of this stage is having a new collaborative map . Again the new collaborative map will be created at the “Mindmup”.:<https://www.mindmup.com>

2. In pair- Prioritization

This step includes prioritizing the concepts-questions identified in the collaborative concept maps and ranking concepts from the most important to the least important. The connections between the concepts are the critical thinking strategies.

Step 3: In pair- Generation of multiple reasoning items

At this stage each individual creates 3 multiple reasoning questions and they shares them with their partner. Each individual presents their questions, they critique each others questions and revise their questions. The pairs of students share their generated multiple reasoning items and ask each other about the reasons for the response to each question. They assess and give feedback to each other.

Step 4: In group- Assessment

So far, each group of six students, create 18 multiple reasoning items with each pair of students creating six questions; Now, The whole group comes together and reviews the items created in the group. You answer each other's question, criticize and revise the items as a group. At this stage the group leader is responsible to have the group to follow the instructions and guidelines in the Manual. Each pair presents their questions to the larger group, and asks the group to critique their items and discuss their answers. The group members give feedback to each other and revise their items. At this point you decide which 9 multiple reasoning items are better to choose and submit to Moodle. After group discussion and sharing all the questions, the group reduces the 18 items to 9. (Important note: These are the questions that will be used in the mid-term and final exams)

Group leaders' responsibilities: At this point the group leaders get into action. They put all the typed questions/answers by the pairs into a single document and post them to the Moodle where the collaborative maps and questions are available for everyone in the class. (Important Note: The group leaders also fill out "the group report form" about the group discussion to the TA (ezandvakili@umass.edu) within 48 hours after the class meets.

Notes regarding the submission of the assignments:

1- On moodle, there is a place for the submission of the collaborative maps and prioritized lists and all should be submitted at one time there. Do not forget to include your names (Since you are working in pairs, there should be two names and the names should be included both on the documents and on moodle). It does not matter which member of the pair is submitting the documents, because both names are included.

2- On moodle, there is also a place for the submission of the 9 questions by the group leader. Do not forget to include the names of the group members on the document.

Here is the form for group leader:

Section 2

Guidelines for Test Construction

a. Anatomy of a Multiple Reasoning Item

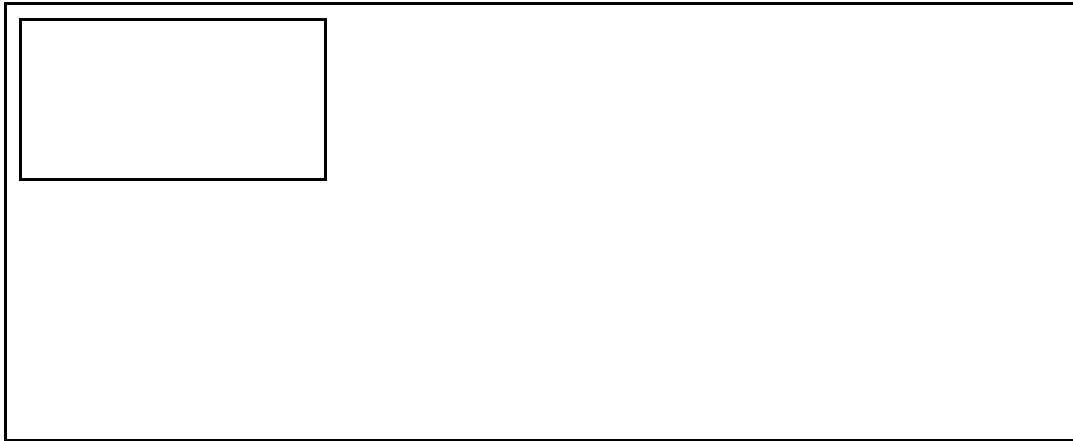
A standard multiple reasoning test item consists of two basic parts: Stem (a concept-question or an hypothesis which either has a problem or is incomplete), and a list of suggested solutions (alternatives). The concept-question is taken from the prioritized list generated from the concept maps. The alternative answers are possible answers to the problem.

An asterisk (*) is used to indicate the answer.

Stem {5. Lev Vygotsky's views on human development can be best categorized as belonging to which of the following theoretical perspectives?

Alternatives

ical	-----Distractor
ionary	-----Distractor
pdynamic	-----Distractor
p-cognitive	----- Answer



C. Terminology Regarding Multiple Reasoning Test

Concept-question or question-concept is an hypothesis about a problem situation. This is the part of the item in which the question is stated for the examinee. The concept-question often begins with the a “Wh” question: what, when, how, where, who at the beginning of each item is followed by the problem situation.

Options/Alternatives: These are the choices given for solving the problem, so the "options" consist of the answer--the correct option--and "distractors"--the incorrect but (we hope) tempting options. The alternatives are different patterns that may or may not be more or less correct. Together the concept-question or hypothesis/ the information in the problem statement(stem) and the alternatives are patterns from which the learner must choose.

Key: This is the correct choice for the item.

Distractors: These are the incorrect choices for the item. The purpose he distractors is to appear as plausible solutions to the problem for those students who have not achieved the objective being measured by the test item. Conversely, the distractors must appear as implausible solutions for those students who have achieved the objective. Only the answer should appear plausible to these students.

D. Guidelines for Developing Test Items

1. Before writing the item, identify the problem or critical question that you want to address and that you want to test. In general, you should not pose more than one problem.
2. The stem can be constructed in two forms: incomplete statement or a direct question or citation. The stem can include two or more events along with one or more events as an alternative. In this format, the alternatives complete the pattern and often include only a single concept. A second possibility is that the stem includes two or more events and the alternatives also include two or more events. This latter item is simply more complex.
3. Do not use unrelated clues to the correct option. Grammatical construction, for example, may lead test-takers to reject options which are grammatically incorrect.
4. The wording of each item should be simple and not complicated.
5. Avoid negatively stated items. If you have to use it, underline it, putting it in capital letters or use italics.
6. Keep each item independent from other items.
7. If one or more alternatives are partially correct, ask for the "best" answer.

8. Make all incorrect alternatives (i.e., distractors) plausible and attractive. It is often useful to use popular misconceptions and frequent mistakes as distractors. Incorporate common errors in distractors.
9. All alternatives should be homogeneous in content, form and grammatical structure.
10. Use 4 or 5 alternatives in each item.
11. Avoid terms such as "always" or "never," as they generally signal incorrect choices.
12. Avoid items based on personal opinions unless the opinion is qualified by evidence or a reference to the source of the opinion (e.g., According to the author of this passage, . . .).
13. Avoid the excessive use of "All of the above" and "None of the above" in the response.
14. After the options are written, vary the location of the correct answer on as random a basis as possible.
15. Have your group members review the items for possible ambiguities, redundancies or other structural difficulties.

For example, consider: "The American flag has three colors. One of them is (1) red (2) green (3) black" versus "One of the colors of the American flag is (1) red (2) green (3) black" ; In particular, irrelevant material should not be used to make the answer less obvious. This tends to place too much importance on reading comprehension as a determiner of the correct option.

16. Do not use exact wording from the textbook. (Paraphrase it!)
17. Use grammar and spell check.
18. Use the active voice.
19. The ideal question will be answered by 60-65% of the tested population.
20. Avoid giving unintended cues – such as making the correct answer longer in length than the distractors.
21. Use the text book's examples as a basis for developing your items.
22. Do not make the items complicated and impossible to reply to it. Use the main points of the book to generate your items. (Avoid window dressing (excessive verbiage) in the stem.)
23. Use letters in front of options rather than numbers; numerical answers in numbered items may be confusing.
24. Make sure that there is one and only one correct option.
25. Use multiple reasoning to measure higher level thinking. (WH questions)

The stem of the original item below fails to present the problem adequately or to set a frame of reference for responding.

Example:

World War II was:

- A. The result of the failure of the League of Nations.
- B. Horrible.
- C. Fought in Europe, Asia, and Africa.
- D. Fought during the period of 1939 to 1945

There should be no grammatical clues to the correct Original

Example:

Albert Einstein was a:

- A. Anthropologist.
- B. Astronomer
- C. Chemist.
- D. Mathematician

Revised ex1

In which of these time period was World War II fought?

- A. 1914-1917
- B. 1929-1934
- C. 1939-1945
- D. 1951-1955
- E. 1961-1969

Revised ex2

Who was Albert Einstein?

- A. An anthropologist.
- B. An Astronomer.
- C. A chemist.
- D. A mathematician.

Alternatives should not overlap (e.g., in the original form of this item, if either of the first two alternatives is correct, "C" is also correct.)

During what age period is thumb-sucking likely to produce the greatest psychological trauma?

- A. Infancy
- B. Preschool period
- C. Before adolescence

D. During adolescence

E. After adolescence

Revised ex:

During what age period is thumb-sucking likely to produce the greatest psychological trauma?

A. From birth to 2 years old

B. From 2 years to 5 years old

C. From 5 years to 12 years old

D. From 12 years to 20 years old

E. 20 years of age or older

Example of how the greater similarity among alternatives increases the difficulty of the item.

Easy

Who was the President of the U.S. during the War of 1812?

A. Grover Cleveland

B. Abraham Lincoln

C. James Madison

D. Harry Truman

E. George Washington

More Difficult

Who was President of the U.S. during the War of 1812?

A. John Q. Adams

B. Andrew Jackson

C. Thomas Jefferson

D. James Madison

E. George Washington

Examples:

- Most information is given in the stem.

Good Example

Following a second episode of salpingitis, what is the likelihood that a woman is infertile?

a. Less than 20%.

b. 20 to 30%

c. etc.

Bad Example

Following a second episode of salpingitis:

- a. the likelihood that a woman is infertile is less than 20%.
- b. the likelihood that a woman is infertile is 20 to 30%
- c. the likelihood that a woman is infertile is greater than 50%
- d. etc.

Good Example

_____ a day keeps the doctor away. a. A banana

- b. An apple
- c. A steak
- d. A peach
- e. A good jog

Bad Example

An _____ a day keeps the doctor away. a. banana

- b. apple
- c. steak
- d. peach
- e. good jog

Answer and alternatives should be about equal length.

Good Example

The average weight of an adult male in the United States is:

- a. less than 150 pounds
- b. more than 200 pounds
- c. between 150 and 170 pounds
- d. between 171 and 185 pounds
- e. between 186 and 200 pounds

Bad Example

The average weight of an adult male in the United States is:

- a. less than 150 pounds
- b. less than 175 pounds
- c. more than 185 pounds d. more than 200 pounds

- Avoid “none of the above” and “all of the above.”

Good Example

What is the number obtained when the circumference of a circle is divided by its diameter?

- a. 1.61
- b. 2.36
- c. 3.14
- d. 4.32

Bad Example

What is the number obtained when the circumference of a circle is divided by its diameter?

- a. 1.61
- b. 2.36
- c. 3.14
- d. none of the above ("c" and "d" are correct)

E. Checklist for Reviewing Multiple reasoning Items

- 1- Has the item been constructed to assess a single critical “Wh” question?
- 2- Is the item based on a specific problem stated clearly in the stem?
- 3- Does the stem include as much of the item as possible, without including irrelevant material?
- 4- Is the stem stated in positive form?
- 5- Are the alternatives worded clearly and concisely?
- 6- Are the alternatives mutually exclusive?
- 7- Are the alternatives homogeneous in content?
- 8- Are the alternatives free from clues as to which response is correct?
- 9- Have the alternatives “all of the above” and “none of the above” been avoided?
- 10- Does the item include as many functional distractors as are feasible?
- 11- Does the item include one and only one correct or clearly best answer?
- 12- Has the answer been randomly assigned to one of the alternative positions?
- 13- Is the item laid out in a clear and consistent manner?

14- Are the grammar, punctuation, and spelling correct?

15- Has unnecessarily difficult vocabulary been avoided?

16- If the item has been administered before, has its effectiveness been analyzed?

APPENDIX B

PRACTICUM STAGES

Practicum Stages (Presented as PowerPoint in class)

1- Find your group members (1 min)

Raise your hand and Show the number of your group to the class, so you can find each other easily

2- Choose a group leader (1 min)

For each session, you will choose a person to be the leader of your group, so each group member will have only one opportunity to be the group leader.

Being a group leader is an obligation and one of the most important parts of group activity.

Group leader should solve the problems of the group. For example: Pairing up the students for sharing their maps.

Synthesis

3- Social synthesis (Chose a partner in your group to share your concept maps) (1 min)

Note: You should choose a different partner for each session, since we want you to make improvement in your communicative skills and learn new things from each other.

All of you have different talents and knowledge so let`s learn from each other

4- Cognitive synthesis: Share your individual concept maps (feedback provision) (10 min)

At this stage, you share and explain about your individual map that you generated at home. You talk about the reasons and logic behind not only the concepts you chose to use in your maps but also about the connections among them. You discover the gaps in each other`s map which is the picture of your thinking.

7- Generate your collaborative conceptual map (handwritten in the class- digital at home) (15 min)

Note: At this stage, you can use all available resources to generate a great conceptual map.

What are the resources:

Critical thinking tools (WH questions)

Your individual maps

Power-point from the lecture (We post it on Moodle after each lecture session)

Textbook

8- Generate a list of the concepts from the most important to least important ones (10 min)

Note: You need the list to construct your multiple-choice items. (Tell your partner why you think the concepts are important)

9- Generate Your multiple-choice items based on the list and the map that you have (20 min)

In each group, each individual generates 2 questions using (what, when, where, why, who and how), 1 compound, 1 "what if"

Each pair shares the questions and assess each other. Please make suggestions for revisions.

Each pair generates a compound(mixed) question.

The group members get back together and share their questions, revise them and assess each other.

Each group generate one "what-if" question.

You need to discuss and think critically to generate this question.

Notes for creating questions

Since you are equipped with critical thinking tools(why,when,how,where,why,who) you can generate great questions which are appropriate and can be used in your exams)

Note 2: Please follow the guidelines for test construction. (checking for grammar, spelling and do any necessary revision,)

10- Assessing each other (5 min) (each pair 3 min to ask the questions from the group)

Each pair will ask the group to reply to their items and discuss their answers.

You can give feedback to each other and revise each other items.

Don't forget that most of the score for each session will be given to your group activity.

Each individual will post the questions and each pair will post the collaborative map.
She/he should type the 2 items (mixed question and what if question) in one document (Microsoft word) and post it on Moodle, so the whole class will have access to generated items that will be modified and used for both mid-term and final exams. (Don't forget to put on the paper the number or name of your group
Group leader should send the report to TA.

Formatting of the questions

Font Size: 12

Font: Times New Roman

Spacing: 2

Capital Letters should be used for alternatives and the answer should be written after the alternatives:

A child typically has a vocabulary of about 50 words at which of the following ages?

- A. 6 months
- B. 12 months
- C. 18 months
- D. 24 months

Answer: C

Please ask and answer the questions from chapter 7

Arrange the chairs of your group in row.

(1000000000000000000000000000000 min)

APPENDIX C

QUESTIONNAIRE

ID number:

What is your age:

What year in the college are you: (Freshman, sophomore, Junior, Senior)

Your field of study/what college are you in:

Gender:

Ethnicity/Race:

1- How satisfied are you with the practicum part of the class?

Circle one number: (least satisfied) 1 2 3 4 5 6 7 (most satisfied)

2- How much have you enjoyed each of the following activities during the practicum part?

a) Concept map 1 2 3 4 5 6 7

b) Critical thinking 1 2 3 4 5 6 7

c) Collaboration 1 2 3 4 5 6 7

d) Multiple reasoning items generation 1 2 3 4 5 6 7

e) Assessment (using your own items for exams) 1 2 3 4 5 6 7

3. Do you think concept maps are helpful in the process of your learning?

Why?

Yes No

4. How did you like the instruction for generation of your maps? (ordering of the concepts, connection between the concepts), Was it clear?

5. What do you think about the ordering of the concepts and the connections between concepts and critical thinking questions?

6. How did you like your involvement in generation of digital map? Do you like it more if you could generate hand-written map? Why? Please Compare and describe your experience.

7. Do you think applying critical thinking strategies (WH questions) are helpful in the process of learning? Yes No
Why?

8. Do you find generating the multiple reasoning items helpful in your process of learning and assessment? Yes No
Why?

9. How do you like your involvement in generating the multiple reasoning items? Please describe it?

10. How do you like your involvement in editing of your questions that were shared on google drive? How much did you learn from it?
11. How did you like the idea of adding the form “group activity” to report the level of the engagement of your group members for each session?
12. Do you think using your own items for your assessment? Was helpful for your learning skills? Yes No
13. Please explain any other positive or negative comments that can be helpful to the 3CA procedure.
14. What improvements would you suggest for concept maps? Critical thinking and collaboration? Multiple reasoning items generation?
15. Did you find the activities and procedures to be fair?

Thank you

No	Components of 3CA	No. themes	Themes	Frequency
1	Concept Map (CM)	1	- Organization	➤ 12
		2	- Thinking	➤ 7
		3	- Visual Learning	➤ 14
		4	- Making connections	➤ 5
		5	- Not helpful	➤ 6
2	Critical Thinking (CT)	1	- Thinking about questions and concepts in different way	➤ 32
		2	- Thinking deeper	➤ 9
		3	- Thinking critically about what you are learning	➤ 10
		4	- Making you think forwards and backwards	➤ 1
			- Not helpful, extra, not sure	➤ 6
3	Collaboration (CO)	1	- Supportive, like it, helpful	➤ 21
		2	- Not helpful	➤ 1
4	Creation of Multiple Reasoning Questions (MRQ)	1	- Putting them in the role of instructor	➤ 2
		2	- Helping with critical thinking	➤ 12
		3	- Helping to understand better	➤ 7
		4	- Helping to organize my thinking	➤ 8
		5	- Fun and creative	➤ 3
		6	- Improving the depth of their thinking	➤ 8
		7	- Not helpful and tedious	➤ 5

5	Using MRQ they created for their own Assessment (A)	1	- All students were enthusiastic about using their own questions for assessing themselves (“Like it a lot”)	➤ All
6	What could be added to the whole process	1 2 3 4 5	- Nothing, this is great - No comment - Adding on line, extra quizzes - Variety in assignments - More time	➤ 18 ➤ 6 ➤ 4 ➤ 3 ➤ 8

Thematic Analyses from the student’s questionnaire

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