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Infusing Critical and Creative Thinking and Metacognition in ICT Education: A Classroom Study

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Abstract

Enormous student motivation and perseverance are required for Traditional IT courses. To overcome these problems, IT lecturers at UAE University's University General Requirements Program have promoted a natural way of infusing creative and critical thinking in the classroom by structuring lessons in which students manage their own thinking, not a physical performance in the class. Three main critical and creative thinking methodologies (Open Compare and Contrast, Focused Compare and Contrast, and Determining Parts-Whole Relationships) were used with five ICT sections (about 100 students). This paper describes the new lesson plans, their overall effectiveness, and future plans. It also discusses the impact of these lessons on student learning and comprehension and also in terms of educational goals, contents, and assessment. The outcome of this research indicates that ICT classroom teaching methods changes will help students to become critical thinkers, able to search out, understand, analyze, and synthesize information.

Keywords

Infusion, Critical, Creative, Thinking, Metacognition, Cognitive Skills, Parts-whole relationship, ICT, UGRU, and Graphic Organizer.

1. Introduction

Learning in the United Arab Emirates is witnessing a major paradigmatic shift, from the traditional rote-learning format to one in which students are actively engaged in their own learning process. While core values that are central to Islamic beliefs are retained, the methodology now focuses on teaching curriculums based on thinking, rather than rote memorization.

In Spring 2005, the University General Requirements Unit (UGRU) of the United Arab Emirates University (UAEU), replaced the traditional Information Technology (IT) curriculum with a new Information and Communication Technology (ICT) curriculum. An examination of this new curriculum, in terms of educational goals, content, teaching methods and assessment, revealed that UGRU lecturers find the new ICT curriculum better than the previous traditional curriculum in all these areas. Traditional IT courses require enormous student motivation and perseverance. To overcome these problems, ICT lecturers have infused creative and critical thinking in study material, homework and quizzes, successfully integrating thinking skills into the technologically oriented curriculum. Infusion is a natural way of structuring lessons in which students manage their own thinking, not a physical

performance in the class. Three main critical and creative thinking methodologies (Open Compare and Contrast, Focused Compare and Contrast, and Determining Parts-Whole Relationships) were used with five ICT sections (about 100 students). This paper describes the infusion of critical and creative thinking into lesson plans, their overall effectiveness, and future plans. It also discusses the impact of these lessons on student learning and comprehension and also in terms of educational goals, contents, and assessment. The outcome of this research indicates changes in the method of teaching ICT will help students to become critical thinkers, able to search out, understand, analyze, and synthesize information.

This research has been carried out in two phases. In the first phase initial response of students towards the new methodology has been observed and reported, while in the second phase the comparison of learning outcomes will be evaluated. This paper takes care of the first phase of our research. The next paper will address the evaluated outcomes.

1.1 Prelude

First let us understand and analyze creativity, communication, collaboration, environment, and the human brain. Perhaps we should begin with a more basic question: what do we mean by creativity? The basis of creativity is achieving something that did not exist previously, breaking down established patterns, seeing things in a new way. But what drives people to think of something new? How does the creative process work? The creative process may manifest itself in different ways. “Chance favors the prepared mind,” the famous scientist Louis Pasteur once said. Pathologist Peyton Rouse spoke likewise of “a prepared mind making its own chances.” Are we going to prepare our students for the future using new tools of information technology, creative and critical thinking, enhancing the value of good communication, and habits of collaboration or do we simply wait for the chances (Larson, 2000)?

Several influences have converged to create a new emphasis on the teaching of a thinking skills based IT curriculum around the world. Prominent among these are workplace readiness and the constructivist movement (West Virginia Office of School-to-Work, 1997). Education in the Arab nations was tied to religion for many years and traditional teaching techniques relied primarily on rote learning within a lecturer-centered, religious-oriented context. However, teaching thinking in IT is not at all antithetical to the Holy Qu’ran, in which more than 640 verses challenge believers to use their minds for critical thinking, problem-solving, creative thinking, and decision-making. In the 21st century, it is particularly important to cultivate these skills to enable our youth to function effectively in their own world as well as in the global community (Alsuwaidi, 2001).

The new ICT curriculum focuses on critical and creative thinking. Perkins (Perkins, 1994) notes six basic priorities for lecturers who actively teach for understanding rather than for memorization. Cognitive research and theory has changed the way many in the education system think about educational practice, including curriculum design, assessment, and learning environments. Greeno, Collins, and Resnick (Greeno, Collins, & Resnick, 1996) emphasize that the design of learning environments can support cognitive or brain-based learning. Brooks and Brooks (Brooks & Brooks, 1993) describe several of these. For example, students need to be provided with curriculum holistically, emphasizing large concepts, rather than the fragments, or basic skills as building blocks that is typically the current approach (Sharma, Alsuwaidi, Hussein, & Boylon, 2005)(Sharma, Alsuwaidi, &

Boylan, 2006). These skills are used intelligently in the new ICT curriculum lesson plans infusing critical and creative thinking and metacognition. This paper is based on ways of infusing the teaching of critical and creative thinking into contents instruction. This paper also presents an ICT teacher-oriented approach to improving student thinking that blends sound theory and effective classroom practice and its influence on the students which will encourage other ICT teachers to apply similar approach.

1.2 Infusing Critical and Creative Thinking into Content Instruction and Metacognition

It is ordinary thinking done well that is our goal when we "teach thinking." How can we teach students to improve the quality of their thinking? The thinking skills movement of the 1980s produced special programs and emphasized instructional methods to foster thinking. Three principles emerged from these efforts:

- The more explicit the teaching of thinking, the greater impact it will have on students.
- The more classroom instruction incorporates an atmosphere of thoughtfulness, the more open students will be to valuing good thinking.
- The more the teaching of thinking is integrated into content instruction, the more students will think about what they are learning.

These principles provide the basic rationale for infusing critical and creative thinking into ICT content instruction. The thinking skills which can be used in ICT classrooms fall into the three main categories: skills at generating ideas, skills at clarifying ideas, and skills at assessing the reasonableness of ideas. Strategies for skillful decision making and problem solving provide the link between the more circumscribed thinking skills that appear in each of the three categories and the authentic thinking tasks students must engage in both in and out of school or college.

The structures of infusion lessons involve infusing critical and creative thinking into content instruction. This way of teaching students how to think skillfully blends features of two contrasting instructional approaches that educators have taken to teaching thinking: (1) direct instruction of thinking in non-curricular context and (2) the use of methods which promote thinking in content lessons. Infusion lessons are similar to, but contrast with, both of these types of instruction. The diagram in figure 1 represents this relationship (Swartz, Fischer, & Parks, 1998).

In the infusion lesson students not only engage thoughtfully with what they are reading, but their attention is also focused on the thinking process that they are learning. Such an interrelationship distinguishes an infusion lesson from other practices to prompt thinking in content lessons. Let us summarize the four basic components of an infusion lesson (Costa, 1984)(Costa, 1991)(Perkins, 1987)(Swartz & Perkins, 1990)(Swartz, Schroder, & Parks, 1994)(Swartz, Fischer, & Parks, 1998).

The lesson introduction. Focusing students' attention on the thinking that they are learning is done differently in each of the four sections of the lesson. Students are introduced to the thinking skill goal of the lesson along with the content. This is achieved by a discussion or activity designed explicitly to

- Demonstrate to the students themselves what they already know about the thinking skill being taught

- Show students why this type of thinking is important
- Help them to relate its importance to their own experience
- Introduce them to the process of engaging in the thinking skilfully
- Introduce them to the significance of engaging in this kind of skilful thinking as they reflect about the content they are learning

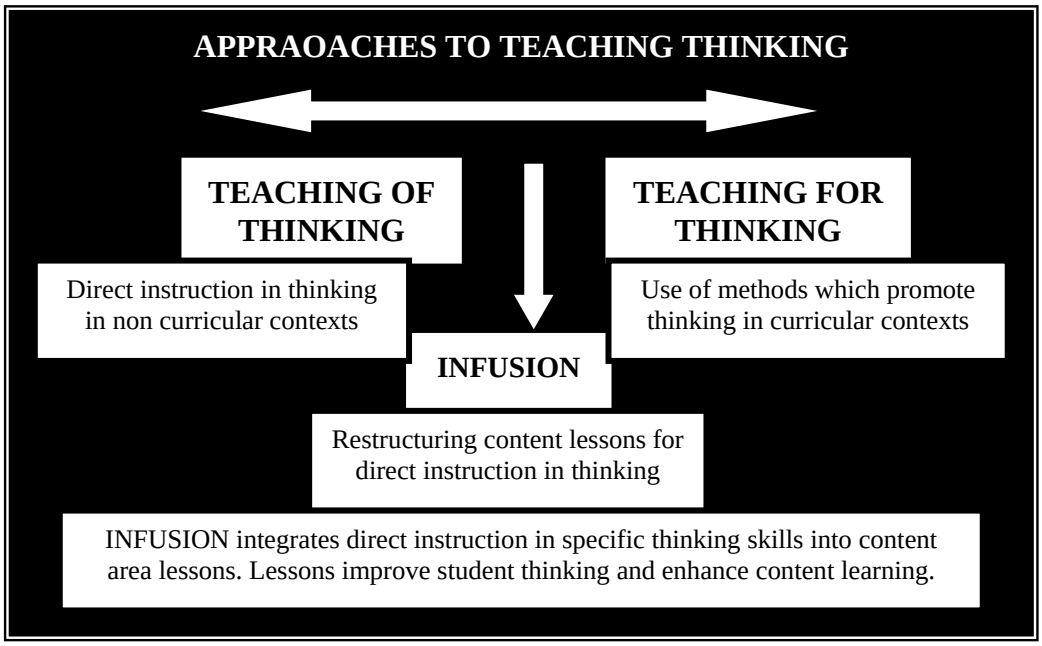

Figure 1: The basic idea of an Infusion lesson (Swartz, Fischer, & Parks, 1998).

Thinking actively. Next, students engage in an activity in which they are guided through a skilful performance of the kind of thinking being taught. In this part of the lesson, teaching the content and teaching the thinking skill are combined. Two explicit thinking prompts guide the thinking activity:

- Verbal prompts (usually questions)
- Graphic organizers.

The basic components of infusion lesson are described below.

Thinking about thinking. In the next part of the lesson, the teacher engages the students in a reflective activity in which they distance themselves from the lesson's content so as to consider the thinking they did. Students map out their own thinking process explicitly, commenting on how easy or hard it was, how they might improve it, whether this was a productive way to think about such issues, and planning how they will do the same kind of thinking in the future. This is the main metacognitive section of infusion lessons. Including a special metacognitive section in these lessons should not preclude asking metacognitive questions in other sections of the lesson. The more such questions are peppered throughout infusion lessons, the more practice you are giving students in becoming more reflective about the way that they think and the more likely they are to guide themselves to improve the way they think.

Applying the thinking. Finally, the teacher helps the students apply the thinking skill or process taught in the lesson to other situations. These transfer activities should occur soon after the other three parts of the lesson have been completed and should be reinforced in other activities throughout the school year. Important additional practice is offered by both "near transfer" examples (those from the same field as the thinking activity in the lesson) and "far transfer" examples (those from other disciplines or from personal experience).

1. 3 ICT Curriculum and Critical Cognitive Skills

Beginning Spring 2005 semester, ICT curriculum has been introduced in the UGRU. This curriculum helps students learn critical cognitive skills as well as technical skills relevant for a first year developmental program. One of the things that the new curriculum has done is fill in some of the gaps that existed between the IT curriculum and the UGRU Conceptual Framework. This is the document that defines the knowledge, skills and predispositions that students leaving UGRU are expected to achieve. The new ICT curriculum contents have been built around six learning areas. These six learning areas are intended to build on each other to form a spiral of learning experiences for students. Figure 2 shows the conceptual diagram of the learning areas and how they are related (Ranginya & McKenzie, 2005).

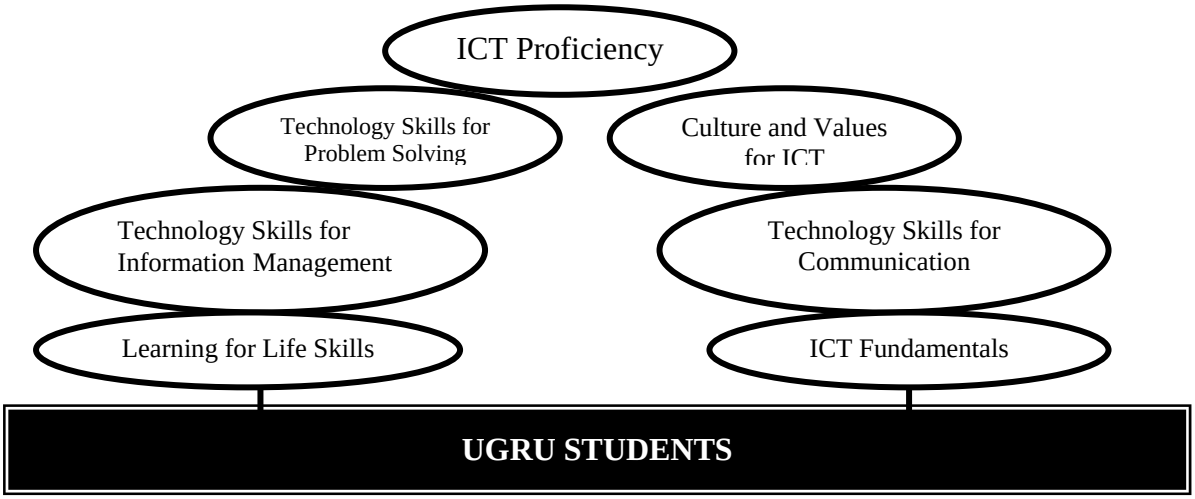

Figure 2: The relationship of ICT learning areas (Ranginya & McKenzie, 2005).

These learning areas are same for both the levels of the IT program; ICT1 and ICT2. The key difference between the two levels is that while learning "how to" tools are heavier in the first level, these are de-emphasized in the second level. Instead students will apply the skills in a variety of ways to solve problems, to improve their communication skills and to organize information better. The way of learning/teaching ICT is mostly done through the use of tasks (Ranginya & McKenzie, 2005).

While technical IT skills are deemed important and should be learned, it is felt that it should be extended to include critical cognitive skills to better prepare students for university life and beyond. Students entering UGRU already possessing the skills find that this curriculum provides sufficient critical cognitive challenges useful for their preparation for college and beyond. The new ICT curriculum emphasizes academic achievement as much as, and in some cases more than IT skills development. While technical skills are deemed important and should be learned, it is felt that it should be extended to include critical cognitive skills to better prepare students for university life and beyond.

Students entering UGRU already possessing these skills find that this curriculum provides sufficient critical cognitive challenges useful for their preparation for college and beyond. Students not yet familiar with the technical skills find that at level one they can still learn how to use those skills but in the context of scenarios or tasks that require mastery of both cognitive and technical skills (Ranginya & McKenzie, 2005). By combining the two areas, students coming out of the program are able to successfully perform the tasks below:

- **Access:** Knowing about and knowing how to collect and/or retrieve information.
- **Manage**: Applying an existing organizational or classification scheme.
- **Integrate**: Interpreting and representing information. It involves summarizing, comparing and contrasting.
- **Evaluate**: Making judgments about the quality, relevance, usefulness, or efficiency of information.
- **Create**: Generating information by adapting, applying, designing, inventing, or authoring information.

2. Research Objectives

Some of the reasons for the infusion of critical and creative thinking and metacognition in ICT classrooms are as follows: (i) there is a gap in present and future Information Technology (IT), taught in higher education, and real use of IT. (ii) Students find traditional classroom lessons boring. (iii) Traditional IT courses require enormous motivation to go through the material, let alone learn from it. (iv) Serious concerns can be raised regarding gaining relevant knowledge or developing required skills through traditional approach. (v) Different students have different styles and strategies of learning which has not been addressed by traditional classroom lessons.

We strongly believe that infusion of critical and creative thinking and metacognition in ICT classrooms can be an effective counter to many of the aforementioned issues.

3. The Research Design

Three main critical and creative thinking methodologies (Open Compare and Contrast, Focused Compare and Contrast, and Determining Parts-Whole Relationships) which are described below were initially used with five ICT sections (about 100 students). Later on only two sections continued with infusion lessons while other sections were brought back to traditional classroom lessons. A classroom survey instrument along with teacher's observations was used as a means of data collection.

This research has been carried out in two phases. In the first phase initial response of students towards the new methodology has been observed and reported while in the second phase the comparison of learning outcomes will be evaluated. This paper takes care of the first phase of our research. The next paper will address the evaluated outcomes.

Let us understand basics of the three main critical and creative thinking methodologies (Open Compare and Contrast, Focused Compare and Contrast, and Determining Parts-Whole Relationships).

3.1 Open Compare and Contrast

One way to counter making too narrow a comparison and/or contrast is to use brainstorming to identify as many different similarities and differences as we can. We then select those similarities and differences that are significant or relevant to our goals, explicitly drawing out their implications. We call this broad consideration of similarities and differences open compare and contrast. See figures 3 and 4.

3.2 Focused Compare and Contrast

There is a second way to compare and contrast that makes our search for similarities and differences more organized from the outset. We first determine the types of similarities and differences that we should consider in order to achieve our goal. These factors then guide our search for specific similarities and differences. When we have located information about these factors, we then draw conclusions about the two things compared. This is called focused compare and contrast.

3.3 Determining Parts-Whole Relationships

Everything around us is made up of parts. Man-made things, like automobiles and TV sets, depend for their functioning on the proper operation of their parts. Many natural objects, including the bodies of animals, the solar system, and great rivers, have parts that combine and operate together for the functioning of the whole. Recognizing how parts contribute to the whole and how each part functions can help us better understand the world around us. Knowing the function of parts can also contribute to our creativity. The common problems with the way we think about parts-whole relationships are as follows:

1. We define parts based only on their appearances. (Our characterization of parts is **hasty**.)
2. We don't think of subdividing parts into other parts. (Our consideration of parts is **narrow**.)
3. We don't connect parts together in relation to the whole that they comprise. (Our thinking about parts is **scattered**.)

Determining the relationship between parts and whole is a basic analytical thinking skill. In its most complete form, we strive to understand the basic parts of an object, an organism, a composition, or a system in terms of how the parts function together in the structure or operation of the whole. The key to understanding parts-whole relationships is understanding what the parts do in relation to the whole, not just their immediate appearance.

3.4 Collection of the data

The survey tool was used in the five sections anonymously. Students were not given any hint in advance. They were told not to write their names on the survey instruments to keep the survey as much as impartial as possible.

OPEN COMPARE AND CONTRAST

1. **How are they similar?**
2. **How are they different?**
3. **What similarities and differences seem significant?**
4. **What major categories, patterns or themes do you see in the significant similarities and differences?**
5. **What interpretation or conclusion is suggested by the significant similarities and differences?**

FOCUSED COMPARE AND CONTRAST

1. **What is the purpose of the comparison and contrast?**
2. **What kinds of similarities and differences are significant to the purpose of the comparison and contrast?**
3. **What similarities fall into these categories?**
4. **What differences fall into these categories?**
5. **What patterns of similarities and differences are revealed?**
6. **What conclusion or interpretation is suggested by the comparison and contrast that is significant to its purpose?**

DETERMINIG PARTS-WHOLE RELATIONSHIPS

1. **What smaller things make up the whole?**
2. **For each part, what would happen if it was missing?**
3. **What is the function of each part?**
4. **How do the parts work together to make the whole what it is or operate as it does?**

Figure 3: Thinking maps for open compare and contrast, focused compare and contrast and Determining Parts-Whole Relationships

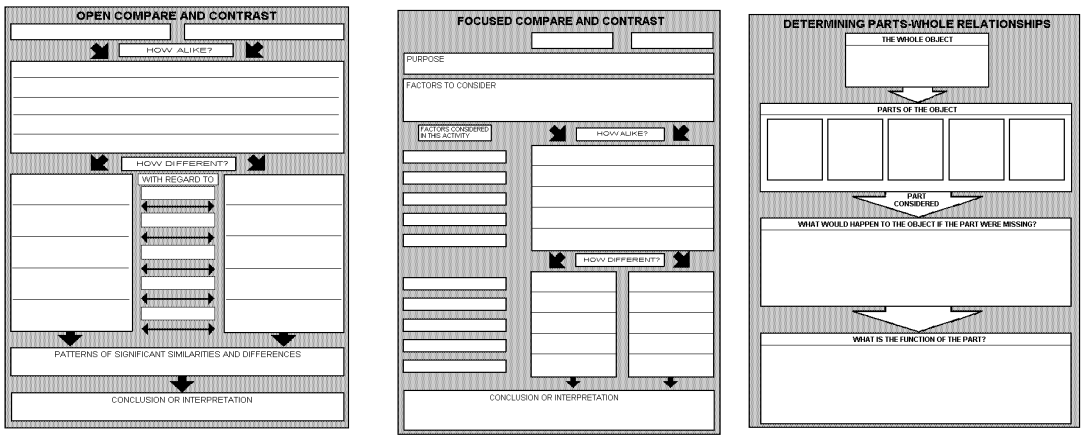

Figure 4: Graphic organizers for open compare and contrast, focused compare and contrast and Determining Parts-Whole Relationships

3.5 Data analysis

The data analysis has been done by one of the co-author who was not the part of the survey design team. He was suggested to be very impartial in data analysis. The co-author who conducted the survey and collected data was not allowed to discuss anything with the co-author who did the data analysis. To keep the process very honest one of the co-authors was

chosen from another college to supervise the whole process. The co-author who is involved in finalizing the results and summarizing the whole paper has no information about survey, data collection and data analysis.

4. Findings & Discussions

4.1 Students' Likings Survey of Different Critical and Creative Thinking Methods

To determine the students' opinions on different critical and creative thinking methods the following five questions were asked. The students' feedbacks with data analysis are as follows.

Question 1
Which thinking skill method do you like best? Number 1 (First), 2(Second) and 3(Third)?

Students' Responses:

Focused compare and contrast	Open compare and contrast	Determining Parts-whole relationship	Order
18	38	6	**First**
26	10	23	**Second**
15	13	28	**Third**

Table 1: The order of students' opinions on thinking skill methods.

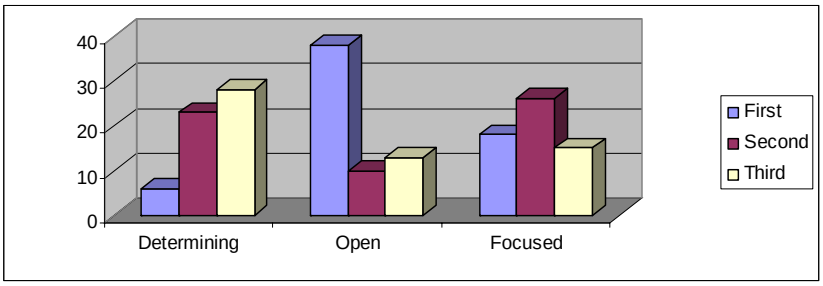

Figure 5: Graphical representation of the students' opinions on thinking skill methods.

Question 2
Which type of lesson do you like better? (i) Lesson without thinking skill and (ii) lesson with thinking skill.

Students' Responses:

Lesson with thinking skill	Lesson without thinking skill
61	13

Table 2: Students' opinions on infusion lessons.

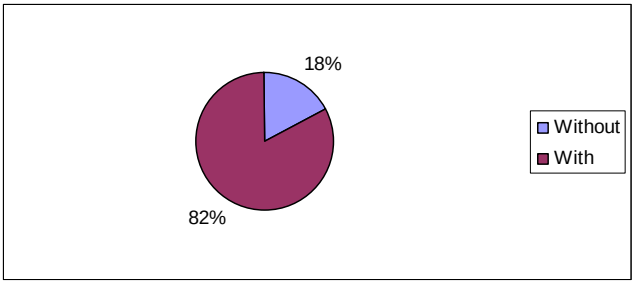

Figure 6: Graphical representation of students' opinions on infusion lessons.

Question 3
Which thinking skill have we learned so far?

Students' Responses:

Focused compare and contrast	Open compare and contrast	Determining Parts-whole relationship
10	15	8

Table 3: Students memory about thinking skill methods.

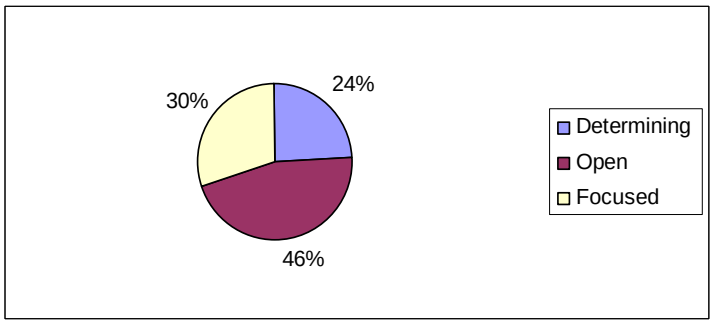

Figure 7: Graphical representation of students memory about thinking skill methods.

Question 4
Was using Graphic Organizer in all the thinking skills helpful to you?

Students' Responses:

No	Yes
4-	45

Table 4: Students' responses about using Graphic Organizer with thinking skill methods.

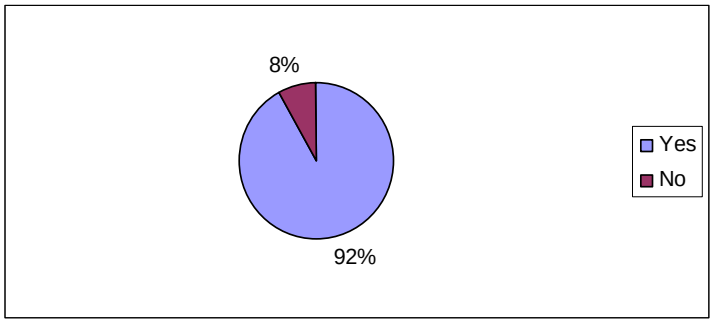

Figure 8: Graphical representation of students' responses about using Graphic Organizer.

Question 5
In the Think-Pair-Share activity, was writing out your statement beforehand important?

Students' Responses:

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No	Yes
1	43

Table 5: Students responses about writing out statement before Think-Pair-Share activity

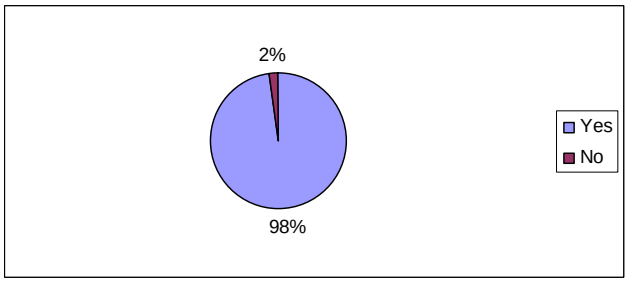

Figure 9: Graphical representation of responses on writing out statement before Think-Pair-Share activity.

4.2 Benefits of Infusion Lessons on Students' Classroom Learning

To find the benefits of infusion lessons on students' classroom learning the following sixteen questions were asked. These questions are built around six learning areas on which ICT curriculum contents are designed. These questions also take care of the conceptual framework for ICT literacy (See Figure 2. The students' feedbacks with data analysis are shown in Table 6. The graphical analysis is shown in Figure 10.

No	Yes	Benefits in the classroom:	
0	74	It improved my reasoning	A
1	72	It increased my creativity. Now I can handle new problems easily	B
2	71	I am clear about concepts in the lesson	C
7	67	It improved my participation in class	D
6	68	It increased my confidence level	E
8	68	Lesson helped me to improve my interaction in the class	F
14	60	Now I can work more properly in my group	G
10	64	My thinking vocabulary has increased	H
8	66	Lesson was more enjoyable	J
7	67	I can organize information better now (by learning Access)	K
7	67	I can solve problems (mathematical) easily (using Excel) now	L
6	68	ICT is helping me in solving day-to-day problems	M
8	66	I know basic fundamentals of ICT now	N
7	67	ICT is helping in my daily communication (Word and PowerPoint)	O
8	65	I can use ICT programs in Arabic also	P
10	64	I think ICT makes you honest because computer does not cheat.	Q

Table 6: Sixteen questions based on ICT conceptual framework & learning areas and students' responses.

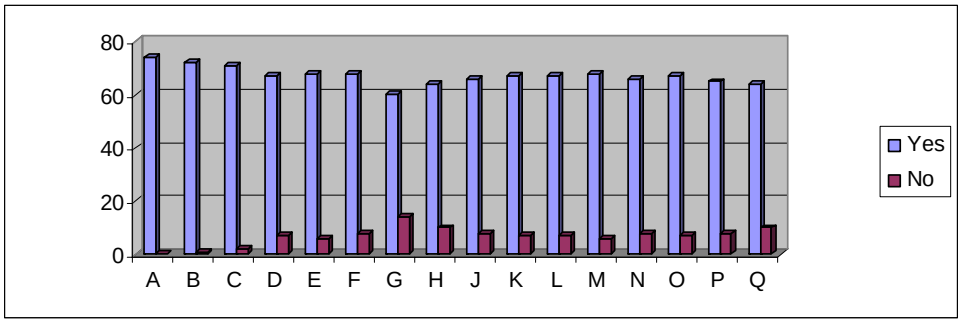

Figure 10: Graphical analysis of students' responses about ICT learning areas.

5. Conclusions

This research was undertaken in two phases. In the first phase students' initial responses towards the new methodology were observed and reported while in the second phase the comparison of learning outcomes will be evaluated. This paper deals with the first phase of our research. The next paper will address the evaluated outcomes.

Our research clearly shows that UGRU students are intelligent enough to evaluate new methods of classroom learning. They also appreciated and enjoyed infusion lessons with metacognition.

Students' responses in Tables l to 6 and Figures 5 to 10 are positive indicators of improvement in classroom learning process as well as homework and quizzes using learning skill methods. The initial outcomes of the survey on students' opinions on different critical and creative thinking methods and benefits of infusion lessons on students' classroom learning are very encouraging.

Infusing critical and creative thinking skills with metacognition in the ICT curriculum is one of the right steps towards educating students of higher education in the new Arab world. Some areas of the lesson plans may need improvement, but the current trend is one that will be consistent with guiding our students to become critical and creative thinkers, able to search out, understand, analyze, and synthesize the information they will need to become confident world citizens and world leaders.

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