A REVIEW OF DIFFERENCE TYPES OF THINKING IN FOSTERING STUDENT INTELLIGENCE

By :

Tajularipin Sulaiman, Norhasni Zainal Abiddin, Aminuddin Hassan,
Tan Huey Yee
Faculty of Educational Studies
Universiti Putra Malaysia
nonie@ace.upm.edu.my

ABSTRACT

This article discusses the usage of thinking in fostering student intelligence. The types of thinking and different theories on intelligence were discussed. The types of thinking which were discussed include critical thinking, analytical thinking, practical thinking, creative thinking, convergent thinking, divergent thinking, lateral thinking, and vertical thinking. Student's intelligence can be fostered by encouraging students to engage in different types of thinking. Ways to encourage students to use the different types of thinking which can help foster intelligence were also discussed in this article.

Keywords: analytical, convergent, creative, critical, divergent,

INTRODUCTION

Educators often stressed the importance of teaching students how to think and not simply present students with study materials and expect them to memorize every single bits of them (Ilyenkov, 2007). This is a well known slogan among the educators. However, what does it mean – to "think?" or What is "thinking"? This is not a simple question and has no clear cut answer to this question (Ilyenkov, 2007).

Thinking process can be defined in different ways (Halpern, 2003). From the point of view of a biologist or neuropsychologist, thinking is known as the activation of neurons in the brain. Other researchers define thinking as using words, images, and symbols consciously and unconsciously. While others define thinking as the flow and transformation of information through a series of stages (Halpern, 2003). According to Reisberg (2001, as cited in Halpern, 2003) a key point of thinking is that some internal representation (knowledge) are being manipulated and transformed in a symbolic way which can be used to solve problems and decision making.

One of the most controversial topics in psychology is "intelligence" (Halpern, 2003). Many psychologists still debate on what the term "intelligence" really means (Ceci, 1996, as cited in Halpern, 2003). The question on whether does learning or teaching one to think in a different way (eg. critically, analytically) made one more intelligent depends on how the term "intelligence" is being defined (Halpern, 2003).

Intelligence cannot be foster if intelligence is view as fixed quantity that can be measured by test items (Halpern, 2003). According to Halpern (2003) the believe that intelligence is static is incorrect and damaging. An individual is considered as intelligent than others if individual can learn to be a better thinker and are able to use the thinking skills acquires across different situations (Halpern, 2003). There are different views on intelligence and will be discussed briefly in this paper.

Gardner (1983, as cited in Sellars & Sanber, 2006) introduced multiple-intelligence theory which identified eight intelligences: logical-mathematical, linguistics (verbal), naturalist (observing and understanding natural and human-made

patterns and systems), spatial, musical, bodily kinesthetic (movement), interpersonal (understanding others), and intrapersonal (understanding self). Intelligence is seen as dynamic which can be fostered instead of being viewed as fixed entity (Gardner, 1983, as cited in Sellars & Sanber, 2006).

Sternberg and Grigorenko (2003) also viewed intelligence as multidimensional. Sternberg and Grigorenko (2007) introduced the theory of "Successful Intelligence" or which is also known as Triarchic Theory of Intelligence is composed of analytic, creative, and practical intelligences. Analytical intelligence consists of the ability to analyze, judge, evaluate, compare, and contrast. Creative intelligence consists of the ability to create, design, invent, originate, and imagine. Practical intelligence involves the ability to use, apply, implement, and put in practice (Sternberg & Grigorenko, 2007). Successful intelligence are a basis for both school and life achievement (Sternberg, 2002). Sternberg noted that there are very few tasks that are purely analytic, practical, or creative (Santrock, 2008). Most tasks require a combination of the skills. It is important for teachers to take note that teaching successful intelligence does not mean teaching everything three times (Sternberg, 2002). Instead, teachers need to balance their teaching whereby sometimes teach analytically, practically, or creatively. This gives students an opportunity to learn through analytical, practical, and creative thinking (Sternberg, 2002). Intelligence can be fostered using programs that are specifically designed (Sternberg & Grigorenko, 2007).

Cattell (1971, as cited in Lefrancois, 1993) differentiate between two kinds of intelligence: fluid intelligence and crystallized intelligence. Fluid intelligence (fluid abilities) are not learned and less affected by context. Fluid intelligences are reflected in the individual's ability to solve abstract problems and in measures of general reasoning, memory, attention span, and analysis of figures. Crystallized intelligence (crystallized abilities) are intellectual abilities that are mainly verbal and that are highly affected by culture, experience, and education. Crystallized intelligences are reflected in measures of vocabulary, general information, and mathematic skills. Fluid intelligence helps one to solve abstract and novel problems, while crystallized intelligence allows one to cope with one's life challenges (Gerrig & Zimbardo, 2008).

In order to help foster students' intelligence, intelligence should be seen as dynamic. By viewing intelligence as dynamic, students can be taught of using different types of thinking to foster their intelligence which makes them to be more intelligent. The following section will discuss on the different types of thinking and how we as teachers can encourage or teach students to use the different types of thinking by incorporating the activities in our teaching lesson which will help to foster students' intelligence.

Types of Thinking in Fostering Student Intelligence
Critical Thinking

The theory of critical thinking started off with the work of Bloom (1956, as cited in Duron, Limbach, & Waugh, 2006) who identified six levels within the cognitive domain where each of it is related to a different level of cognitive ability. The six levels are *Knowledge*, *Comprehension*, *Application*, *Analysis*, *Synthesis*, and *Evaluation*. *Knowledge*, *comprehension*, and *application* are considered as the lower level of thinking which requires less thinking skills while *analysis*, *synthesis*, and *evaluation* are considered as higher level of thinking which requires more thinking skills. *Knowledge* focused on remembering and reciting information. *Comprehension* focused on relating and organizing information which was learned previously. *Application* focused on applying information based on rule or principle in a specific

situation. *Analysis* defined as critical thinking which focused on parts and its function as a whole. *Synthesis* defined as critical thinking which focused on putting parts to form a new and original whole. *Evaluation* defined as critical thinking which focused on valuing and making judgments based on information. Critical thinking is likely to occur when students are required to perform in the *Analysis*, *Synthesis*, and *Evaluation* levels of Bloom's taxanomy.

According to Fischer and Spiker (2000, as cited in Halpern, 2003) the definition of critical thinking often include reasoning/logic, judgment, metacognition, reflection, questioning, and mental processes. Duron, Limbach, and Waugh (2006) stated that critical thinking is the ability to analyze and evaluate information. Halpern (2003) defined critical thinking as:

> *"the use of cognitive skills or strategies that increase the probability of a desirable outcome. It is used to describe thinking that is purposeful, reasoned, and goal-directed - the kind of thinking involved in solving problems, formulating inferences, calculating likelihoods, and making decisions, when the thinker is using skills that are thoughtful and effective for the particular context and type of thinking tasks."*

Critical thinking does not only consist of thinking about your own thinking or making judgments and solving problems but it is using skills and strategies which increase the likelihood of achieving "desirable outcomes" (Halpern, 2003). Critical thinking is always necessary in our daily life as well as in education setting. The most important part of critical thinking is the evaluation component. When one thinks critically, one is evaluating the outcomes of his or her thought processes such as how good a decision has been made or how well a problem has been solved. Sometimes, critical thinking is known as directed thinking because it emphasize on achieving a desired outcome (Halpern, 2003).

There are two types of thinkers: critical thinker and passive thinker (Duron, Limbach, & Waugh, 2006). Critical thinkers develop important questions and problems, formulate the questions clearly and explicitly, gather and assess relevant information, use abstract ideas, think open-mindedly, and communicate with others effectively. Passive thinkers, on the other hand, are often egocentric, answer questions with either yes or no and view their perspectives as the only one that make sense and only their facts are view as relevant (Duron, Limbach, & Waugh, 2006).

Santrock (2008) suggested few ways which teachers can use to incorporate critical thinking in their lesson plan. These include: (1) Ask students "how" and "why" instead of only asking "what"; (2) Argue in a reasoned way instead of using emotions; (3) Be aware that sometimes there is more than one explanation or answer; (4) Compare various answers to a question and judge which is the best answer; (5) Evaluate and question on what other think rather than instantly accept truth; and (6) Ask questions and consider beyond what is known to create new ideas and information.

Duron, Limbach, and Waugh (2006) suggested 5-step framework which can be implemented in any teaching or training setting to help students to learn critical thinking skills. The first step is to *determine learning objectives* that define what behaviours students should exhibit when the class end. The learning objectives need to be tied to the higher levels of Bloom's (1956, as cited in Duron, Limbach, & Waugh, 2006) taxanomy – *Analysis*, *Synthesis*, and *Evaluation*.

Second step is to *teach through questioning* (Duron, Limbach, & Waugh, 2006). The type of questions that are developed must be appropriate to accomplish an objective. Questioning techniques can be used to foster students thinking ability.

Questions can be categorized as convergent and divergent questions. Convergent questions search for only one or more specific correct answer, while divergent questions search for a wide variety of answers. Convergent questions used Bloom's lower levels of thinking while divergent questions use Bloom's higher levels of thinking. Divergent question encourage student discussion as well as critical thinking. According to Limbach and Waugh (2006) good questions is the key that encourage critical thinking.

Third step is to *practice before you assess* (Duron, Limbach, & Waugh, 2006). Teachers should choose activities that promote active learning. The three components of active learning are: *Information and Ideas, Experience,* and *Reflective Dialog. Information and Ideas* involve primary and secondary sources accessed in class, outside class, or online. *Experience* involves doing, observing, and simulations. *Reflective dialog* involve papers, portfolios, and journaling. The key idea of active learning is in-depth reflective dialog.

Fourth step include *review, refine, and improve* (Duron, Limbach, & Waugh, 2006). Teachers need to refine their courses to ensure that their teaching methods can help students to develop critical thinking skills. It is important to consider student feedback as this will also help teachers to improve their teaching methods and the course.

The final step is to *provide feedback and assessment of learning* (Duron, Limbach, & Waugh, 2006). Teacher should provide good feedback to their students. When providing feedback to students, teachers should be thoughtful and purposeful. The feedback that are given to students should be informational, agreed upon standards, specific and constructive, quantitative, prompt, frequent, positive, personal, and differential (Wlodkowski & Ginsberg, 1995, as cited Duron, Limbach, & Waugh, 2006).

The use of the 5-step framework to help students to learn critical thinking skills is not an easy task in which it requires a change in traditional lecture-based teaching methods. The initial change may lead to uncomfortable and unfamiliar to both teachers and students. However, the change will then lead to learning experiences which are both enjoyable and valuable for both teachers and students (Duron, Limbach, & Waugh, 2006).

Teachers can use the strategies suggested by Santrock (2008) and Duron, Limbach, and Waugh (2006) to encourage students to use critical thinking as this can help foster students intelligence. In addition, engaging students in activities such as collaborative learning (Gokhale, 1995), extensive writing assignments (Tsui, 2002), and have class discussion (Tsui, 2002) can also encourage students to use critical thinking.

Analytical Thinking

Analytical thinking which is also known as convergent thinking is often associated with academic intelligence (Sternberg, 1996, as cited in Uszynska-Jarmoc, 2005). Analytical thinking refers to the ability to process information at a faster rate, retrieve information from long-term memory, multi-tasking, and having good memorization skill (Uszynska-Jarmoc, 2005). Analytical thinking is used to examine, analyze, evaluate, judge, compare, and contrast (Uszynska-Jarmoc, 2005).

This type of thinking mainly refers to memorizing information (Uszynska-Jarmoc, 2005). This type of thinking helps individuals to solve problems which they encountered in different subjects. Students who prefer analytical thinking are excellent at performing tasks that require them to find differences and similarities,

analyzing and synthesising, evaluating and criticizing, searching for, explaining and then evaluating hypothesis (Uszynska-Jarmoc, 2005).

In order to teach students analytical thinking, teachers should teach analytically whereby provide students with task that require analyzing, critiquing, judging, comparing and contrasting, evaluating, and assessing (Sternberg & Grigorenko, 2003). For example in a science class, teacher can engage students in using analytical thinking by encouraging students to analyze data from an experiment, evaluate if the experiment test the hypothesis it is supposed to test, or ask students why the moon is not as bright as the sun (Sternberg & Grigorenko, 2007). By encouraging students to engage in analytical thinking, this can help foster students analytical intelligence as defined by Sternberg and Grigorenko (2007). In solving problems using analytical thinking, Sternberg and Grigorenko (2007) suggested that students should identify the problem, allocate the resources, represent and organize information, formulate a strategy, monitor problem-solving strategies, and evaluate the solution. According to Sternberg and Grigorenko (2003) teaching for critical thinking is similar to teaching analytical thinking.

Practical Thinking

Practical thinking is important in solving real world problems (Uszynska-Jarmoc, 2005). Real world problems are problems that are perceived as difficult situations that require finding necessary solutions as finding solutions is important to move on to another step. Practical thinking is required when dealing with everyday personal and practical problems. It may also involve when dealing with new and unusual situations in everyday life. Students who have often use practical thinking will often perform better in situations that require practical implication of the knowledge and abilities that they have obtained (Sternberg & Spear-Swearling, 2003, as cited in Uszynska-Jarmoc, 2005). It is important to take note that practical thinking is very important as real-life problems are inseparable in human daily life and solving such problems are necessary in human activity (Uszynska-Jarmoc, 2005). Practical thinking is used to apply, utilise, implement, and activate.

In order to engage students in practical thinking, teachers should teach practically whereby encourage students to apply, use, put into practice, implement, employ, and render practical what they know (Sternberg & Grigorenko, 2003). For example in Science class, teacher can have students to use what they have known about photosynthesis to discuss why plant life is important for the world's supply of oxygen (Sternberg & Grigorenko, 2007). Engaging students in the use of practical thinking will foster their practical intelligence. Practical intelligence can be taught to students by teaching students to use effective strategies for reading, writing, homework (Sternberg & Kaufman, 1998, as cited in Woolfolk, 2004). In addition, teachers can encourage students to engage in practical thinking by giving students some real life examples and have students to think about it.

Creative Thinking

According to Santrock (2008) creativity is the ability to think differently and coming up with a unique solutions for the problems. The aspect of creativity is its consequence (novelty and quality) and not the process that lead to consequence (Halpern, 2003). Creativity is not a single trait that people either have or do not have. Creative thinking involves cognitive processes that occur in a situation. The cognitive processes involve originality in one or more of the processes that can lead to creative outcomes – ways of identifying a problem, defining a problem, generating and

evaluating possible solutions, and judging how uniquely and how well the problem is solved (Halpern, 2003).

Students who can think creatively are able to solve tasks that require applying new concepts in a new context such as imagining things, discovering things, designing or creating new and original things (Uszynska-Jarmoc, 2005). Examples of creative thinking include having students to use their imagination to draw or write a story.

Creative thinking can be encouraged in a group or individual (Rickards, 1999, as cited in Santrock, 2008). One way to encourage creative thinking is brainstorming (Rickards, 1999, as cited in Santrock, 2008). This technique encouraged students to come up with creative ideas in a group and voice out anything that seems to be relevant to a particular situation. During brainstorming, students are asked not to criticize any ideas which are given until the end of brainstorming session.

Creative thinking can be encouraged by providing environments that stimulate creativity in which the classroom environment accepts and reinforces new ideas (Runco, 2006, as cited in Santrock, 2008). Teachers who encourage creativity often rely on student's curiosity. Students were given exercises and activities which can help stimulate them to find insightful solutions for problems rather than asking a lot of questions that are only based on memorization. Teachers should not over control students (Amabile, 1993, as cited in Santrock, 2008). Teachers should avoid telling students exactly what to do as this can make them feel that originality is a mistake. Students should be given the freedom to select their interest and teacher support them. Students who are under rigid surveillance, their creative thinking can be diminished. Teachers can also guide their students to help them think in flexible ways (Santrock, 2008). Students who can think creatively often approach problems in many different ways.

By encouraging students to use creative thinking, this can help foster students creative intelligence. Sternberg and Grigorenko (2007) noted that full creativity require a balance between analytical, practical, and creativity thinking. In order to engage students in creative thinking, teachers should teach creatively whereby encourage students to engage in task that requires students to create, invent, discover, imagine if, suppose that, and predict (Sternberg & Grigorenko, 2003). In order to teach students to engage in creative thinking, there are many programs developed to train people to be creative (Halpern, 2003). However, according to Halpern (2003) the training programs often share common principles. In addition, students can be encouraged to engage in visual thinking to improve their creative thinking (Halpern, 2003).

Many teachers are not sure on how to encourage creativity among their students (Sternberg & Grigorenko, 2007). Sternberg and Grigorenko (2007) suggested few ways to teach student to think creatively which include: engage students in redefining problems, question and analyze assumptions, generate ideas, and tolerate ambiguity. In class, teacher can help encourage student's creative thinking by having students to choose their own topics for presentations or papers (Sternberg & Grigorenko, 2007). Teachers can also engage students in activities which require them to persuade others in accepting their ideas. This is one practical aspects of creative thinking (Sternberg & Grigorenko, 2007).

Convergent and Divergent Thinking

Convergent thinking aim of producing one correct answer to a clearly defined question (Cropley, 2006). Convergent thinking often generates orthodox (Cropley,

1999, as cited in Cropley, 2006). It stressed on speed, accuracy, and logic. It focused on recognizing familiar, reapplying set techniques, and accumulating information (Cropley, 2006). Thus, it is suitable in situation where there is one exact answer and requires individuals to recall what has been learned. The key point of convergent thinking is that it leads to a single accurate answer and there is no doubt. Answers are either right or wrong and are always linked to knowledge. Sometimes it involves manipulation of knowledge one has based on standard procedures while sometimes its main purpose is to increase knowledge.

On the other hand, divergent thinking is thinking that aims to produce many possible answers to the same questions (Cropley, 2006). Divergent thinking often generates variability (Cropley, 1999, as cited in Cropley, 2006). It focused on recognizing unfamiliar, making unexpected combinations, transforming information that is known into unexpected forms (Cropley, 2006). The key point of divergent thinking is that answers to the same questions may differ slightly from person to person. The answers may be new, novel, or unexpected.

Convergent and divergent thinking is often seen as conflicting or competing processes (Getzels & Jackson, 1962, as cited in Cropley, 2006). Convergent thinking was sometimes seen as bad and is often exaggerated as evil in education (Cropley, 1967, as cited in Cropley, 2006). Creativity is often equated with divergent thinking (Getzels & Jackson, 1962, as cited in Cropley, 2006). However, in recent years, there has been awareness that creativity does not only derive from divergent thinking but also requires convergent thinking (Brophy, 1998, as cited in Cropley, 2006).

In contrast to what is often believe, both divergent and convergent thinking lead to production of ideas (Cropley, 2006). Convergent thinking often generates orthodox while divergent thinking often generates variability (Cropley, 1999, as cited in Cropley, 2006). This seems to confirm that divergent thinking is synonymous with creativity. The divergent thinking that was examined by Guilford (1959, as cited in Cropley, 2006) includes sensitivity to problems, word fluency, ideational fluency, semantic flexibility, associational fluency, and originality. However, it is important to take note that the production of variability based on fluency, flexibility, and originality does not determine creativity. Variability may cause surprise to individuals but may be insufficient because surprise may be developed based on unregulated self-expression or by doing things differently from the usual without taking into consideration of accuracy, meaning, sense, significance, or interest. Thus, it is crucial to differentiate between mere novelty and novelty that can be label as "creativity."

According to Cattell and Butcher (1968, 271, as cited in Cropley, 2006) the novelty which was developed based on nonconformity, lack of discipline, and blindly rejecting what already exist is known as "pseudocreativity." An example of pseudocreativity is novelty that is generated in daydreams. Creativity is not based on surprise that stray away from usual but instead is called as "effective surprise" which was introduced by Bruner (1962, p.3, as cited in Cropley, 2006).

In developing effective novelty, Finke, Ward, and Smith (1992, as cited in Cropley, 2006) differentiate between two broad processes which is generating novelty and exploring novelty when it is being generated. Generating novelty does not necessarily lead to creativity but may lead to pseudocreativity (Cropley, 2006). Thus, converting novelty into effective novelty (eg. creativity) requires both generation (via divergent thinking) and also exploration (via convergent thinking). Generating novelty via divergent thinking involve few processes such as linking, transforming, reinterpreting, and branching out. Exploring novelty via convergent thinking involve

avoiding risk, being certain, staying within limits, seeking simplicity, and assessing technical and financial feasibility (Cropley, 2006).

Divergent and convergent thinking works together to produce effective novelty (Cropley, 2006). The basic explanation of the joint roles of convergent and divergent thinking in developing effective novelty is based on the assumption that convergent thinking is a prerequisite for effective divergent thinking. Creativity requires both divergent and convergent thinking. Thus, it is important that one engage in both divergent and convergent thinking when one is thinking creatively. This implies that in order to foster student creative intelligence, student's needs to engage in both divergent and convergent thinking.

In order to encourage students to use convergent thinking, teachers can present students with the necessary study materials. Teacher need to encourage their students to be logical. Teachers can encourage students to engage in divergent thinking through giving student an essay topic and have students to discuss by giving as many ideas as possible. In addition, by having students to freely discuss on a topic by giving ideas or point of views can help encourage divergent thinking.

Lateral and Vertical Thinking

According to DeBono (1977, p. 195, as cited in Halpern, 2008), "vertical thinking is concerned with digging the same hole deeper. Lateral thinking is concerned with digging the hole somewhere else." DeBono (1968, as cited in Halpern, 2003) distinguished between lateral and vertical thinking.

Lateral thinking is a way of thinking "around" a problem (DeBono, 1968, as cited in Halpern, 2003). Lateral thinking generates ideas and is sometimes used as a synonym for creative thinking or discovering ideas (Halpern, 2003). It promotes the development of unconventional new ideas (DeBono, 1967, as cited in Lazarova-Molar, 2008). Ambiguity or uncertainty can be tolerated and it is not restricted by relevant information (Lazarova-Molar, 2008). Irrelevant information can be considered as it might potentially lead to producing new ideas. Lateral thinking can be in multidirectional and does not necessarily be in sequence. It is unnecessary to have correct idea at every step. Lateral thinking is based on the idea of richness whereby having many ideas is similar to having good ideas or coming up with many solutions to a problem. The goal is to explore as many possible answers and have subjects to think out of the box. Sometimes what is seen as failure can lead to a very good solution to a given problem (Lazarova-Molar, 2008).

On the other hand, vertical thinking is a careful, logical, straightforward way of thinking (DeBono, 1968, as cited in Halpern, 2003). Ideas are generated based on a set of standards or methods. Vertical thinking is known as the refinement or improvement of the existing idea (DeBono, 1967, as cited in Lazarova-Molar, 2008). Ambiguity or uncertainty cannot be tolerated and is restricted by relevant information. Information that is irrelevant cannot be considered. Vertical thinking proceeds in a sequence and only proceeds when there is a direction. Vertical thinking is based on the rightness of information, whereby every information that is presented need to be correct (DeBono, 1967, as cited in Lazarova-Molar, 2008).

School teachers need to encourage students to use lateral thinking at the same intensity as using vertical thinking (Lazarova-Molar, 2008). There are few ways that teacher can use to encourage students to use lateral thinking. Teachers should have looser problem definition. By having too restrictive problem definitions will inhibit student's creative thinking. Student should not be taught that there is always only one correct answer. The attitude of believing that there is always only one correct answer

will also inhibit student's creative potential. Students should be encouraged to look for many answers using different ways. Students should also be allowed to make mistakes in the intermediate steps. By making mistakes, it is seen as distractions that may help to further the thinking process (Lazarova-Molar, 2008).

By having students to engage in lateral and vertical thinking, this can help foster student's intelligence such as in analytical or creative intelligence. Vertical thinking is considered as associated with analytical intelligence or academic intelligence because in vertical thinking, information that is presented must be either correct or incorrect. On the other hand, lateral thinking is considered as associated with creative intelligence.

CONCLUSION

A brief discussion on thinking and the different theories on intelligence were discussed. The types of thinking which were discussed above include critical thinking, analytical thinking, practical thinking, creative thinking, convergent thinking, divergent thinking, lateral thinking, and vertical thinking. Student's intelligence can be fostered by encouraging students to engage in different types of thinking. Ways to encourage students to use the different types of thinking which can help foster intelligence were discussed.

From the discussion above, analytical thinking is sometimes known as critical thinking and convergent thinking. As according to Sternberg and Grigorenko (2003), teaching analytical thinking is similar to teaching critical thinking. Teaching students to use analytical thinking can help foster students' analytical intelligence. Teaching students to use practical thinking can help foster students' practical intelligence while teaching students to use creative thinking can help foster students' creative intelligence. Analytical, practical, and creative thinking makes up the theory of "Successful Intelligence" as described by Sternberg and Grigorenko (2003). It is important to take note that teacher can teach analytically, practically, and creatively in any subject matter. Convergent and divergent thinking were found to be important for creative intelligence as creativity requires the use of both convergent and divergent thinking. Lateral thinking is seen as important in analytical intelligence while vertical thinking is seen as important in creative intelligence. Thus, it is important to teach students to use different types of thinking as it can help foster students intelligence.

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