The Relationship between Cognitive Development, Teaching Creative Thinking, Assessment, and an Interdisciplinary Approach

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Abstract

Cognitive development is widely considered to be one of the most important aspects of students' learning. It relates to the identification of patterns, relationships, and the use of language. It concerns with the affective development, which is related to the emotions and the psychomotor development - the movement and activities that are associated with the mental process. One of the main issues is the challenges teachers face to address these categories in a specific topic. The standardized assessment tests such as Trends in International Math and Science Study TIMSS and the Program for International Student PISA have three main categories: knowledge, application and reasoning. It is interesting, and important to note, that learning has similar categories: knowledge, skills, and understanding. Considerable attention must be paid in aligning the learning domains to the assessment domains in order to raise students' attainment in the standardized assessments. In order to achieve these results, it is important to understand the kind of knowledge being learned, how memory works, how best to teach for creativity, and how people learn. Interdisciplinary Science, Technology, Engineering and Math STEM is a new reform in education which helps to develop students' 21st century skills and creative thinking. A new framework is being proposed, to develop students' skills through teaching them an interdisciplinary STEM curriculum using authentic tasks (problem-based learning) that leads them to higher-order thinking skills. This paper is presenting a critical reflection on cognitive development, teaching creativity, assessment types, and an interdisciplinary STEM approach, and the relationship between them.

Keywords: Cognitive Development, Assessment, Creativity, Interdisciplinary STEM

1. Introduction

To expect all the children of the same age to learn from the same curriculum is like expecting that all the children wear the same size of clothes. Students are different in the way they learn. They are kinesthetic, visual, auditory and tactile learners. Educators should know: how information is best perceived; the type of information preferred; how learners organize the information; how information is processed; and the progress of learners' understanding (Reiser & Dempsey, 2007). Differentiating the curriculum to suit all the learning styles is the main point to meet students' needs. In addition, to understand the way of teaching, which should be rich with different tasks and authentic activities. This paper critically reflects on the relationship between the theories of cognitive development, teaching creative thinking, assessment, and an interdisciplinary STEM approach that leads to higher-order thinking skills. A clear gap has occurred in schools between the way students are assessed and the way they learn. It was argued by Drake and Reid (2017) that the assessments are not aligned to the way students learn in the classrooms. Long et al. (2011) classified learning into three categories: knowledge, skills, and understanding, while assessment domains are classified as: knowledge, application, and reasoning. Accordingly, understanding the connection between learning and assessment by using the memory process will be discussed in order to understand how to fill the gap which has occurred. It is important to note that the standardized assessments such as TIMSS and PISA are designed according to the cognitive domains: knowledge, application, and reasoning. In addition, TIMSS and PISA focus on applying skills in real-life applications. Teachers in schools feel the tension between developing students' creativity and preparing them to perform well in the standardized assessments (Beghetto, 2015). STEM education has been taken as an example to explain how students can acquire the 21st century skills and how creativity has been integrated into the learning process. A conceptual framework has been developed to explain how students develop their cognitive and metacognitive thinking (ElSayary, Forawi & Mansour, 2015). The STEM education has been reinforced recently in the United Arab Emirates. The ADEC (Abu Dhabi Department of

Education and Knowledge) aims to develop 21st century skills including creative thinking skills through introducing a new department of STEM education (AlQubaisi, 2014). A significant problem has arisen which is the tension teachers feel between facilitating meaningful and effective learning and the accountability of international assessments that force them to teach toward tests (Heddy & Pugh, 2015). The focus on internal and international assessments reduces the amount of time available for integrating infusion within teaching and learning (Heddy & Pugh, 2015). In addition, assessments set a challenge for teachers where the great focus was on the nature of the integrated knowledge and less focus given to the way students are assessed (Drake & Reid, 2017).

2. Cognitive Development

Learning is the ability to think differently in solving real-life problems and scenarios. It allows learners to control the environment through anticipating the outcomes (Long, Wood, Littleton, Passenger & Sheehy, 2011). Thus, it is the process of constructing new knowledge based on the prior knowledge (Wiggins & McTighe, 2005). The most classical and widely used way of thinking is Bloom's taxonomy. Bloom (1956) classified learning objectives to cover the three major domains: cognitive, affective and psychomotor development. The cognitive development relates to the recognition of patterns and the use of language. The affective development is related to the emotions. Finally, the psychomotor development covers the movement and activities that are associated with the mental process (Orr, 1992). The aim of this taxonomy is that the teachers address these categories in the specific topic they teach. In actual fact, it is too challenging to include the full range of learning domains in planning and teaching each lesson (Long et al., 2011). There is a common approach to combine these categories of Bloom's taxonomy to just have three main headings that address the use of knowledge, solving problems and the ability to use and transfer what students have learned in new situations.

According to Long, Wood and Littleton (2011), the main three categories of learning are knowledge, skills and understanding. The knowledge is the recalling of prior information and recognition of specific patterns. The skills are the ability to use knowledge and integrate information to produce meaningful tasks. The understanding is to solve problems and transfer what they have learned into new situations. Figure 1 below shows the three learning categories.

Learning Categories

Knowledge
• recognition of information

Skills
• ability to integrate knowledge to carry out meaningful task.

Understanding
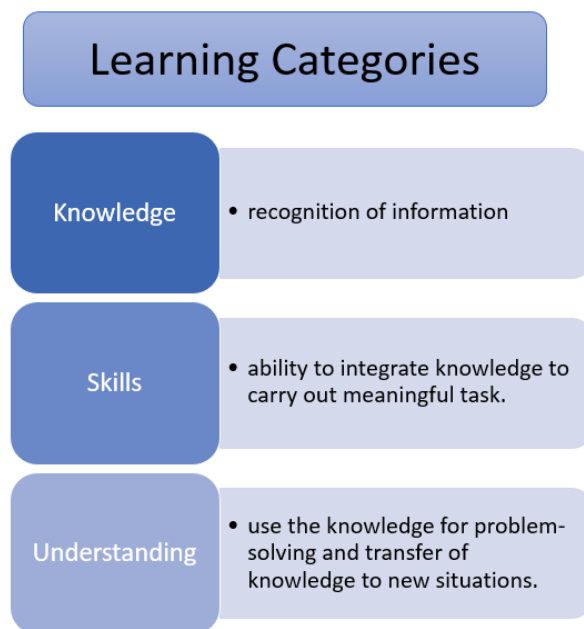• use the knowledge for problem-solving and transfer of knowledge to new situations.

Figure (1): The classification of the learning categories

There are three important elements involved in the teaching-learning process: teacher, student and assessed outcomes. The assessed outcomes help students to improve their learning and fill the gap that has occurred. In addition, they help the teacher to modify their instructions for the students. It is a cycle of teacher-student feedback, which lies in planning assessment and instructions in alignment. Biggs (1996) presented the constructive alignment

theory that lies in aligning between curriculum, assessment and instructions. Bass (2014) supports the constructive alignment where the assessment tasks used should focus on the social and cognitive pedagogies that engage learners in procedural learning. As a result, the amount of time students spend in the schools learning in a meaningful environment makes a good opportunity for them to foster and nurture creativity. In addition, the assessment tasks should allow students to use integrated knowledge to solve real-world problems and use higher-order cognitive processes that provide challenge, interest and motivation (Meyers & Nulty, 2009).

The cognitive approach in psychology has been seen as a processor where the input of information passes through a program to produce an output (Long, Wood & Littleton, 2011). The cognitive processes develop the mental representations of knowledge. The mental process is represented through connecting the ideas, facts and information through functioning as it is using skills, process and strategies. This connection moves the brains of learners from the understanding of information to the ability to use that information. Understanding the information of facts and ideas is called declarative knowledge, while the ability to use the information through strategies or process is known as procedural knowledge. Figure 2 below shows the relation between the two types of knowledge.
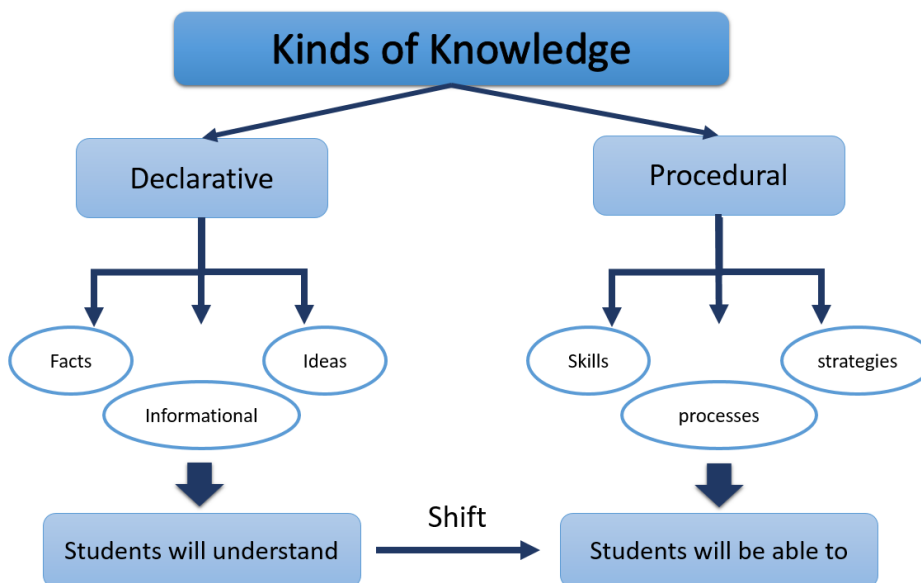

Figure (2): The relation between the two types of knowledge

The primary purpose of memory is the storage of information, which is considered to be the input. It passes through processes in order to be used and reproduced. The study of memory is important to education in terms of understanding the process of losing or forgetting information. The information (input) passes through three different stages. The first stage for the information is called the short-term memory where the information is stored for a short time. The information might be lost if it does not go through rehearsals in the working memory stage. The working memory is the active process of short-term memory that allows us to generate the information in a visual, auditory and spatial way. This brings in the role of differentiating the instructions for the students. The working memory allows the learner to use two things together if one thing needs more attention than the other. Furthermore, it is possible to do two things together if they are in different models, such as to do visual and auditory tasks simultaneously. However, if the two models are the same, such as two visual tasks or two auditory tasks, it will lead to interference and confusion. The short-term memory and working memory are close to thinking and may last for only a few seconds. The long-term memory is the main storage of information, and it lasts for a long time: days, weeks or years. The main characteristics of the long-term memory are that it can be of a lifetime's duration, has a very large capacity, has mainly semantic coding, and information can be lost through interference. Figure 3 summarizes the structure of memory.
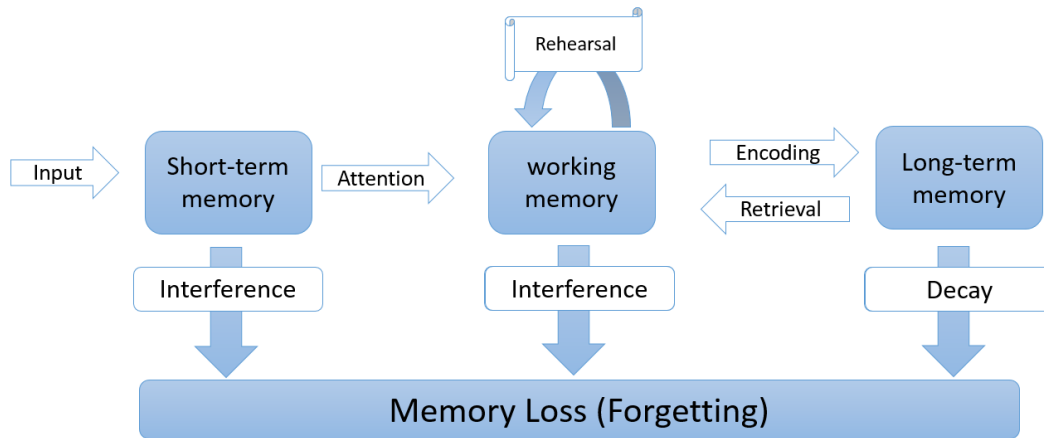
Figure (3): The structure of the memory and how the information is transferred from one stage to another until it reaches the long-term memory

The forgetting is the failure to register information to the long-term memory, which is called "fail to learn". Without encoding and rehearsals that are involved throughout the process of the working memory, learning will not progress and develop. The short-term memory and the working memory might lose knowledge to memory loss when failing to learn or finding difficulties in separating information, which is known as the interference theory. The process of the working memory requires the interpretation and the use of existing schemas (knowledge and ideas). This is based on the Piagetian theory about the schemas which is the mental patterns that guide behaviour. It involves the demonstrating of patterns with young children and develops to involve a more complex sequence of expectations and actions with older children and adults.

3. Teaching Creative Thinking

Creativity is to think outside the box. It is the interaction between the field, domain and individuals (Csikszentmihalyi, 1999). Creativity is a cognitive ability that should be developed across one's lifespan. Sternberg (2006) stated that creativity requires the combination of interconnected elements: knowledge, cognitive abilities, ways of thinking, personality and motivation. The operation of creativity starts by thinking of knowledge or information, where the working memory influences the ability to think divergently (thinking about many solutions) and convergently (focus on one way) in solving problems. It includes reasoning, inferences, and decision making where people select one alternative from many outcomes. There is an argument that teachers discourage creativity, hence that divergent thinking and independence occur with the convergent thinking (Torrance, 1963). Teachers should work on guiding students through the learning process and leave the learning outcomes open-ended, to accommodate and expect the unexpected and unique products that encourage creativity (Cheng, 2015; Earl, 2013). It is highly recommended that teachers should attend professional development programmes about how to integrate creativity and reflection in their teaching practices.

Creativity became a goal for curricular reform. There are different approaches to the teaching of thinking. These are the teaching *of* thinking, teaching *for* thinking, and infusion. The teaching *of* thinking is the direct instruction given in a non-curricular context. The teaching *for* thinking is the use of different methods that allow thinking in the curricular context. Infusion is the restructuring of a content for a direct instruction of thinking. It is the integration of teaching *of* thinking and *for* thinking. In addition, it improves students' thinking skills and enhances content learning. The figure below shows the ways of thinking.

Approaches to Teaching Thinking

Teaching of thinking

Direct instruction in thinking in non-curricular contexts.

Teaching for thinking

Use of methods which promote thinking in curricular contexts.

Infusion

Restructuring content lessons for direct instruction in thinking.

INFUSION integrates direct instruction in specific thinking skills into content area lessons. Lessons improve student thinking and enhance content learning.
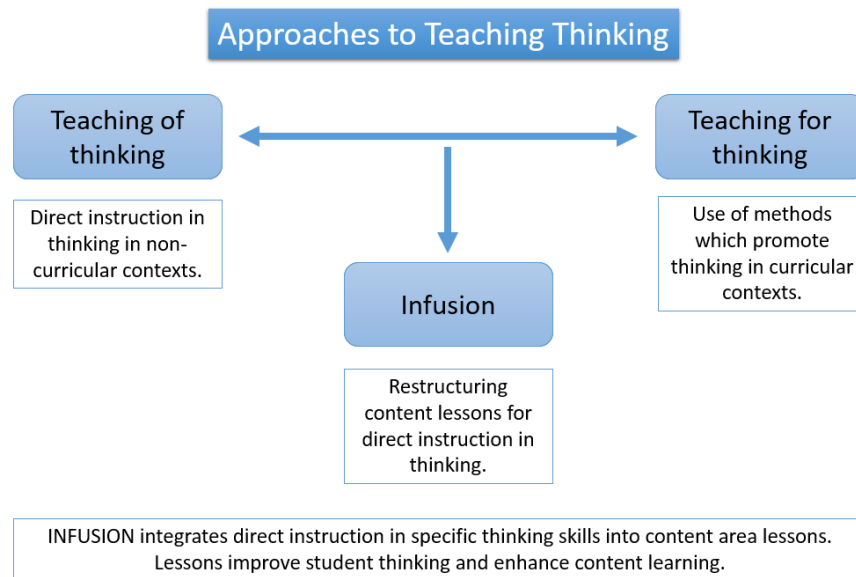
Figure (4): The approaches to teaching thinking (Source: Critical Thinking Books & Software, 1998)

There are different strategies that can be used to foster the infusion method, which are: scientific method, discovery learning, collaborative learning, interdisciplinary approach, problem solving, guided inquiry and constructivism. A review carried out of the research on infusion approach in teaching thinking states the advantages and importance of integrating an infusion approach within teaching and learning processes (Zulkpli, Abdullah, Abdul Kohar & Ibrahim, 2017). The authors stated that the essential elements to make teaching skills more effective are through focusing on dispositions, knowledge and skills (Zulkpli et al., 2017). Lin's (2014) study reported that the infusion approach gives positive feedback in teaching and learning as well as helping teachers to integrate critical thinking and creativity skills in classrooms. Another study (Zohar, 2013) mentioned that the use of infusion approach aimed to foster students' thinking.

Kaufman and Beghetto (2009) propose a framework of creativity that is called the "4C model of creativity" which enables individuals to understand the scale used to measure creativity. The categories of creativity were designed to be: Mini-c, Little-c, Pro-c, and Big-C (Kaufman & Beghetto, 2009). The Mini-c level was created by Kaufman and Beghetto (2009) as the simplest form of complexity toward the creativity. It is inherent in the learning process, which is known as transformative learning and focuses on the personal and developmental aspects of creativity (Runco, 1996; Vygotsky, 1967). The advantage of the Mini-c is that it sparks the importance of the innovative interpretations of individuals' actions and experiences as it helps in assessing, monitoring and developing creativity (Wang & Greenwood, 2013). This level of creativity is in alignment with the Vygotskian conception of cognitive and creative development of learners, in which they use their working memory in organizing and transforming information using their existing knowledge (Kaufman & Beghetto, 2009). The next level is Little-c creativity that occurs during everyday activities where the non-experts may participate in doing creative actions. Students who learn new concepts, make a new metaphor, or scored high in the Torrance test are considered to be in the Little-c level of creativity (Kaufman and Beghetto, 2009). It has a positive impact on individuals and their zone of influence. The Pro-c level is known as the professional expert creativity where it is a progression beyond the Little-c but less than the Big-C (Kaufman & Beghetto, 2009). It is the level of attaining professional experience in a certain field where it is the acquisition approach of creativity (Ericsson, 1996; Ericsson, Roring & Nandagopal, 2007). Finally is the Big-C level which is known as creative genius that involves winners of prestigious awards or people included in an encyclopedia (Kaufman & Beghetto, 2009). So the first level of creativity is the Mini-c that is followed by the Little-c. From the Little-c, there are two transitions: first is informal preparation to the pro-c level; second ends by reflection. The pro-c has two main paths: the first one is the people who remain creative in their professional lives. The second path is developing their creativity to reach the highest level (Big-C) (Kaufman & Beghetto, 2009). The figure below represents the relation between the levels of creativity.
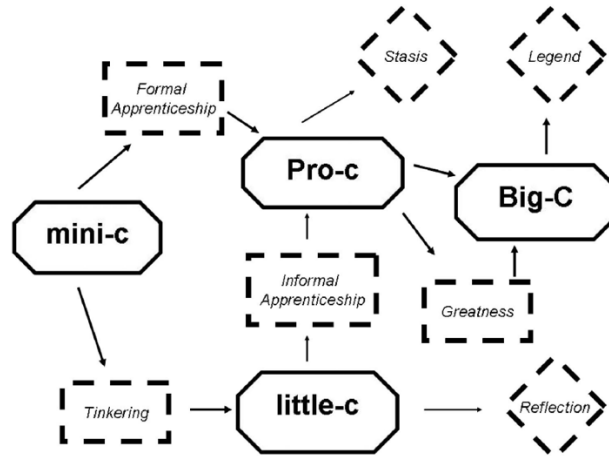
Figure (2): The 4C model of creativity (Kaufman & Beghetto, 2009)

4. Assessment

There is no teaching without assessment. Planning for instructions also means planning for assessment in order to improve the quality of teaching and learning (Wiggins, 1990). There are three main types of assessment: assessment *of* learning; assessment *for* learning; and assessment *as* learning (Earl, 2013). Assessment of learning is the formal assessment or evaluation which is used to judge students' learning and performance, which is called summative assessment. On the other hand, the summative assessment can be used also to improve the quality of future learning. The key assessor of this type of assessment is the teacher and the reference points are the students (Earl, 2013). Assessment for learning is the informal forms of assessment that involve a dialogue between the teacher and the students and is called formative assessment. It guides the teacher to modify instructions for students to learn as well as informing students how they go about learning. Types of formative assessment are considered to foster students' metacognitive skills where they are able to evaluate their work, reflect, write reports, maintain portfolios, and make presentations (Tan et al., 2014). The key assessor in this type of assessment is the teacher and the reference points are the students (Earl, 2013). Finally, the assessment as learning, which is called authentic assessment, allows students to have several checking points to reflect on and improve their work (Barnett & Ceci, 2005). The key assessor in this assessment is the student and the reference points are their personal goals and external standards (Earl, 2013). Litchfield and Dempsey (2015) proposed the shift in time allocation from the traditional way of formative assessment to involve several authentic tasks where students have the opportunity to reflect upon their work. Earl (2013) shifted the focus from the summative assessment to the authentic assessment, as shown in the figure below.
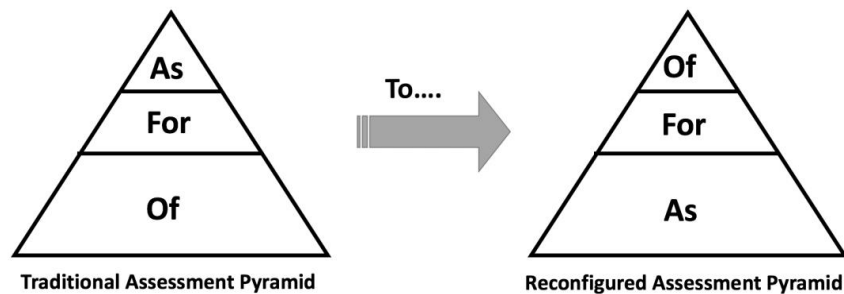

Figure (7): Shifting the balance from traditional assessment model to reconfigured assessment model (Earl, 2013)

Gettings (2017) pointed out that the assessment as learning helps in transforming students' habits of mind

and changes their perceptions of viewing the world. This is because students are engaged in real-world problems that require the use of integrated knowledge and allow them to envision divergent possible solutions, observe and reflect during the work process, and be open to new suggestions and opinions. Almqvist, Vinage, Vakeva and Zanden (2017) reported that the main purpose of assessment as learning is sustainability. Most assessments in the schools imply to state one single answer for a problem. This is known as convergent thinking, which is to focus on one solution to solve a problem. It is essential to assess students' ability in finding several solutions to the same problem. This is called divergent thinking and requires high interactions from students to inquire, brainstorm and reason to find alternative solutions for a problem. These actions are done in the working memory where the students use and apply their skills in the new information to find solutions and then these travel to stay in the long-term memory where there are dispositions of skills they have acquired.

5. Interdisciplinary STEM Approach

One of the most essential reforms in education is implementing STEM (science, technology, engineering and math) education into schools. Corpley (2015) mentioned three elements that enhance creativity in STEM education. First, students should learn an integrated curriculum in order to solve complex problems. Second, students should be motivated and encouraged when engaged in creative tasks. Third, students who complete or produce creative products should be rewarded. Sternberg (2015) stated similar strategies that are used to drive the development of students' cognitive, collaborative and content learning. They should: be involved in open-ended projects; ask questions and analyse assumptions; generate ideas and work collaboratively with others; be motivated intrinsically and extrinsically; be able to use information from different subjects; be involved in challenging tasks; assess risk and judge whether the risk is acceptable; think deeply over an ill-structured problem; use creativity as an assessable component of their project; do a project based on their interests in order to find their desired field; be pushed to the extent of their ability; and be assessed authentically according to their abilities (Sternberg, 2015). Furthermore, it was emphasized in a previous research into STEM education that it fosters students' 21st century skills as it cut across three types of learning: the cognitive, collaborative and content learning (Hewlett Foundation, 2010). In each type of learning, the students acquire some of the skills by learning through the problem-based learning approach. To draw logical inferences connecting creativity skills, the problem-based learning approach and STEM education, a strong relation between them has been noticed (ElSayary, Forawi, and Mansour, 2015). Learning STEM through the problem-based learning approach fosters creativity and improves students' 21st century skills. This is due to the three types of learning that the students pass through in order to reach their goals and produce outcomes. Students develop certain skills within each type of learning, as mentioned in the figure below. The figure shows the conceptual framework that has been developed to develop students' 21st century skills and enable them to reach the higher-order thinking.
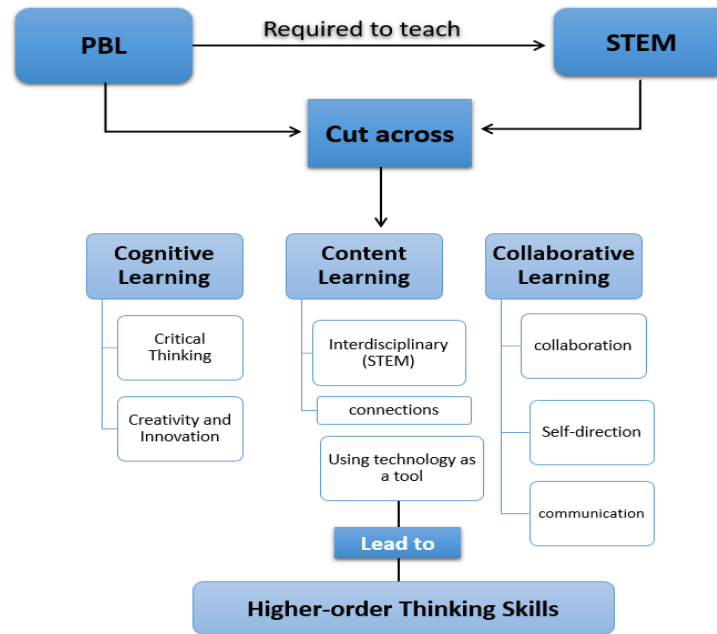
Figure (5): A conceptual framework that shows the three types of learning that cut across PBL

6. The Relationship: Cognitive Development, Assessment and Interdisciplinary STEM

Learning is the core of education and involves changes in learners' knowledge, skills and understanding. Memory is the storage of information through processes managed by the brain. It includes short-term memory and working memory that have a limited capacity of storing information and a limited timeframe also. The long-term memory has the largest capacity to store information for a long time. The short-term and working memory sometimes cause forgetting, when interference occurs. The memory is considered to be the connection between the learning and the assessment, where the learners do the rehearsals of information in the working memory to move it to the long-term memory, then it can be retrieved again while assessing students' skills and knowledge.

By contrasting these learning categories with the assessment categories in the standardized assessments of TIMSS and PISA, which are knowledge, application and reasoning, we find that they are serving each other. This could be the reason behind the gap found between the learning and assessment of learners. The standardized assessments assess the students' abilities and skills that are not developed during the learning process. The **knowledge** in assessment assesses the recalling and recognition of the learners' knowledge. The **application** in assessment is to use the skills they acquired during the learning process to apply them in solving problems. Finally, the **reasoning** category in assessment is to assess the students' understanding of the concepts by reflecting on their learning and relate what they have learned into new situations. The figure below shows the relation between learning categories and assessment categories.
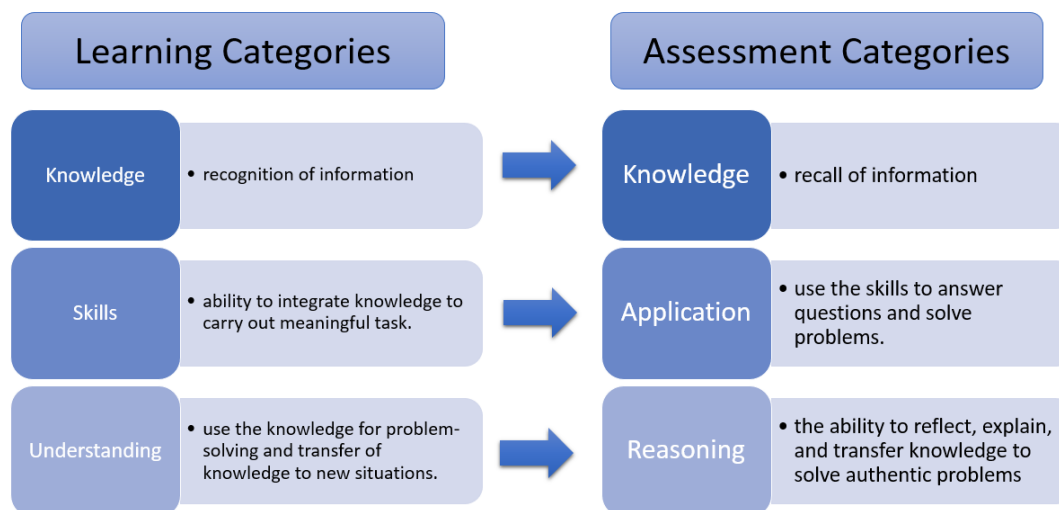
Figure (6): The relation between the learning categories and assessment categories

The improvement of learning and memory occurs when improving the plan and structure of knowledge is carried out. It is important not to ignore the significance of understanding the knowledge, that is set as the most effective form of learning. By applying these ideas to education, teachers and educators in their classrooms should be the "guide on the side instead of sage on the stage" (Slavin, 2012, p.219), as the students will be working in groups and leading their own learning journey.

Creativity is very important in order for students to learn and requires using the three types of learning which are knowledge, skills, and understanding. Students use the facts and recognition of knowledge and information to apply this information using their skills to infer, reason and relate their understanding to new situations. Creativity approaches students and organizes their thinking while solving problems through the divergent and convergent thinking. Teaching creativity in schools has been challenging due to the complex stages of divergent and convergent thinking. It is like the rollercoaster: the students reach high to think divergently in many ideas to define their problems then think low convergence to focus upon the problem, and again high divergence to find alternatives of the solution and back again to low convergence to focus on the best solution.

Infusion is an instructional strategy that nurtures creative thinking by integrating the teaching of creative thinking skills within the syllabus content. For inferring and connecting the infusion with teaching creativity, STEM education is considered, and the content restructured to form a real-life problem that is offered to students and they have to lead their learning journey to find the solution through the problem-based learning strategy that improve their 21st century skills, including creativity.

The art of STEM education is that it shifts from the 'daisy model' to the 'rose model'. The daisy model refers to the separate subjects and students have to connect between them and find the relations between disciplines, while the rose model refers to the interconnection between the disciplines to form a real-life problem that students need to solve. The STEM disciplines have been described as the parts of the human body: "science is the musculoskeletal system, technology is the hand, engineering is the brain, and mathematics is the heart and blood" (ElSayary, Forawi and Mansour, 2015, p. 364). This lies in the strong relation between the disciplines in STEM education and how they form real-life scenarios and problems. There are arguments that adding the art to the STEM fosters creativity (Yakman, 2007). Further research should be applied to understand to what extent the language art and art and design can foster creativity.

7. Implications

Understanding the learning and assessment categories and the connection between them is significantly important in order for teachers to produce a meaningful learning environment for students. Teachers should align between the desired outcomes, assessment and instructions in addition to focusing on how to integrate an infusion approach within teaching and learning. This will allow students to learn different things based on their interests and

it also promotes their competencies in a real-world context with many unknowns and uncertainties (Cheng, 2015). The cognitive and social development of students is significantly important in preparing them to be users of information rather than receivers of information. Furthermore, the complex problems that students are engaged in allow them to switch between divergent and convergent thinking which leads them to a higher level of thinking (Kaufman & Beghetto, 2009). Learners need to be provided with skills, dispositions and information that prepare them for future jobs that do not yet exist. It was found that the assessment *as* learning has a positive impact on students' learning and transformation in their habits of mind due to the several checking points that allow them to self-assess their work, receive feedback and reflect on their learning (Litchfield & Dempsey, 2015). Moreover, previous research findings mentioned the impact of adding art to STEM in developing students' higher-order thinking (Costantino, 2018; Perignat & Katz-Buonincontro, 2018). On the other hand, Drake and Reid (2010) emphasized that the integrated curriculum reduces the stress of teaching multiple expectations. In addition, aligning assessment with the curriculum standards using backward design allows for acquiring deep assessment literacy (Drake & Reid, 2017). Prof. Sufian Forawi stated in "Theoretical Framework of Effective STEM Education: The UAE context" that it is important to innovate curriculum and methodology in studying and practising a subject in a real-world concept, which is achieved by the incorporation of STEM education into school curricula (AlSawaleh, 2017). STEM education and adding the art subjects to STEM is focusing on integrating design, thinking and infusion as part of the k-12 educational experience (Gross & Gross, 2016). The relationship between cognitive development, assessment and interdisciplinary STEM education helped in transforming students' learning through students' mastery of key concepts while transforming their learning attitudes, values, beliefs, and skills (Slavich & Zimbardo, 2012). Zumdick (2011) described the world as a huge laboratory where people are always looking for a new way of living and participating, using new materials and new techniques through focusing on the learners' inner ability and potential that investigates the inspiration, imagination and intuition. The continuous change in the world challenges teachers to focus on developing students' skills in real-life applications in addition to the focus on the core subjects (Merilainen & Piispanen, 2013). The 21st Century Civil Skills Pedagogical Content Knowledge (21st Century CSPCK) attempts to identify the nature of the pedagogical knowledge required to shift learning from traditional to transformational (Merilainen & Piispanen, 2013). The traditional schools assume that learning is the students' responsibility, however the transformational schools share learning via a professional learning community that includes and goes beyond teachers and students (Chaltain, 2011). Furthermore, traditional schools focus on and emphasize test results while the transformational schools focus on students' aspirations and life options (Merilainen & Piispanen, 2013). The UAE has set an action plan that states the huge investments into STEM education in schools that will consequently affect the workforce (Mosier, Levine & Perkins, 2013). Accordingly, recommendations have been raised that aim to reform the national curriculum into STEM as a key to develop the skills required to meet the UAE's national strategy goals of transitioning to a knowledge-based economy (AlSawaleh et al., 2017). In addition, there should be a reform of teaching methodologies in order to ensure that teachers provide consistent teaching strategies aligned to authentic assessment (AlSawaleh et al., 2017). Some organizations such as the Organization for Economic Cooperation and Development (OECD), Assessment and Teaching of 21st Century Skills (ATC21S), Partnership for 21st Century Skills (P21), Canada 21, and the International Society for Technological Education (ISTE) are influential participants that advocate for deep learning as an important goal for the 21st century pedagogy (Drake & Reid, 2017).

Well-educated prospective teachers have a great input in impacting and developing the countries in every aspect (Yildirim & Selvi, 2016). Educators carry the responsibility of training prospective teachers as individuals who think scientifically, criticize, communicate, collaborate, accept others, and respect human rights where they will impact students' learning (Yildirim & Selvi, 2016). Development of the STEM curriculum is like the classic railroad that is switching stations of junctions a hundred times in addition to the mechanical installations that enable railway trains to switch from one track to another (Rolling, 2016). These processes cannot be done without collaboration, where teachers should collaborate in developing the STEM curriculum rather than individual teachers working in isolation (Rolling, 2016).

8. Conclusion

Learning is the starting point of cognitive development. The learning process occurs when the students receive the information in their short-term memory and rehearse the information in the working memory so that it will go on to be stored in the long-term memory. Students develop their skills while solving real-life problems with

integrated disciplines (STEM) to think divergently in finding the alternative solutions, which is the higher level of creativity. During the process in the working memory to store the information in the long-term memory, the disposition of the skills occurs (Long et al., 2011). It is like an operation of the learning process. The final stage in this operation is to be sure that the learning cycle is moving smoothly when assessing the students' knowledge and skills by retrieving it again in the working memory. A gap has occurred between the way of delivering knowledge to learning and the method of assessment. Teachers should be aware of and understand the learning categories in order to construct students' knowledge effectively. Creativity is not receiving attention in teacher education programmes (Davies et al., 2004). It is significantly important to increase teachers' awareness of identifying creative thinking, attitudes and dispositions (Long & Plucker, 2015). As a result, students' scores will be raised in the standardized assessments. Shifting the balance between the three types of assessment (assessment **of**, **for** and **as** learning) is important, to focus more on assessment **as** learning (authentic assessment) that requires students to reflect and receive feedback about their work in order to improve (Earl, 2013). Finally, adding art to STEM will make the cognitive process flourish that develops students' 21st century skills and leads to higher-order thinking (Yakman, 2007). Accordingly, students' interest toward STEAM subjects will be increased, especially the females' (Roehrig et al., 2012). Further investigations should focus upon the impact of adding art to STEM education, the nature of each subject of STEAM education, and exploring the effectiveness of using authentic assessment tasks within STEAM education.

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