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REVIEW

Translating theory into practice: integrating the affective and cognitive learning dimensions for effective instruction in engineering education

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Learning in the cognitive domain is highly emphasised and has been widely investigated in engineering education. Lesser emphasis is placed on the affective dimension although the role of affects has been supported by research. The lack of understanding on learning theories and how they may be translated into classroom application of teaching and learning is one factor that contributes to this situation. This paper proposes a working framework for integrating the affective dimension of learning into engineering education that is expected to promote better learning within the cognitive domain. Four major learning theories namely behaviourism, cognitivism, socio-culturalism, and constructivism were analysed and how affects are postulated to influence cognition are identified. The affective domain constructs identified to be important are self-efficacy, attitude and locus of control. Based on the results of the analysis, a framework that integrates methodologies for achieving learning in the cognitive domain with the support of the affective dimension of learning is proposed. It is expected that integrated approach can be used as a guideline to engineering educators in designing effective and sustainable instructional material that would result in the effective engineers for future development.

Keywords: affective-cognitive learning approach; self-efficacy; locus of control; attitude

1. Introduction

Effective engineering education is important in developing engineers whose decision-makings can contribute greatly towards the socio-economic well-being of a nation. Their role in the development of industries, infrastructures and general well-being cannot be underestimated (Megat Johari et al. 2002). However, engineering subject matter is often challenging to teach if one is not equipped with the appropriate pedagogical skills and knowledge for ensuring learning (Akasah and Alias 2010; Kort and Reilly 2002). Thus, a thorough understanding among engineering educators of what constitute learning and how to achieve the desired learning outcome is extremely important. Here lies the gap between what is required and what exist; engineering educators who are in great need of teaching and learning expertise are not always in possession of the very thing

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that they need as training in teaching skills is not part of the training of the engineering educators. According to Kort and Reilly (2002), engineering educators, especially the inexperienced ones are lacking in certain areas of engineering education pedagogy.

Understanding of how people learn can be gleamed from available learning theories (Hassan 2011). However, the abundance of learning theories that are not always in agreement with one another might not be helping to engineering teachers. For example, the definition of learning itself is varied. In the behaviourist paradigm, learning is perceived as a relatively permanent change in behaviour as the result of practice or experience with a demonstrable outcome (Davison, Neale, and Kring 2008) where external indicators can be used to measure learning gains. However, in the socio-cognitivist's context, learning is not always demonstrable and sometimes can be implicit in nature where a learner may not be aware that they have actually learned – as in latent learning (Mayer 2008). For instance – taking an example from everyday life – student A; who comes to school every day with student B who drives the car, may learn the route to school equally well as student B demonstrating latent learning by student A (Ormrod 2000). Thus, engineering instructors need to be aware of the various ways of how students learn and the various types of learning that may occur to design teaching strategies that will target their desired learning outcomes. Moreover, the application of the learning theories to engineering education varies with the situational demands. Therefore, to address particular need, an integrated designing learning experience that targeted a students' development is required (Vanasupa, Stolk, and Herter 2009). However, trying to make sense of the multitude of theories can be confusing to novice teachers, what is more to engineering teachers who have not had any exposure to teacher training as it is not part of their engineering training.

The goals of engineering education, in general, do encompass the three learning domains advocated by the Bloom's taxonomy (Bloom 1956); namely the cognitive, affective and the psychomotor domain. Nevertheless, one goal that often attracts attention and focus of inexperienced lecturers is the goal that is associated with the ability to manipulate process, solve and produce a new knowledge (Gondim and Mutti 2011) which is primarily learning within the cognitive domain. The affective aspects of learning that include emotional elements such as empathy, enthusiasm and motivation which are influential in achieving the desired learning outcomes on engineering contents are not receiving much attention. The role of affects in knowledge transfer and skills enhancement has not been fully understood by engineering educators (Kort and Reilly 2002), although research from other disciplines such as the behavioural neuroscience (Ladouceur 2012), clinical psychology (Davison, Neale, and Kring 2008) and neurosciences research has substantiated the role of affects in generating physiological changes which are also indicative of learning (Lu and Zhang 2009). The integrated affective-cognitive therapies are used to determine the aetiologies and prognosis of psychopathologies such as eating disorder, somatisation disorder, depression, anxiety disorder, and stress appraisal. However, in the classroom, for example, students experience the affective aspects of classroom learning such as feeling of acceptance or rejection, positive or negative attitude, good and bad feeling, enthusiasm, and motivation which interact with the cognitive aspects of learning that can promote or hinder learning. Consequently important are affects that according to Lu and Zhang (2009) and Ladouceur (2012) without affects, students cannot reflect and will find difficulty in judging their learning gain. The emotional state of a student plays a crucial role in making a balance between mind and body states that helps a student in regulating their goals to enhance their learning. Furthermore, ignoring the affective dimension of learning – indicative of an inadequate understanding of how students learn – can lead towards undervaluing a student's capabilities which can increase the level of frustration among the engineering lectures. Moreover, affective learning enables the lecturer to gain valuable information regarding student's reaction to instructional strategies (Akasah and Alias 2010). In-addition, Strobel et al. (2011) has also highlighted the need to better appreciate the contribution of the affective dimension as the existing engineering education practice tend to emphasise the acquisition of knowledge (cognitive dimension) with relatively less emphasis on valuing the acquired knowledge (affective dimension). As a consequence, engineering is often perceived as object-oriented rather than people-oriented. Denton and McKinney (2004) suggest that the affective and cognitive learning act in 'reciprocity' which means that they are mutual interacting determinants of each other. Therefore, the purpose of this paper is to put forward existing learning theories that can increase one's understanding of the interdependent role of the cognitive and affective dimension of learning culminating in a proposal of an affective-cognitive teaching and learning framework for promoting cognitive learning. The three objectives of this paper are given below:

(i) To identify the learning theories that describes the role of affects in learning of the cognitive domain.
(ii) To identify the important affective attributes that influence learning in the cognitive domain and
(iii) To propose an affective-cognitive teaching framework based on the synthesis of the selected learning theories for learning in the cognitive domain.

The rest of the paper is organised as follows: Section 2 provides the method used to gather and analyse the data; Section 3 gives an overview on the learning theories and their critical evaluation with detail explanation on the related and supporting theories. Section 4 discusses the proposed framework which is based on the theoretical foundation gained from the selected learning theories to be followed by the conclusion section.

2. Method

To achieve the above-mentioned objectives theoretically, grounded work was undertaken that allows the researchers to generalise the work across the studies which will increase the external validity of the findings (Ormrod 2000). Twenty learning theories under four major theories namely behaviourism, cognitivism, socio-culturalism, and constructivism were initially reviewed. Theories that do not include the role of the affective element in the acquirement of learning were later on excluded from further analysis. The selected theories were critically reviewed from the perspective of engineering educational demands. The theories that were chosen for further analysis are those that have underlying philosophies which are suited to and can be applied in engineering education, i.e. they embody all the required elements that make education effective (Hassan 2011). The understanding gained how learning occurs from the selected theories is expected to provide the guideline for engineering teachers in teaching and learning as well as in the assessment process.

Important concepts under the various theories were identified and their contribution to learning was studied. They were classical conditioning and operant conditioning under behaviourism, assimilation and accommodation under cognitivism, as well as zone of proximal development (ZPD), scaffolding and apprenticeship under constructivism. Under socio-culturalism three sub-learning theories (Pervin 2007) were selected namely, the social-cognitive theory, attribution theory, and cognitive-dissonance theory. The theories that were excluded (as shown in Table 1) includes information processing theory which focuses solely on communication development; psychoanalysis which studies personality and states of mind namely unconscious, subconscious, and conscious state; humanistic theory which focuses on free will and the personal growth of the individual; and Gestalt theory which deals with the principle of totality, perception and sensation (Davison, Neale, and Kring 2008). These theories are considered to be unrelated as the body of knowledge is not related to further understanding of the role of affects in cognitive learning.

Table 1. Excluded learning theories and their focus areas.

Theories/school of thoughts	Focus areas
Information processing theory	Communication development (input, process, output), signal processing
Psychoanalysis	State of mind (conscious, subconscious and unconscious)
Humanistic theory	Personal growth, free will
Gestalt theory	Principle of totality, perception in learning, sensation, illusion
Experimental-cognitive psychology	Memory processing (encoding, retrieved, stored)

Source: Brown (2004).

Each selected learning theory was further analysed to understand the role of identified psychological constructs namely, locus of control, self-efficacy and attitude influence cognitive learning in engineering education. These psychological constructs were chosen as they are assumed to be the fundamental attributes in promoting success in learning in general.

3. Results

This section is divided into two subsections; the first section focuses on objective (i) and (ii) and the second section focuses on objective (iii).

3.1. *Relevant learning theories and their applications in engineering education*

Based on the initial analysis of the literature on learning theories, six learning theories were identified which includes three sub-theories (Figure 1). The sub-theories are social-cognitive theory for self-efficacy, attribution theory for locus of control and cognitive-dissonance theory for attitude formation are the subcategories under socio-culturalism. A combination of the six theories is expected to be adequate in developing guidelines for teaching and learning in engineering education. The learning theories are related to each other in terms of their emergence. Basically, the deficiency of one learning theory gives rise to a new learning theory. The explanation to these theories and how they can be applied to engineering education will be presented in the following sections. This detail is to meet the first and second objective of this study.

3.1.1. *Behaviourism*

Behaviourism is a school of thought that studies the overt measurable characteristics of behaviour (Davison, Neale, and Kring 2008). Behaviourism proposes two major principles of learning

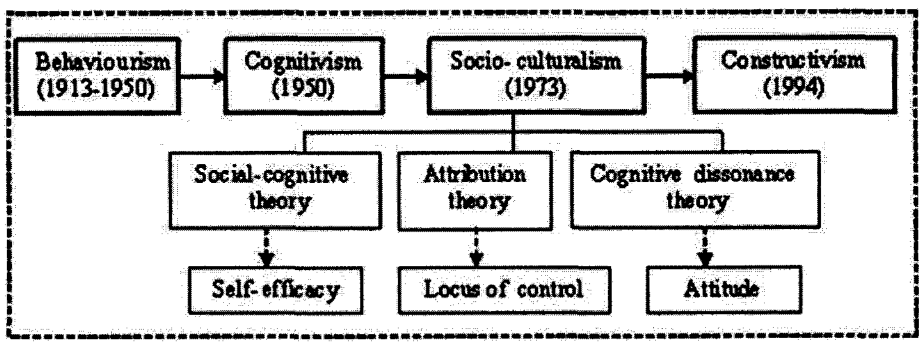

Figure 1. Block diagram illustrates the successive development of learning theories.
Source: Lowenthal and Muth (2008), Ormrod (2000).

namely, law of association, under classical conditioning, pioneered by Pavlov and law of reinforcement under operant conditioning that is pioneered by skinner. Law of association explains the phenomenon of learning as a passive response (R) to stimulus (S), i.e. the behavioural response to any event determines S–R connection which makes the consequences explicit (Mayer 2008). Law of reinforcement gives emphasis on the consequences of any event and outcome that played a critical role in shaping the behaviour of a learner (Adam 2007). Behavioural reinforcement determines the probability of a specific type of behaviour occurring. If the behaviour is positively reinforced, then learning is strengthened in the form of the desired behaviour. If, on the other hand, the demonstrated behaviour is followed with a punishment or an aversive response, then the specific behaviour will be weakened. Skinner believes that a teacher can promote confidence and positive attitude in students through positive reinforcement during instructions. Naturally, capabilities of students must be evaluated to make instructions appropriate (Deubel 2003). Thus, teacher's positive reinforcement in the form of approval can lead students to the next step of understanding and learning (Hassan 2011).

Tolman, who was dissatisfied with behaviourism, extended the behaviourist learning theory and proposed his expectancy theory (Davison, Neale, and Kring 2008). He included internal mental phenomenon to the existing theory in trying to explain how learning occurs. According to him, learning is acquired as a result of a stimulus–organism–response (S–O–R) which was an extension of the S–R connection. For example, a teacher's delivering of a lecture is a stimulus; a student's learning process, or organising the information is organism and the learning outcome is the response.

3.1.1.1. *Behaviourism in engineering education.* Behaviourism provides useful guiding principles for teaching and learning in engineering, although no affective attributes can be explicitly identified under this school of thought. However, such affective indictors can be observed when they are linked to the behavioural indicators.

Behaviourist learning theory provides the basis for effective teaching techniques that can be used in teaching of the many complex engineering concepts and tasks. For instance, drill and practice and programmed instruction – common techniques used by engineering educators – emerge from behaviourism. Task repetition in drill and practice not only helps a student in accomplishing the target task but it also promotes habitual learning. In programmed instruction, where a new learning material is presented in graded sequence of controlled steps, difficulty level can be adjusted depending on student's level of understanding and potential for learning (Adam 2007). In addition to guiding learning, behaviourism also provides some guiding principles for assessment. For example, the syllabi often combine pure scientific theories with application, and this is a situation where behaviourism often works well (Hassan 2011). Other useful applications of behaviourism include behaviour shaping and behaviour modification and task analysis. A wide range of techniques based on operant conditioning are often applied in engineering education to reinforce appropriate behaviour. These techniques can be directly or indirectly related to affective and cognitive learning. The application of behaviourist techniques such as appreciating appropriate behaviour, reinforcement, and motivation implicitly targets some affective learning goals although the explicit target is the cognitive learning goals. Thus, there are considerations for the affective learning needs in behaviourism although not explicitly stated. In other words, although, the affective dimension of learning is not explicit under behaviourism; affective learning can still be observed and measured explicitly through behavioural observation.

3.1.2. *Cognitivism*

Cognitivism is the second major learning theory reviewed which deals with the internal mental processes (Lowenthal and Muth 2008). It is a study on latent behaviour focusing on the role of cognition in learning (Ormrod 2000). The term 'cognition' refers to the thinking pattern which includes processes of memorising, forgetting, elaborating, transforming and storing the information. Thus, cognitivism focuses on the unobservable phenomenon that is happening inside the head. Piaget, a well-known cognitivist studied the cognitive developmental stages of a child. His view poses that knowledge is constructed when a student is encountered with a cognitive conflict. He identified two processes in cognitive development namely assimilation and accommodation which are two sides of adaptation to learning (Deubel 2003; Hassan 2011). Assimilation is the process of incorporating new knowledge into the existing knowledge. It is the basic underlying structure of any learning. An example of assimilation is illustrated here in the case of a student who is new to learning statistics. In learning statistics, a learner uses knowledge of formula to do manual calculations to find answers to problems, such as finding the value for mean, mode or median. Although the subject is new, the student's prior knowledge gained from mathematics learning of the same materials would help the student in learning the mentioned statistical techniques. Accommodation on the other hand is the process of amending existing cognitive schema (knowledge structure). It is associated with the modification of the same learning into multiple ways. For example, when the student who has learnt how to calculate mean, mode and median is now taught how to calculate standard deviation, the student will need to add new information to the existing ones. The existing knowledge structure will need to be modified to take in the new knowledge.

3.1.2.1. *Cognitivism in engineering education.* Cognitivism deals with a person's cognitive abilities and the mental processes of an individual when completing an intellectual task (Hassan 2011). Cognitivism shed light on the way students constructed their self based on their affects, thinking and behavioural intensions. The creation of self-image, self-regulation, and self-concept is associated with affective and cognitive learning. Self-image (cognition) refers to ability to think about oneself. However, self-image is not necessarily had to reflect reality. The concept is related to 'Ideal self' coined by Roger. Self-image is a major factor in human social behaviour, and, therefore, a widely studied topic in the social sciences. Self-regulation (behaviour or behavioural intension) refers to the ability to control one's own behaviour (Bandura 1977). Self-concept (affects) refers to the totality of perceptions that an individual has of him/herself. Self-image is a core construct in Carl Roger's theory of personality. It develops through interactions with others and involves one's presence in an activity. Thus, self-concept is largely based on the social evaluation (Pervin 2007). These internally held beliefs ultimately influence learning outcomes (Vanasupa, Stolk, and Herter 2009). Furthermore, students' psychological attributes namely self-efficacy, locus of control and attitude depends on their cognitions. The magnitude and the direction of these psychological attributes are also based on the belief system which is cognition. Therefore, cognitions are attached to affects. Affects influence the progressive development in the levels of thinking and knowledge gain, the process of accommodation and assimilation, problem-solving skills which are integral to engineering education. Hence, the mental process involved in learning, the desire to achieve and goal accomplishment shares a part of cognitivism. Thus, there is a connection which ranging from affective involvement to cognitive learning gain (Felder et al. 2000; Ormrod 2000).

3.1.3. *Socio-culturalism*

Socio-culturalism is the third major theory that attempts to look at the important contribution of society on the cognitive development (Pervin 2007). It focuses on the interaction between people and it deals how behaviour is modified due to influence of societal factors (Festinger 1957). A class is composed of diversity in terms of cultural and social backgrounds. The environmental factors such as peer pressure, student's relation with teachers and other social context plays essential role in learning. In a classroom sometimes abundance of information on the same topic

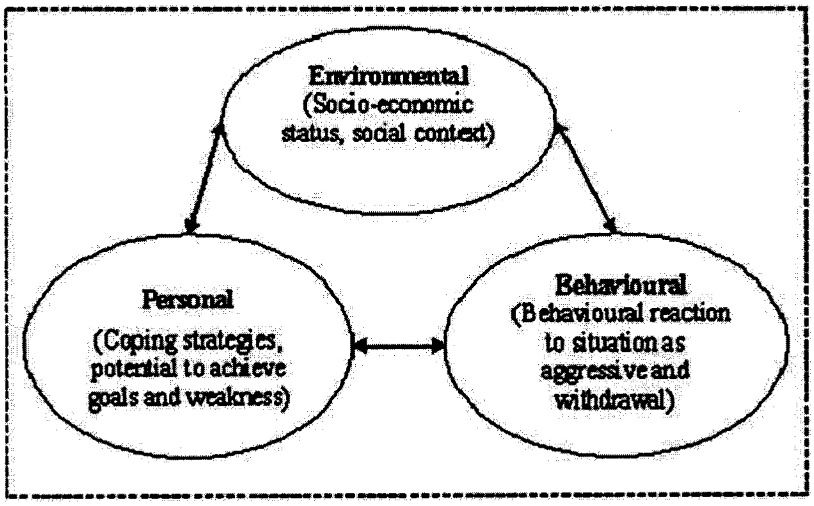

Figure 2. A product that suggests the interrelated contributing factors while considering the sociocultural perspective in learning.

Table 2. A brief summary to the psychological variables of the study.

Variables	Definitions	Author and year
Self-efficacy	'A belief on self capacities to attain particular task'	Bandura (1977)
Locus of control	'Person's perception of a control over the environment either internal or external'	Hildenbrand (2009)
Attitude	'A Predisposed reaction towards an object, or situation, that accompanied by the feeling and emotions'	Festinger (1957)

makes student confused. However, the internalisation (affective learning) closes the gap between these processes and help in promoting a clear understanding of the concepts at hand, resulting in individual learning output and uniqueness. For example, during a class discussion, some of the meaning of some concepts may become clearer when students share information with each other (Ormrod 2000). Figure 2 illustrates the interrelated contribution of social factors towards learning.

The theories on psychological variables such as self-efficacy, locus of control and attitude, respectively, emerged from the philosophy of socio-culturalism. A theory is an explanation on a particular way in which variables are referred to. Philosophy on the other hand is a manner of thought that gives a proper method of reasoning. In this instance, the term theories refer to the particular theories associated with the selected variables (i.e. locus of control, self-efficacy and attitude). All these variables are largely studied by social psychologists. Thus, they are termed as a philosophy of socio-culturalism. Table 2 provides a brief summary on the selected psychological variables explained earlier in Section 3.1. The detailed explanation to these variables is given below.

3.1.3.1. *Socio-culturalism in engineering education.* Social, cultural and environmental factors are responsible in the construction of self belief, perception of self and self-concept, and the level of attribution one makes (causes to consequences). According to socio-culturalism, maladaptive behaviour is the result of either direct bad experience or exposure to inadequate models. Therefore, motivational technique, vicarious learning, modelling and persuasive communicative skills (verbal skills encouragement to overcome self-doubt) are the best useful technique for boosting the level of self-efficacy, which leads students to take the responsibilities of the learning outcomes (locus of control) thus helps in developing a positive attitude (Bransford 2000). Modelling lies in the centre of socio-culturalism. It can be symbolic or indirect (literature, movies) and a direct model (life model). In a classroom environment, peers have been shown to be extremely influential models in the formation of the self concept and belief. Modelling is the best way of promoting personal responsibilities (internal locus of control) and other pro-social values (Felder et al. 2000; Mayer 2008; Ormrod 2000). In a nut shell, socio-culturalism focused on the building-up of relationship of students with the surrounding. The tendency of the relationship depends on the emotional attachment. If a student is able to develop a strong relationship with the surrounding then he/she can face any obstacle by taking supportive help from the environment. One of the best ways of boosting the self is motivational videos. Technical skills, teamwork, and industrial workplace representation is often a desirable skill for engineering graduates. Such expertise can be gained via a role model and motivational videos and persuasive techniques are the best source to boost self confidence among engineering graduates (Akasah and Alias 2010).

(a) *Social-cognitive learning theory*

The social-cognitive learning theory has emerged from the work of Bandura. According to him, learning is a result of the maximum impact of societal interaction and vicarious learning (Bandura 1977). Social interaction is an integral part of an individual's daily life and the social impact during the socialisation process can result in learning (change in cognition). There are numerous studies that support the claim that affective cues generally influence the social-cognitive processes (Bandura 1977). Bandura has emerged the concept of self-efficacy. Self-efficacy is a belief or expectation of a student that he/she can perform well, and ability to accomplish a particular task (Bandura 1977). Researchers have reported that self-efficacy is a good predictor of academic success. Its level is increased when a student perceives that he/she could perform well. For example, when students are exposed to a new task (such as using a computer programming in engineering) for the first time, their psychological state such as anxiety, stress can increase because the self-efficacy of the student is still underdeveloped. However, a triggering statement such as 'you can do this' can act as a motivator for these students. Furthermore, the use of persuasive communication skills and motivational videos could be the most effective technique to help students find the strategy to cope with the situation. Students can then become more relaxed and can begin to perform the task at hand with a calm state of mind as an indication of increased self-efficacy in the task (Krause et al. 2007).

(b) *Attribution theory*

Attribution theory is the most influential theory for human motivation with particular implications for academic motivation (Hildenbrand 2009). According to attribution theory, people attempt to perceive the outcomes of their performance (successes and failures) along with the three parallel dimensions, i.e. internal versus external dimension, stable versus unstable dimension and control versus uncontrolled dimension, respectively. The factors that attribute the consequences and influence the performance of students are ability, task difficulty, effort and luck (Hildenbrand 2009). See Table 3 that gives a visual depiction of how the dimensions and factors of attribution theory relate to one another.

Internal versus the external dimension is related to the personal factor and the behavioural outcomes are linked to the personal reasons. For example, if a student is successful in academics then they tend to believe that the outcome is a result of their effort. If on the other hand, a student faces failure then they blame the environmental factors such as time shortage and luck. Stable versus unstable dimension is related to the situational factor and behavioural consistency of a student that can be determined through these phenomena. If a student obtains the same and persistent results over time on the same actions, then the student tends to believe that the academic outcome will be the same even after putting some efforts. However, instability will be reason if students get different consequences on the same action then they tend to believe

Table 3. Attribution theory dimensions and factors.

		Dimensions		
		External/internal	Stable/unstable	Controllable/uncontrollable
Factors	Ability	Internal	Stable	Controllable
	Task difficulty	External	Unstable	Uncontrollable
	Efforts	Internal	Stable	Controllable
	Luck	External	Unstable	Uncontrollable

Source: Hildenbrand (2009).

Table 4. Rotter's locus of control.

	Attribute	Outcomes
Internal locus of control	Ability	Typical
External locus of control	Chance/fate	Atypical

the situation to be unpredictable so they have a lack of coping strategies. Controllable versus uncontrollable determines the level of determination to a particular task. If the consequences are according to students thinking, then a schema developed that they have the ability to alter outcomes. Nevertheless, if outcome is the result of uncontrollable cause, then the individual does not believe that he/she can easily alter the outcome even if they want (Hildenbrand 2009). Instead of using the three dimensions of the attribution theory, only one external vs. internal dimension is used in this study. Locus of control has been included as one of the dimensions of attribution theory which is based on a framework of Rotter's social learning theory of personality. Table 4 depicts one dimension of Rotter's locus of control.

Locus of control is a belief or expectancy which can cause an outcome either internal or external (Mayer 2008). Students having an internal locus of control believe that their own ability or skill determines the outcome. In contrast, the external locus of control is the belief that the consequences or what happens to them is not under one's control. They tend to assert their potentials less frequently and experience feeling of despair excessively. Therefore, the level of success is lower in people attributing their outcomes to an external locus of control. It is also revealed that students mostly attribute their outcomes to those factors that act as a defence mechanism in which they feel themselves comfortable. Regarding academic achievement, researches indicated internal locus of control is more associated. Moreover, students feel a positive emotional response of pride for the success (Davison, Neale, and Kring 2008).

(c) *Cognitive-dissonance theory*

Cognitive-dissonance theory postulates a psychological state which refers to mental conflict which is created when beliefs or opinions do not go parallel to each other (Festinger 1957). The persistent state between the cognitions develops equilibrium in the thinking process. However, if the cognitions are opposite to each other, discrepancy will occur which causes a state of non-equilibrium that leads to dissonance in cognitions. As a consequent, a motivational drive will emerge to reduce the dissonance by altering the existing beliefs and opinions. Therefore, cognitive-dissonance theory explains the relationship between cognition and behaviour in the attitude formation process. Attitudes are beliefs and opinions that can influence behaviour either positive or negative (Festinger 1957). From an educational perspective, an attitude is developed when curiosity is produced in learning among students. Therefore, a student must find a deficiency in learning to put active effort to overcome the deficiency in order to establish a better understanding of learning (Chowdhury 2004). Attitudes are not directly observed, but the actions and behaviours to which they contribute could be measured (Chowdhury 2004).

3.1.4. *Constructivism*

Constructivism is a learning theory which posits the phenomenon that learning is the construction of knowledge on the basis of personal understanding (Adam 2007). Bruner's discovery learning and Vygotsky's ZPD were the prominent work in the field of constructivism. Bruner's view poses the active engagement of students in the learning process, while Vygotsky revealed that learning is constructed by sharing meaningful information in a social context. They found relevancy between society, cognition, and affection in learning. Vygotsky developed the concept of ZPD that focuses on the person's potential or developmental opportunities in task accomplishment with the societal support. The intellectual cognitive abilities of students and the capacities to adapt an environment determine their behaviour in learning. Constructivism built between the personal past experience of students and the modification to new learning. Students are core matter while teachers just act as facilitators (Botto, Schorr, and Lema 2006). Consequently, learning is constructive when an active role is played by the learner. Lecturers can merely provide information. A learner is one who initiates, regulates and actively engages in their learning (Vanasupa, Stolk, and Herter 2009). This unique perspective to education views knowledge as a product of reality. Cognitivists consider the mind as a reference tool to the world, whereas constructivists believe that the mind filters the input from the world to produce its own unique reality (Davison, Neale, and Kring 2008). This subjective part is related to affective learning. Therefore, this approach to learning is considered the feeling; valuing, appreciation and these are affective factors incorporating cognition.

3.1.4.1. *Constructivism in engineering education.* Cooperative learning, leadership qualities, problem-solving, creativity and active participation are characteristics of engineering education. In addition, when students are given a difficult task, students usually give up, therefore, team work is desirable for lab testing and gaining technical skills in engineering education. Teaching and learning theories of constructivism is related to affective-cognitive learning. The construction of knowledge shares the cognitive part while subjective understanding of knowledge is the affective learning. Literature supported the notion that cooperative and active learning which are the essential techniques of constructivism involves the method of argument, and dialogue with peers. These sorts of activities develop the conflicts among concepts. Eventually cooperative learning helps in learning a single situation that can be analysed with multiple perspectives. This active exercise provides prompt feedback and clarity to students. The use of cooperative learning enhances individual accountability, team work, leadership qualities, communication skills, self-assessment of team functioning. As constructivism placed a great importance to cooperative learning which promotes communities of learners and sense of belongingness which is an affective attribute. Thus, constructivism performs dual tasks as it engages a student actively in learning and during the learning process it also helps a student to raise awareness about his/her friends and peers (Felder et al. 2000).

According to the engineering educational context, ZPD can be observed in laboratory testing and project work. An example could be construction engineering programmes in first-year students in which student's mental and mechanical skills can be evaluated for a specific mental level. With Vygotsky's ZPD contextual framework, the concept of cognitive apprenticeship can be introduced. It is a methodology based on the contemporary instructional learning model that suggests that student learning is acquired with the scaffolding of the teacher. The learning obtained in a group whereby the student interacts with other students thus learning is attained in a shared responsibility of diversity in skills and knowledge. Subsequently, in the second year, the progressive complexity of project increases with the student's acquisition of the knowledge. This is the stage for the generation of ZPD; a beginning of new concept development with the new factual knowledge base (Hassan 2011).

3.2. *Summary on learning theories and affective attributes*

In this section, a summary on the learning theories and the affective attributes is discussed. Learning theories provide explanation on how people acquire learning, including what affects learning gains which can be a source of knowledge and guidance for researchers and practitioners in engineering education sectors (Hassan 2011; Tomei 2001). Based on the analysis of twenty learning theories; four major school of thoughts namely behaviourism, cognitivism, socio-culturalism, and constructivism were considered. Three associated sub-theories were identified to be relevant to engineering education, i.e. social-cognitive theory, attribution theory and cognitive-dissonance theory. Further analysis of the theories yielded three affective attributes that were deemed to be relevant to learning in engineering education namely self-efficacy from the social-cognitive theory, locus of control from the attribution theory and attitude towards engineering from the cognitive-dissonance theory. The main source of guidance for this study is obtained from three theories; the social-cognitive learning theory, attribution theory and cognitive-dissonance theory that fall under the social-culturalism schools of thoughts. The contributions of the four schools of thoughts on engineering learning have been duly acknowledged by other as they can be widely utilised and integrated into the different educational systems within engineering education (Hassan 2011). Table 5 reveals a brief summary of selected learning theories, principles, focused areas, educational implication and examples, respectively.

4. The proposed framework for teaching cognitive domain via affective domain

The propose framework integrates knowledge gained from the learning theories. The integrated affective-cognitive teaching and learning approach takes into considerations the affective learning needs in addition to the cognitive learning needs. This approach is in line with the recommendation by Chowdhury (2004) who insists that learning could be enhanced if the learning needs of the cognitive domain are integrated into that of the affective domain. Cognitive learning success can be gained via the support of the emotional attachment formed through the affective learning process. An example of cognitive learning is problem-solving, and the ability to manipulate information while an example of affective learning is developing appreciation towards the need for safety in task execution.

In light of new developments, advances and academic challenges in engineering education; a single educational theory is not sufficient (Hassan 2011). Therefore, multiple theories have been referred to in the design of the framework. The summary of the selected learning theories has been presented earlier in Table 5. Elaboration of the theories will be given in the discussion of the framework.

The framework is expected to support novice teachers in preparing suitable learning materials to support students' learning without the need for them to actually master the theoretical underpinnings of learning. The proposed framework will help teachers to create learning materials and environment that boost self-efficacy, locus of control and positive attitude towards engineering. This situation will lead to increased students' self-worth which catalyses students learning towards the ZPD. Positive attitudinal and motivational changes in the learning process will lead to positive desirable consequences in academic performance. Therefore, the affective learning gain can be used to support the internalisation of the cognitive content (Lashari et al. 2012). For example; positive reinforcement in particular, has been associated with appropriate positive behaviour such as paying attention, decreasing misbehaviours that brings out the desirable consequences (Felder et al. 2000). Behaviourism which emphasises observable behaviour, provides the guiding principle for creating the connection between affects and cognition. For example, in Skinner's empirical approach to assessment which is the knowledge related-grading system

Table 5. Summary on the perspectives of learning theories.

Theories	Principle	Focused area	Educational implications	Examples
Behaviourism	• Learning a result of S–R connection (association) and learning through reinforcement	• Impact of feedback and reinforcement	• Behaviour modification	• Stimulus: teacher's question
		• Measures observable behavioural characteristics	• Systematic desensitisation	• Response: students answers
			• Relaxation technique	• Appreciation, rewarding remarks by teacher
			• Exposure	
Cognitivism	• Assimilation, accommodation	• Attribution style	• Magnification or minimisation	• Schema development
	• Language development, concept formation and information processing	• Gradually maturity of developmental stages in cognitive process	• Arbitrary inference (false prediction as overestimating the possibilities of negative outcomes)	• Ways of attribution to their outcomes (give causes to their consequences)
Social-culturalism	• Impact of racial and cultural factors on learning (socio-economic status, family, peers and friends)	• Learning through socialisation process	• Peer teaching	• Magnitude of relationships
			• Vicarious learning	• Ask students to comments on his/her fellows in a classroom
			• Audio–video presentation	
			• Modelling	
Constructivism	• Individual's uniqueness in the concept on personal experience and peer learning or group project	• Mutual planning, cooperative learning, discovery learning	• Ask open-ended questions as 'How might information be useful'	• Provide student many opportunities to experiment novel objects or deals with different problems
	• Transformation of information on cognitive structure	• Individual accountability	• Promotion of reasoning such as asks them why they prefer particular method	• Active engagement of students in class activities
				• Group processing (how well the team is functioning)

Source: Adam (2007), Davison, Neale, and Kring (2008), Ormrod (2000).

(criterion-referenced assessment), student's performance is compared to the course plan or criteria of the curriculum instead of comparing between students (Hassan 2011). The consequence of student's performance determines whether they are rewarded or not which creating good or bad feeling (affects) which will be associated with academic achievement (cognitive learning). Therefore, at the beginning of a new cognitive learning task, attention to a student's affective needs must also be considered and met which will ultimately reinforce the cognitive learning potential. A teacher's simplified explanation of a complex concept to a class using brainstorming and concept mapping before delivering a lecture is an example where a teacher is attempting to fulfil student's cognitive as well as affective learning needs. The step by step teaching technique helps the student in developing a better understanding of a complex concept which is otherwise quite difficult to master if not broken down into its smaller parts is another example where afterwards students perceive the completion of each piece as a success and promotes further learning efforts (Pervin 2007).

Hassan (2011) further suggests that rewards in the form of teacher's approval which is a form of positive reinforcement can lead student towards continued efforts and goal accomplishment. Persuasive communication skills, motivational videos and speech are the techniques within the social-culturalism paradigm that develop students' emotional attachment to learning while cognitive reconstruction, arbitrary inferences are the techniques of cognitivism. These techniques can be applied in the classroom when a student gives up. Cognitive reconstruction techniques can help a student to view a learning task in a more realistic manner without jumping to hasty negative conclusion, resulting in the perception of a learning goal as being achievable through elimination of negative thought. Cooperative team work, scaffolding and apprenticeship, trial and error in problem-solving, innovation, lab testing are the techniques of constructivism which develop a conductive learning environment for students. Furthermore, teamwork promotes valuing of working with peers and classmates. The techniques from the various underlying are here represented in the proposed framework (Figure 3).

4.1. *Three applications of the proposed framework*

Two examples are presented to show how the proposed framework has been applied and one typical lesson plan that was used in an actual classroom.

4.1.1. *Example 1*

Example 1 illustrates the usage of materials from the statics and dynamics course on the topic of equilibrium of a rigid body. The course is offered in the Diploma of Engineering programme in Universiti Tun Hussein Onn Malaysia (UTHM). The aim of the topic was to enable students to calculate support reactions. The specific learning outcomes of the unit were able to draw the free body diagram of a rigid body, 'able to identify the number of reactions on rigid body' and 'able to calculate the magnitude of reactions on a rigid body'. Prior knowledge required were knowledge of Newton's law and vector algebra. The flowchart of the proposed framework is divided into five stages that go in a cyclic chain of affective and cognitive dimension, thus, the example is discussed accordingly.

Affective dimension stage: The lecturer gave a brief motivational lecture to promote students' emotional attachment to learning and the emphasis was on the importance of correct computational procedures. Then, the lecturer asked a series of questions to judge students' duty conscience and the mental presence.

Example: A short lecture on an example of a real-life structural support failure involving material and life loss.

Cognitive dimension stage: In this phase, the lecturer gave a short lecture (new information) on idealisation of structure_(transforming complex real-world systems into a simple and manageable representation). This is the stage of assimilation.

Example: A lecture on the idealisation of a bridge structure into one beam with two supports only that could be solved using simple vector algebra.

Affective dimension stage: The lecturer gave more real-life examples on other types of structure and encourages students to participate in the discussion to make the lecture interactive. Then the lecturer acknowledged students contribution to make students feel appreciated before moving to

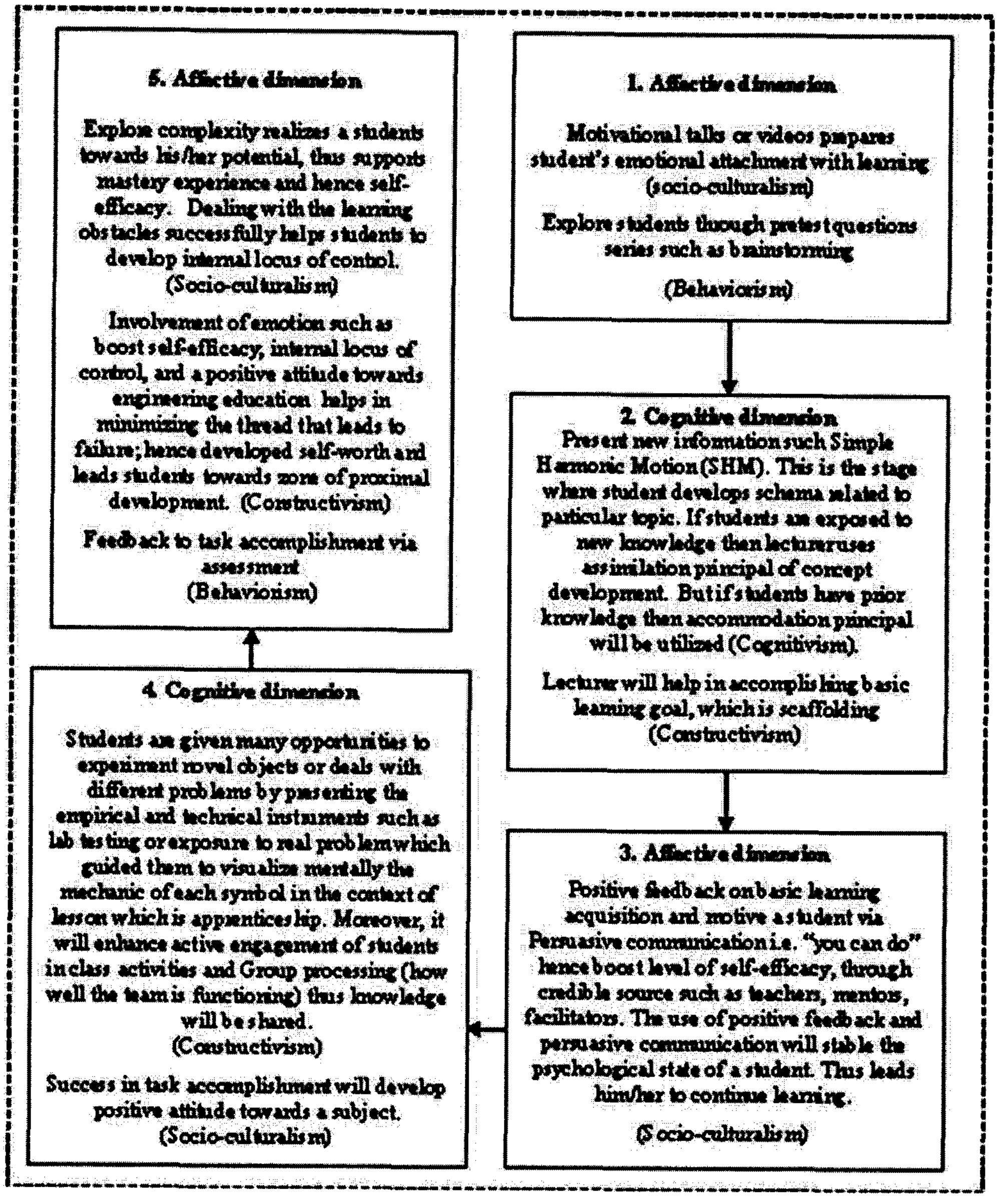

Figure 3. Teaching cognitive domain via affective dimension.
Source: Akasah and Alias (2010).

the next advanced stage of learning which can be done by a series of questions whereby students can answer and received positive reinforcement and feedback.
Example: column/crave/pulley and tackle. To enable students to transform given examples (column/crave/pulley and tackle) into idealised structures as in the second stage.

Cognitive dimension stage: In this stage, the lecturer gave information on how to calculate the magnitude of reactions by the mean of algebraic sum of vector force and moment. The lecturer can start a lesson by giving two simple force systems where students could easily visualise the direction and magnitude of each arrow vector. Then progressively students are exposed to the advanced stage. This is the stage of accommodation.

Affective dimension stage: The lecturer closed the day's lesson with a summary of what has been learnt. The lecturer highlighted student's strength and potentials giving positive feedback and reinforcement to promote improvement and continuing effort towards learning which in-turn increases the level of self-worth.

4.1.2. *Example 2*

In this example 2, a teaching and learning activity related to the simple harmonic motion (SHM) from (Wipfli 2008) is used to illustrate the application of the framework in Figure 3. This activity is suggested to take place in a laboratory. According to the flowchart of the proposed framework, the example is also divided into five stages that go in a cyclic chain of affective and cognitive dimension.

Affective dimension stage: This stage focuses on the affective learning needs where a lecturer can catch students' interest by creating an urge or need to learn SHM using techniques that induces an emotional response. Involving the students in learning and bringing their overt behaviour can be made possible by asking some relevant simple questions such as 'where do you think SHM is applied in the real world?' 'Where can we find an example of SHM?' Such questions could help a teacher in exploring student's background knowledge on the topic.

Cognitive dimension stage: In this stage, a lecturer focuses on cognitive learning where the explanation on SHM can be given, and some examples of SHM applications are discussed (lead them to waves, pendulums, springs, rotation). Then, a lecturer can discuss the important concepts under SHM, period, frequency and amplitude.

Affective dimension stage: This stage again focusing on the affective part of learning in which a lecturer can keep the student motivated and engaged by giving them positive feedback and appreciation. The use of positive feedback helps in sustaining the positive psychological state of minds which should motivate the students to continue in making sustained learning efforts.

Cognitive dimension stage: In this step, a lecturer can ask students to apply their previously learned theoretical knowledge conducting experiment and using tools. Students will have to decide what equipment to use and need to plan on how to collect the necessary data. The focus is in building the knowledge. When the data collection step is completed and the analysis stage is at hand, some instructions can be given to alert students attention to important points and to avoid errors such as 'change only one variable at a time', 'use at least three different masses', etc. Although the focus is still on cognitive learning, the focus is on developing understanding and application of knowledge which is related to a higher level of thinking. To achieve this, students were asked to come up with a suitable conclusion based on the data that they have.

Affective dimension stage: Finally, students should be assessed on their higher order thinking asking them some evaluation questions such as whether their hypotheses were supported or rejected as suggested by Wipfli (2008). Moreover, the lecturers wind up the lesson plan with a summary of what has been learnt which is aligned with highlighted student's strength and potentials for promoting continuing effort towards learning.

4.2. *Typical lesson plan*

Based on the proposed framework, a lesson plan has been designed for thematic approach. The lesson plan illustrates the proposed framework for the course on 'mechanics of materials' and discusses the flow of artefacts that is divided into four phases namely pre-instructional, developing, instructional and evaluation and reflection. The details of the lesson plan are attached in the appendix.

5. Conclusion

The aim of this literature analysis is to identify learning theories that is relevant to cognitive learning via the affective dimensions. As a result of the analysis, four major schools of thought are identified namely behaviourism, cognitivism, social culturalism and constructivism that have underlying philosophies of teaching and learning appropriate to engineering education practices. The selected theories are deemed to be suitable and can be applied in engineering education as they embody all the required elements that make engineering education effective. Based on the information of selected learning theories, a framework is proposed that integrates the affective and cognitive needs of learning. Affective learning in the form of emotional attachment promotes cognitive learning in the form of problem solving, and ability to manipulate information. Hence, learning and psychological demands of student's are taken into account in this paper which has together placed a unique position of student regarding the growing importance of the affective domain in the cognitive domains of engineering education. These psychological traits are essential variables in explaining individual differences. Affective learning helps students in promoting self-determination, it will act as a defence mechanism to improve self-efficacy that leads towards internal locus of control and hence in-turn develops a positive attitude towards learning. It is expected that the proposed integrated affective-cognitive learning approach will help in building a healthy learning environment to boost self-efficacy, locus of control, and to develop a positive attitude towards engineering education in order to minimise the threat that leads to failure.

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