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Cognitive Intelligence: Exploring its Effects to Help Learn, Unlearn and Relearn Engineering for Problem Solving at Workplace through Co-Relating Core and Course Subjects

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Abstract— The purpose of the study was to focus and explore the close interrelationship between core subject, say chemistry and course subject, say material science in engineering and perceived lack of intelligence in understanding the interdependence of the same by students from the view point of tomorrows workplace requirement for problem solving as against an average of the student passing percentage to the tune of 74.75% and 66.06% respectively and average of the yearly appraisal feedback of subject teachers at 84.5% and 82.5% respectively for both subjects since year 2009 till date. A sample of 108 students from Course – Fabrication Technology and Erection Engineering – practical oriented polytechnic course (an off-shoot branch of conventional Mechanical Engineering) was considered eligible as the mean age of the students was 16.81 years (SD = 0.72) and qualification was Post SSC i.e. qualified teenagers for the study. The method used in the study was Relatedness Evaluation Questionnaire (self developed) to determine the above said perceived lack of intelligence and Self Assessment Questionnaire (self developed) to determine the inherent problem solving ability. The questions were designed as per Bloom's Taxonomy, first domain. The results confirmed an essential role of Cognitive Intelligence in perceiving lack of intelligence to the existence of a close interrelationship between core and course subjects as also to determine the ability to use the same for problem solving. A positive correlation (albeit weak) asserts the urgent need to know the process of learn, unlearn and relearn the core and course subjects and vice-versa that may assist to cope with new practical problems at the workplace; therefore it was concluded that such a process should be encouraged in everyday teaching – learning processes.

Index Terms— Interrelationship, Chemistry, Material Science, Cognitive, Workplace

1 Introduction

THE issue of illiteracy in the future will not be defined by those who cannot read and write, but by those who cannot "learn, unlearn and relearn" an apt quote from Alvin Toffler; American writer and futurist, known for his works discussing the digital revolution, communication revolution and technological singularity. A diploma course, no matter what branch of engineering it is helps prepare a student for fieldwork/shopfloor challenges through appropriate core subjects followed by appropriate course subjects pertaining to the specialization. In view of the present scenario, wherein there exists an unbalance between job availability versus job seekers, the course performance of the students is therefore expected to acquiring professional competence with retention and growth on job. To elaborate further on the latter aspect, consider case history of problems as may have been perceived under problem solving from [1], [2], [3];

TABLE 1. HISTORY OF SOLVED TECHNOLOGY PROBLEMS

Sr. No	Core Subject (First Year Engg.)		Course Subject (Second / Third Year Engg.)		Problem factor
1	Cast iron (Chemistry)	→	Cast iron micro-structure, properties and their uses (Material Science)	→	↓
	Get the grapite in the form of nodules by the addtion of nodulizing elements during solidification process	←	Need for control of the micro-structure	←	**Need for ductility in cast iron (not as high as in Mild Steel)**
	↓				
	Ductile Cast iron	→	Ductile cast iron micro-structure, properties and their	→	↓

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			uses		
2	Steel (Chemistry)	→	Steel microstructure, properties and their uses (Material Science)	→	↓
	Controlled combination of low carbon and high chromium in steels	←	Need for control of the microstructure	←	**Need for stainless quality in Steel**
	↓				
	Stainless steel	→	Stainless steel microstructure, properties and their uses	→	↓ ↓
3	Loadingon sheet metal versus plate metal (Strength of material)	→	Strength to weight evaluation parameter (Machine design)	→	↓
	Increase moment of inertia (stiffening methods)	←	Need for effective sheet metal stiffening methods	←	**Need for economy in sheet metal use versus plate metal use**
	↓				
	Improved stiffness in sheet metals	→	Economywith high strength/weight ratio	→	↓ ↓

The above three cases brings forth the need to learn, unlearn and relearn subjects say, material science through chemistry and chemistry through material science and in layman terms may be considered analogous to ordering a cup of hot tea and being served with hot water, tea leaves, lemon, ginger, sugar, etc. separately for self service. So the question is whether a knowledge regarding proper chemical composition of ingredients and process (chemistry) is more important and be learnt independent or whether important is the knowledge needed to have the right cup of hot tea, considering the variety available (material)! The importance of understanding such interdependence as depicted by the analogy underlines the learning, unlearning and relearning process to solve on work engineering problems as concluded by [4] that suggests three thematic issues in the theory of cognition and learning viz. nature of knowing (behaviourist/empiricist view), nature of learning and transfer (cognitive/rationalist view) and nature of motivation and engagement (situative/pragmatist-sociohistoric view) that constitutes a kind of Hegalian cycle of thesis, antithesis and synthesis and [7] that suggests students should acquire a repertoire of cognitive and metacognitive skills and strategies that can be used when engaged in technological activity such as problem solving, decision making and inquiry. Cognitive and metacognitive skills as in [7] are important thinking processes required for problem solving and these skills ought to be taught to students in technology education courses. Careful examination of the cognitive processes employed by students as they work through an ill-defined technical problem provides a means of evaluating the effectiveness of a curriculum approach designed to develop effective problem solvers. Since, the above mentioned process is a continuous teaching – learning process, [5] suggests that the learning environment needs to be open to change and include the wider community. It stresses on the importance of learning how to learn, in preparation for lifelong learning, importance of developing thinking in order to cope with change positively, in lifelong learning, importance of developing general problem solving skills which can be applied to both academic and real life problem solving, importance of acquiring the underpinning cognitive skills needed for academic learning, importance of thinking analytically and critically in order to evaluate, including evaluation of best courses of action, etc. Hands on training as in [6] suggests a Training Needs Analysis combined with work force review and skill mix analysis to identify education and training needs, particularly in post qualifying education viz. Simulation teaching: practicing situations that are not real. To achieve such methods, development of an Integrated Affective Cognitive Teaching and Learning Framework wherein the affective-cognitive teaching and learning framework be developed [9] based on considerations for the needs of the two learning domains; the cognitive domain and the affective domain. In this framework, the existing affective skills be invoked and used to support learning of the cognitive domain as in [9]. Thus, the teaching goals in this case focus on cognitive learning while the teaching and learning activities emphasize equally on the needs of the affective as

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well as the cognitive domain. Understanding of the cognitive domain and affective domain is obtained from Bloom as in [9, 19] but affective domain discussion is out of the defined scope for this paper. Understanding of students' learning preferences and learning stages is important in order to develop appropriate teaching and learning approaches and strategies. Here again, there are many reasons to incorporate an understanding of learning styles in teaching as in [11] such as making teaching and learning a dialogue, responding to a more diverse student body, communicating message and making teaching more rewarding as students bring to the classroom a great diversity of learning styles and therefore the problem is not that faculty/student mismatches occur, but rather it is the failure to acknowledge and work out the potential conflicts and misunderstandings that undermine student learning. This is because as in [8] there are two types; formal operational and concrete operational thinker for any engineering college student. So how does one develop mentally? How does one make the quantum leap from concrete to formal thinking? Mental development as in [8] occurs because the organism has a natural desire to operate in a state of equilibrium. When information is received from the outside world which is too far away from the mental structure to be accommodated, say a problem factor as in Table 1. but makes enough sense that rejecting it is difficult, then the person is in a state of disequilibrium. The desire for equilibration is a very strong motivator to either change the structure or reject the data. If the new information requires formal thinking and the person is otherwise ready, then a first formal operational structure may be formed. This formal operational structure which at first specific for learning in one area is slowly generalized (the person is in a transitional phase). Thus more often the person receives input which requires some formal logic, the more likely he or she would make the jump to formal operational thought. Since this input takes place in a specific area, the transition to formal operations often occurs first in this one area. Also, a person with a less rigid personality structure and tolerance for ambiguity is probably more likely to make the transition. This transition as in [8] is learn to unlearn transition phase and may not be easy. Montgomery Susan M. & Groat Linda N. [10] talks about four principles that have been found to be useful in supporting early engineering learners, such as engage children in solving significant design problems from the beginning, make visible models to support the design task, encourage iterative design and redesign as they are better than single design cycles, provide sufficient time for exposure to engineering material. Schoenfeld, A. H. [12] emphasises on the benefits to students for being consciously aware of how they approach tasks as well as the knowledge that they gain from them. It argues that the ability to reflect on how one operates will both benefit current learning performance and build lifelong learning skills. Schoenfeld, A. H. [12] also suggests that tuning the curriculum through many small-scale, awareness-raising activities and employability-aware reflection could be very powerful. Problem-based learning has been introduced in some engineering departments as in [12] on the grounds that for an equivalent investment of staff time, the learning outcomes of students are improved, as students are better motivated and more independent in their learning and gain a deeper understanding of the subject. It is a style of learning in which the problems act as the context and driving force for learning. It differs from 'problem-solving' in that the problems are encountered before all the relevant knowledge has been acquired and solving problems results in the acquisition of knowledge and problem-solving skills. (In problem-solving, the knowledge acquisition has usually already taken place and the problems serve as a means to explore or enhance that knowledge as was done for the sample survey undertaken). Pina Tarricone, [13] elaborates further on metacognition that refers to one's knowledge concerning one's own cognitive processes or anything related to them, e.g. the learning-relevant properties of information or data. Metacognition refers among other things, to the active monitoring and consequent regulation and orchestration of those processes in relation to the cognitive objects or data on which they bear, usually in the service of some concrete [problem solving] goal or objective. A theoretical framework of thinking and learning based on organization of cognitive resources allows one to make progress towards a central theory for engineering education as in [14]. To demonstrate how the general framework of cognitive resources using the component concepts of activation, association, compilation and control can be applied in the context of a particular knowledge domain, wherein one may have to consider the example of blending two knowledge structures; mathematics and physical knowledge into the engineering skill of modeling. Analyzing this skill in terms of the theoretical framework gives new ways of analysis that permits the identification of specific issues and difficulties that have important educational implications. Christine Nicometo, Thomas McGlamery, Sandra Courter, Traci Nathans-Kelly, and Kevin Anderson [15] talks about lifelong learning, meta-cognition that are important because one can know something at one level (recognize it) and still not know it (know how to use it). Clive L. Dym, Alice M. Agogino, Ozgur Eris, Daniel D. Frey and Larry J. Leifer [16] discusses one major model of design pedagogy; project-based learning, as applied in two course contexts (i.e. firstyear and graduate, globally dispersed) and in several course variations (e.g. single projects, multi-project, case studies, dissection and design projects, etc.). In brief, available research suggests that these kinds of courses appear to improve retention, student satisfaction, diversity, and student learning. On the other hand, it seems clear that the elements of these kinds of courses raise the costs of education (e.g. smaller sections, involvement of senior faculty), but on a macro- or global scale, these costs are likely small compared to the cost of lost human talent in the engineering pipeline. Kolmos A. & Holgaard J. E [17] says reflection is a precondition for problem-based learning, for setting up methodological frameworks, for being innovative and on the meta-cognitive level, for being able to systematically improve individual and organisational learning processes as the overall profile of the engineering student learning preference is similar to several other studies showing that engineering students are active, sensing and visual whereas the sequential tendency is more balanced. Atman Cynthia J., Jennifer Turns, Monica E. Cardella and Robin Adams [18] analyzed design behavior of design educators i.e. instructors who

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are representative of the types of instructors for the students who participated in their previous study and therefore had a better understanding of how engineering educators address design problems raised questions about possible implications for engineering design education and provide a foundation for future exploration of engineering design expertise. The compilation of the above review is now utilized to frame the objective of this paper.

2 Objectives/Hypothesis

Thus the introduction above clearly indicates that Cognitive Intelligence may be expressed in evaluating the ability to learn, unlearn and relearn that may result as the perceived lack of intelligence among engineering students to understand the close interrelationship of core and course subjects in the classroom and the consequences thereso of inability to solve problems. The higher the intelligence displayed would mean outright a higher probability to be able to go to the roots of the problem and come forth with a solution i.e. an expected direct positive correlation. Let us denote the following initials for the rest of the paper to the following terms:
Cognitive Intelligence (CI)
Relatedness Evaluation Questionnaire (REQ)
Self Assessment Questionnaire (SAQ)
Second Year students (SY)
Third Year (TY)
Not Significant (NS)

For correlation:
H0: μ = REQ will have a significant negative relation with SAQ

against

H1: μ = REQ will have an insignificant negative relation with SAQ.

3 Materials and Methods

Participants: A sample of 108 participants representing students was eligible for the study. The mean age in the group was 16.99 years (SD = 0.77) and qualification was Post SSC. The following methods were used in the study. The questionnaire prepared is as per directed by Maharashtra State Board of Technical Education – G Scheme as in [19] in the objective/subjective test evaluation based on Bloom's Taxonomy, first domain. SAQ consists of 5 items. The higher the score, higher is the ability to solve ill defined problems and vice-versa. The psychometric characteristics of the questionnaire was acceptable (George and Mallery, 2003); (Cronbach's alpha = 0.69). The REQ consists of 5 items. The response range is from 1 (Awareness of subjects basics) to 5 (Awareness of subjects applications). The lower the score, stronger is the perceived lack of intelligence to understand the interdependence of the core and course subjects. The questionnaire was acceptable (George and Mallery, 2003); (Cronbach's alpha = 0.64).

Procedure: The method adopted was to present five questions in increasing order of their complexity i.e. Q1 to Q3 was more on recollection of basics and understanding in the interdependence of chemistry and material science towards a more application/analysis and evaluation level as in Q4 & Q5. The questions as mentioned above were assigned a score of 1, 2, 3, 4, 5 for Q1, Q2, Q3, Q4, Q5 respectively which are in the increasing order of their complexity gives an insight to the REQ wherein scores range from 0 to 15 out of 15. Again the same set of questions when presented along with answers after the completion of REQ was assigned a score of 1 ("Strongly No/I don't agree at all") to 5 ("Strongly Yes/I completely agree") hence scores range from 0 to 25. The scores on SAQ versus REQ were analyzed to determine the role of CI to ease out the lack of intelligence in understanding interdependence of core and course subjects in classroom teaching as stated before and improve the problem solving skill using Pearson's correlation methods. Statistics employed were determination of mean, standard deviation, correlation coefficient with P values.

4 Results

The results of the survey are as given below:

Table 2. SY and TY students combined statistics;

SAQ \ REQ	M= 6.09; SD= 5.13; N= 108
M=14.27; SD= 3.41; N= 108	Co-relation co-efficient, r = 0.2103*

*p< 0.05

Table 3. SY students statistics;

SAQ \ REQ	M= 6.14; SD= 5.44; N= 59
M=14.81; SD= 2.26; N= 59	Co-relation co-efficient, r = 0.2050*

*NS, p< 0.05

Table 4. TY students statistics;

SAQ \ REQ	M= 6.04; SD= 4.78; N= 49
M=13.49; SD= 2.43; N= 49	Co-relation co-efficient, r = 0.3025*

*p< 0.05

5 Discussion and Conclusion

The probability of observing the current datas that is non-negative is significant with p< 0.05 for SAQ and REQ as in Table 1. A similar observation is evident when the sample is grouped as second and final year students. Hence, the null hypothesis of a significant negative relation is rejected and the observed non negative relation is not likely would be maybe due to chance.

A briefing on the results of the study conducted is as follows:

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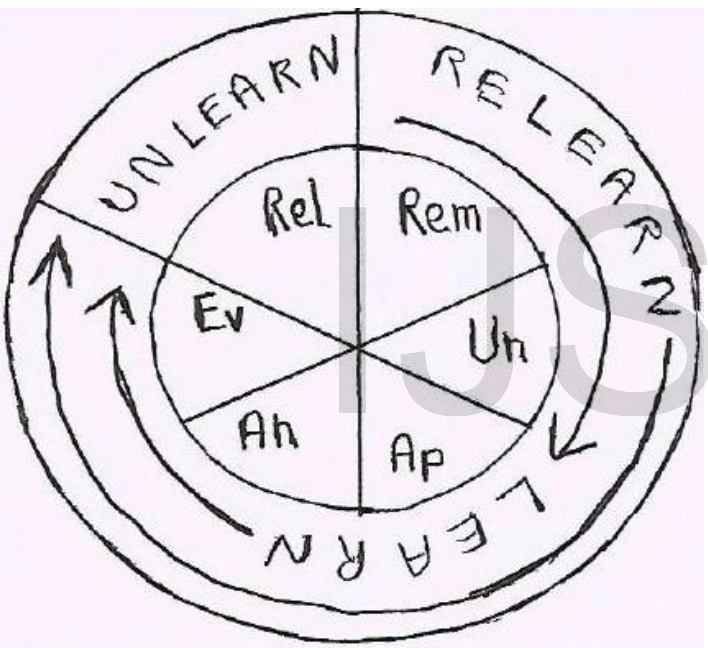
The SAQ versus REQ tests as in Table 1. revealed a weak but a positive correlation; 0.2103 ($p< 0.05$) between both the test assessments. The above scores (Mean & SD) indicate the serious lack of intelligence to understand interdependence between core/course subjects and this trend possibly increases towards the higher level of learning when compared with operational definition of the questionnaires i.e. scores may range from minimum of 0 to maximum 25 (SAQ evaluation) and minimum of zero to maximum of 15 (REQ evaluation). Also, the comparative means of SAQ and REQ viz. 14.27/25 *100 = 57.08% and 6.09/15 *100 = 40.6% implies available positive cognitive intelligence base. Hence, strong are the probabilities that teaching – learning process for the subjects were completed independently and hence the observed lack of information/intelligence with some exceptions as was observed through the self assessment questionnaire. Through this self assessment we arrive to a new paradigm as far as problem solving is considered as shown in the Fig. 1 below.



where,
Rem – Remember
Un – Understand
Ap – Apply
An – Analyse
Ev – Evaluate
Rel – Relate core and course subjects

Fig. 1 Learn, Unlearn, Relearn model (Proposed)

The Learn phase comprising of Remember, Understand, Apply, Analyze and Evaluate leads to a higher level of Create that has been replaced by Relate (core and course subjects) in order to assist the development of creativity for problem solving. This Relate parameter is synonymous with Unlearn phase that motivates a learner to adopt a Relearn phase and start with the cycle of learning again i.e. Remember, Understand, Apply, Analyze and Evaluate. The score of SAQ therefore as in Table1. highlights the inherent ability to remember/recollect previous knowledge of both interdependent subjects and trudge on the relearn path keeping the Problem Factor in hand.

Similarly, the SAQ versus REQ tests as in Table 2. and Table 3. again revealed a weak but a positive correlation; 0.2050 (NS, $p< 0.05$) and an improved one, 0.3025 ($p< 0.05$) between both the test assessments respectively. The scores (Mean & SD) indicate the serious lack of intelligence to understand interdependence between core/course subjects more so for the third year students and this could be extrapolated to the passed out students due to completion of the said subject requirements long back as compared to those in second year who have passed the same in recent times.

However the role of CI was again found to be highly encouraging and if utilized as in Fig. 1 during the teaching, learning & evaluations would provide a more positive correlation between the REQ and SAQ evaluations in context of job retainability and growth in future.

A conclusion on the results of the study may be arrived as follows:
The SAQ versus REQ tests proves that learning, unlearning and relearning process is essential to solve ill defined practical problem that exists on the workplace through an understanding of the interdependence in the core and course subjects. Probable reason for its ignorance could be attributed to the stress on more practical competence achievement especially defined for Diploma level. The overall conclusion that may be interpreted from the results is that since most engineering subjects no matter which branch of specialization it be, have their subjects of branch specialization from second year onwards and the core subjects like physics, chemistry, mathematics, mechanics, technical language, etc. are compulsory at the first year of admission which implies that such problems of correlating the core and course subjects in the regular teaching – learning process and the perceived lack of intelligence therefore may be extrapolated to show that it has to affect other engineering specializations also unless the help of cognitive intelligence as in Fig. 1 had been employed to solve this problem.

6 Future Scope For Research

It has been claimed that emotional intelligence is one of the important factors that determine success in life and psychological well-being [23] and provides evidence for a direct link between emotional intelligence and academic achievement. Emotional intelligence is involved in the capacity to perceive emotions, assimilate emotion-related feelings, understand the information of those emotions and manage them. Nina Ogińska-Bulik [21] also suggests that emotional dissonance, which applies to the frequency of having displayed emotions (usually positive) that are not in line with those genuinely felt (neutral or negative) is rather conceived as stressful (e.g. smiling at a difficult student may create emotional dissonance).

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Frequent experience of emotional dissonance leads to a loss of the capability to regulate one's own emotions, which means the loss of a particular internal resource. In turn, ability to recognize people's emotions and to regulate one's own emotions seems to be very important in teaching – learning processes and defined as emotional intelligence [22]. It refers to one's ability to be aware of one's own feelings, to be aware of other feelings, to differentiate among them, and to use the information to guide one's own thinking and behavior. Hence, approach to problem solving incorporating cognitive intelligence and emotional intelligence as in [27] that found managers high in emotional intelligence revealed less subjective stress and had better physical and psychological well-being i.e. through an ability to recognize the meanings of emotions and the relationships, and to reason and problem- solve on the basis of them. Hence, it was felt that an evaluation of emotional intelligence over and above the cognitive intelligence to counter stress at workplace accompanied with peace of mind was essential with respect to job retainability and growth in a scenario of stiff competition in the job market.

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